OVER AND UNDER VOLTAGE PROTECTION USING GSM MODULE

A Thesis Submitted to the Department of Electrical and Electronic Engineering of BRAC University

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DECLARATION

This is to declare that this thesis titled "Over and Under Voltage Protection using GSM Module" is submitted to the department of Electrical and Electronics Engineering of BRAC University for the partial fulfillment of the degree of Bachelor of Science in Electrical and Electronics Engineering. We hereby affirm that the theoretical research and result was conducted solely by us and has not been presented previously elsewhere for assessment. Materials of the study and work found by other researchers have been properly referred and acknowledged.

Submission Date: 20th August, 2017.

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TABLE OF CONTENTS

Chapter 01

INTRODUCTION

Electrical power distribution system plays an important role in delivering electricity to consumers in overall power system. So for the continuity of this supply we need better protection systems which keep the system intact against from those interrupters which are violating the supply. There are a few motivations the reason we have appropriation automation in distribution system. Until now, the electric power industry need constructed momentous advance previously both aggregate and standard. But, it is anticipated that social request to better benefits might a chance to be asked for. The fundamental capacity of distribution automation system will be the remote control about switches to locate, disconnect those shortcoming and restore the service, when a deficiency happens in the force circulation transport. Smart under and over voltage protection system for home is designed to insure protection of home devices like fan, light lamps, television, refrigerator and all other things you need to protect in case of under and over voltage in main supply. Although there are circuit breakers available in market to provide protection against under and over voltage. But once circuit breaker detect problem in main power supply voltage it turn off main power AC power supply to home devices permanently. Until someone manually press the button on circuit breaker again. The main disadvantage of circuit breaker is that you have to control it manually. The main objective of this project is to add automatic functionality to turn off and turn on main power supply to home devices in case of over voltage and under voltage of main power supply. All electrical devices can bear voltage up to certain limits.

This proposed system will trip the load in the event of the input voltage falling below/above a set value. Two comparators are used as window comparator formed out of one quad comparator IC. This delivers an error output if the input voltage to them crosses the range beyond the voltage window. A relay is then operated to cut off the load for safety reasons. In this project we are going to study the relay and circuit breaker response for over and under voltage condition and also model an embedded system for solving this operation.

Motivation:

In the era of development, advancement and pace we attained efficiency, mobility, flexibility and comfort but we need safe guard as well as. We, as students of electrical side has thus got motivation to design such a system that ensures protection of different electrical junctions and aware us even if we are distant from devices in uncustomary fashion.

The gradual developing rate of accidents because of electrical overflow is alarming for Bangladesh. This project physically gives us little hope to advance a bit for protection of devices and electrical systems.

ACKNOWLEDGEMENTS

First and foremost we are thankful to our God for providing us with the patience and strength to go on and complete this thesis.

We are grateful to our supervisor Avijit Das, Lecturer of BRAC University for his utmost support as well as critical comments and extensive guidelines. His invaluable guidance, excellent research attitude and knowledge about the field of study always encouraged us.

Lastly we offer our regards and gratitude towards all of those who supported us in any aspect during the completion of this thesis.

ABSTRACT

Automation in the distribution field permits utilities on actualize all the adaptable control for distribution systems, which can be used to upgrade efficiency, reliability, quality of electric service. Automation not only upgrade those qualities but also reduces human effort and saves time. Under and over voltage problem is one of the common type of problems which leads most of the insulation and appliance damage throughout our country. In this report we are going to show how under and over voltage problem leads a system into catastrophic situation and also describe how those problems can be minimized economically using automation with a GSM module followed by SMS alert in distribution system.

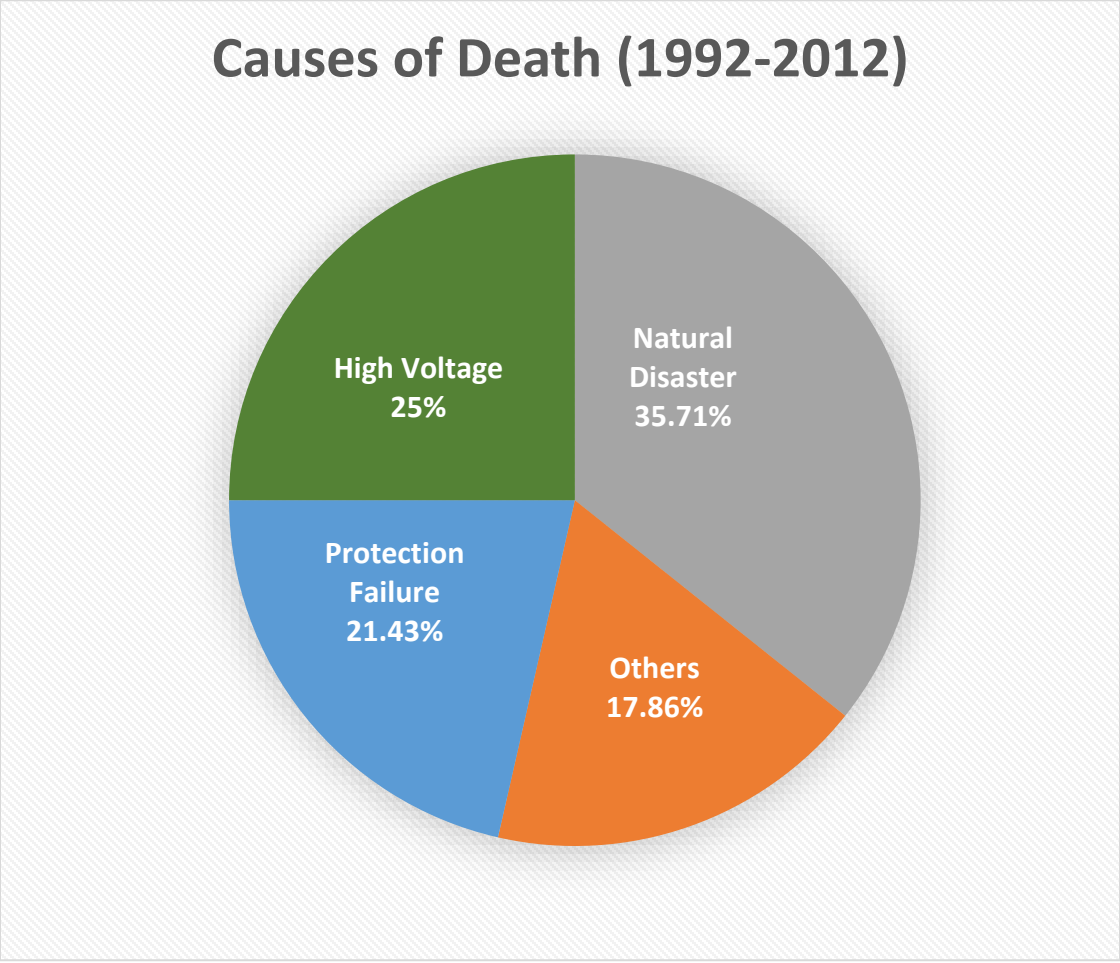
Keywords—Systems; Arduino; Microcontroller; Proteus; System-On-Chip (SOC); Relays; MC circuit Breaker; LCD display; Voltage sensor;

Current Controller.

Chapter 02

Death, Fire and Injuries

Accidents are not something that we can pre-determine and when it comes to the verge of Electricity it's almost impossible to determine. Electricity becoming one of the basic needs of modern society. Each and every minute new devices are connected to the grid and the demand of electricity is rising and the chance of overall accidents are also increasing. These accidents leads to catastrophic situation like seviour injuries, fire and finally death. Some statics are given below emphasizing the overall injuries, fire and death over years of 1992 to 2012.

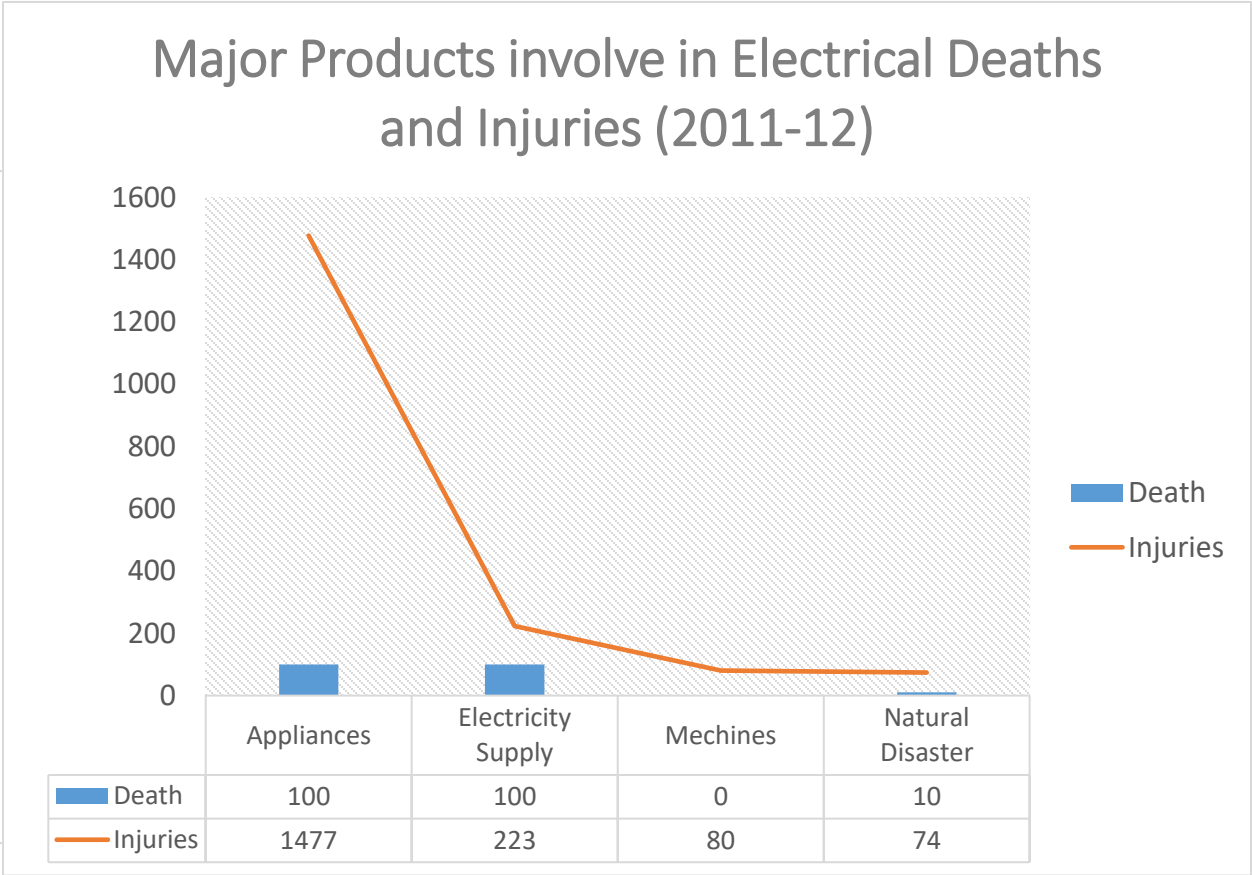


The statics shows that, apart from natural disasters the overall death occurred due to **'High Voltage'** and **'Protection Failure'.**

As we know that from 1992 to 2012 the overall demand is also increasing. Rising demand means increasing the number of appliances which makes our daily life easy and comfortable. According to a new report by the **National Fire Protection Association (NFPA)**. The Electrical Fires report estimates that an electrical failure or malfunction factored in 45,000 to 55,000 home structure fires reported to the U.S. fire departments every year since 2000. These fires, which account for 13 percent of total home structure fires, resulted in annual losses of 455 civilian deaths, 1,500 civilian injuries and $1.5 billion in direct property damage during 2007-2011. Any type of equipment that uses electrical power can have an electrical failure or malfunction. Electrical distribution or lighting equipment accounted for 48 percent of home electrical fires in 2007-2011. Arcing appears to account for most home electrical fires, outnumbering overheating by at least 2-to-1 and as much as 7-to-1.In the report the NFPA is marking National Electrical Safety Month (May) by reminding the public to be aware of the risks associated with the use of electricity, and providing safety tips and information to assist individuals in taking steps to reduce the risk of home electrical fires.

Other key findings in the report have to do specifically with home structure fires involving electrical distribution or lighting equipment, including:

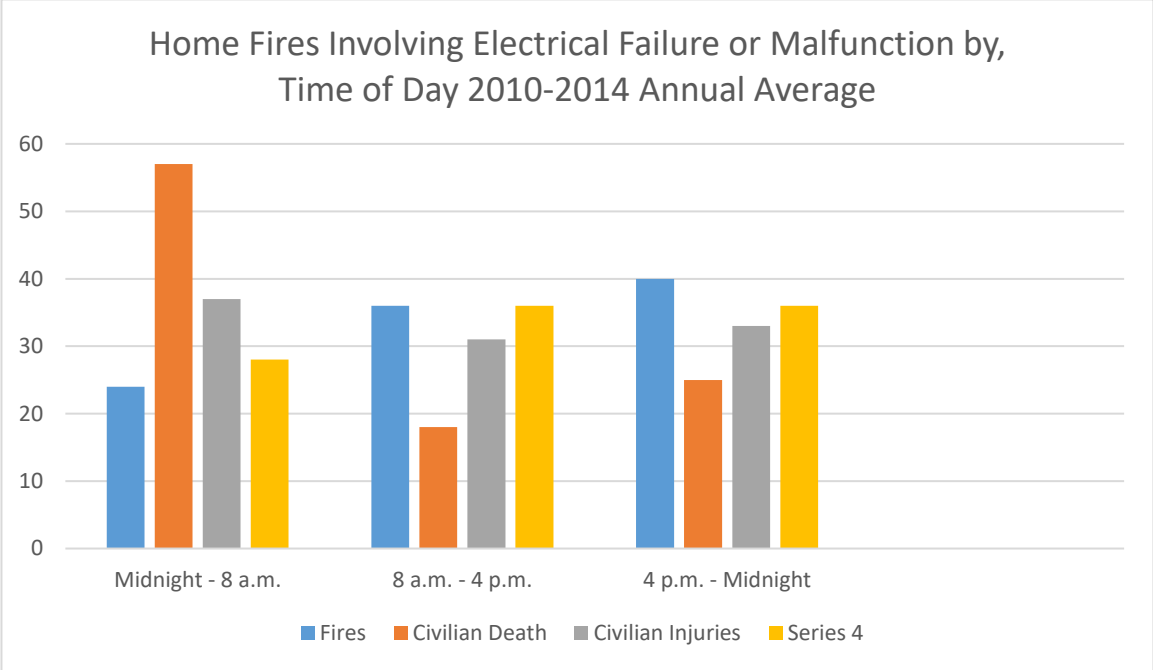
- 63 percent involved wiring and related equipment.
- 74 percent cited some type of electrical failure or malfunction.
- Nearly half (44 percent) of civilian deaths were caused by fires that began in the bedroom, living room, family room, or den.
- Wire or cable insulation was the item first ignited in 32 percent of electrical distribution or lighting equipment home structure fires.



	Appliances	Electricity Supply	Mechines	Natural Disaster
Death	100	100	0	10
Injuries	1477	223	80	74

Some more statics are given below, which shows the overall damage or accidents occurred due to ‘High voltage’, ‘Protection Failure’ and ‘Natural Disaster’.

The Electrical distribution or lighting equipment was involved in 57% of the home fires involving electrical failure or malfunction. One-fifth (19%) of fires involved heating, ventilation and air conditioning equipment, 9% involved kitchen and cooking equipment, and 7% involved personal and household equipment. Electrical fires were distributed fairly evenly by day of week, as shown in Table, with each day of the week accounting for a 14% to 15% share of fires. The following figure shows that the smallest share of electrical fires in homes by time of day in 2010 to 2014 occurred in the period from midnight to 8 a.m., with 24% of fires. However, this period accounted for the highest shares of civilian deaths (57%) and civilian injuries (37%), as well as 28% of



direct property damage. The period from 4 p.m. to midnight accounted for the largest share of fires (40%), while also accounting for 25% of civilian deaths, 33% of civilian injuries, and 36% of direct property damage. Nearly two of five fires occurred in the hours between Electrical Fires.8 a.m. and 4 p.m. (36%). This period was also associated with the smallest share of civilian deaths (18%) and injuries (31%).

The dates above indicates that, the damage due to **'Protection Failure'** around the world is causing enormous deaths and injuries.

Switchgear and Protection

The apparatus used for controlling, regulating and switching on or off the electrical circuit in the electrical power system is known as switchgear. The switches, fuses, circuit breaker, isolator, relays, current and potential transformer, indicating instrument, lightning arresters and control panels are examples of the switchgear devices.

The switchgear system is directly linked to the supply system. It is placed in both the high and low voltage side of the power transformer. It is used for de-energizing the equipment for testing and maintenance and for clearing the fault.

When the fault occurs in the power system, heavy current flow through equipment due to which the equipment get damaged, and the service also get interrupted. So to protect the lines, generators, transformers and other electrical equipment from damage automatic protective devices or switchgear devices are required.

The automatic protective switchgear mainly consists of the relay and circuit breaker. When the fault occurs in any section of the system, the relay of that section comes into operation and close the trip circuit of the breaker which disconnects the faulty section. The healthy section continues supplying loads as usual, and thus there is no damage to equipment and no complete interruption of supply.

Evolution of Switchgear

The switchgear equipment is essentially concerned with switching and interrupting currents either under normal or abnormal operating conditions.

- The tumbler switch with ordinary fuse is the simplest form of switchgear and is used to control and protect lights and other equipment in homes, offices etc.
- For circuits of higher rating, a high-rupturing capacity (H.R.C.) fuse in conjunction with a switch may serve the purpose of controlling and protecting the circuit. However, such a switchgear cannot be used profitably on high voltage system (33 kV) for two reasons.
    - Firstly, when a fuse blows, it take sometimes to replace it and consequently there is interruption of service to the customers.
    - Secondly, the fuse cannot successfully interrupt large fault currents that result from the faults on high voltage system.

With the advancement of power system, lines and other equipments operate at high voltages and carry large currents. When a short circuit occurs on the system, heavy current flowing through the equipment may cause considerable damage. In order to interrupt such heavy fault currents, automatic circuit breakers (or simply circuit breakers) are used.

- A circuit breaker is a switchgear which can open or close an electrical circuit under both normal and abnormal conditions. Even in instances where a fuse is adequate, as regards to breaking capacity, a circuit breaker may be preferable.
- It is because a circuit breaker can close circuits, as well as break them without replacement and thus has wider range of use altogether than a fuse.

Essential Features of Switchgear

The essential features of switchgear are:

1. **Complete reliability:** With the continued trend of interconnection and the increasing capacity of generating stations, the need for a reliable switchgear has become of paramount importance. This is not surprising because switchgear is added to the power system to improve the reliability. When fault occurs on any part of the power system, the switchgear must operate to isolate the faulty section from the remainder circuit.
2. **Absolutely certain discrimination:** When fault occurs on any section of the power system, the switchgear must be able to discriminate between the faulty section and the healthy section. It should isolate the faulty section from the system without affecting the healthy section. This will ensure continuity of supply.

3. **Quick operation:** When fault occurs on any part of the power system, the switchgear must operate quickly so that no damage is done to generators, transformers and other equipment by the short-circuit currents. If fault is not cleared by switchgear quickly, it is likely to spread into healthy parts, thus endangering complete shutdown of the system
4. **Provision for manual control:** A switchgear must have provision for manual control. In case the electrical (or electronics) control fails, the necessary operation can be carried out through manual control.

Types of Switchgear

The switchgear is mainly classified into **two types**,

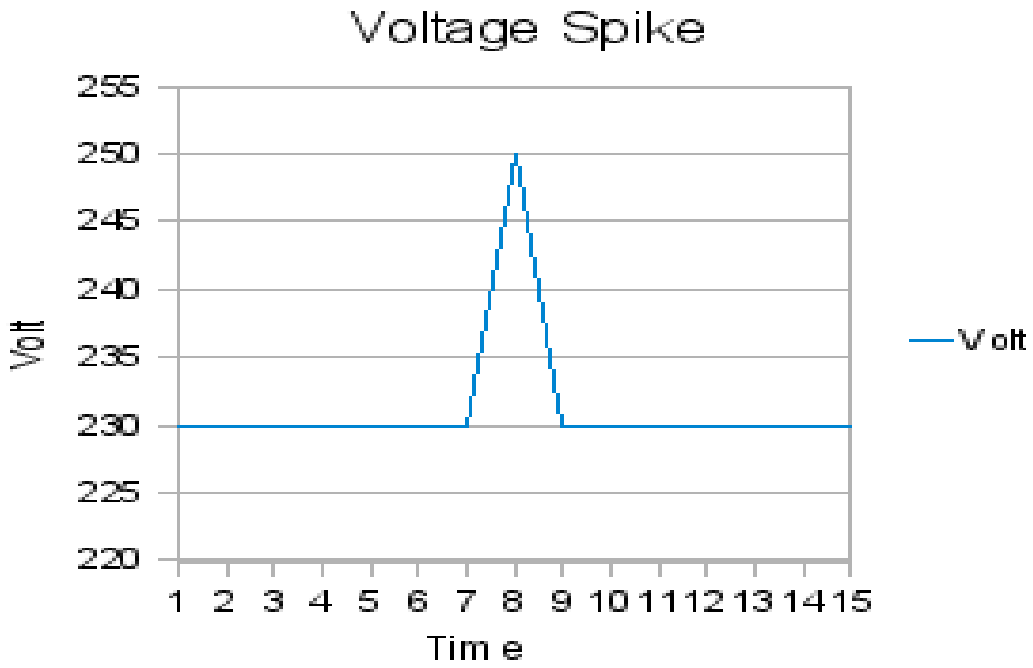
- **Outdoor &**
- **Indoor**

For voltage above 66kV, the output switchgear is used. Because for the high voltage, the building work will unnecessarily increase the installation cost owing to large spacing between the conductor and large size of insulators.

Below the 66kv there is no difficulty in providing the building work for the switchgear at a reasonable cost. The indoor type switchgear is of metal clad type and is compact. Because of the compactness, the safety clearance for operation is also reduced and thus reduced the area required.

What is Over Voltage Protection?

Over voltage protection is a power supply feature which shuts down the supply, or clamps the output, when the voltage exceeds a preset level.



Most power supplies use an over-voltage protection circuit to prevent damage to the electronic components. The impact of an over-voltage condition varies from one circuit to the other and ranges from damaging the components to degrading the components and causing circuit malfunctions or fire.

An over-voltage condition might occur in the power supply due faults inside the supply, or from external causes such as those in the distribution lines.

The magnitude and duration of the over-voltage are some of the major considerations when designing an effective protection. The protection involves setting a threshold voltage above which the control circuit shuts down the supply or diverts the extra voltage to other parts of the circuit such as capacitor.

There are two types of **over voltage**,

- **External Over Voltage &**
- **Internal over Voltage**

External over voltage

This type of over voltages originates from atmospheric disturbances, mainly due to lightning. This takes the form of a surge and has no direct relationship with the operating voltage of the line. It may be due to any of the following causes:

a) *Direct lightning stroke*

b) *Electromagnetically* induced over voltages due to lightning discharge taking place near the line, called 'side stroke'.

c) Voltages induced due to atmospheric changes along the length of the line.

d) *Electrostatically* induced voltages due to presence of charged clouds nearby.

e) Electrostatically induced over voltages due to the frictional effects of small particles like dust or dry snow in the atmosphere or due to change in the altitude of the line.

Internal Over Voltage

These over voltages are caused by changes in the operating conditions of the power system. These can be divided into two groups as below:

1. Switching over voltages or Transient over operation voltages of high frequency:

This is caused when switching operation is carried out under normal conditions or when fault occurs in the network. When an unloaded long line is charged, due to Ferranti Effect the receiving end voltage is increased considerably resulting in over voltage in the system. Similarly when the primary side of the transformers or reactors is switched on, over voltage of transient nature occurs.

2. Temporary over voltages:

These are caused when some major load gets disconnected from the long line under normal or steady state condition.

Effects Of Over Voltage

Over voltage tends to stress the insulation of the electrical equipment's and likely to cause damage to them when it frequently occurs. Over voltage caused by surges can result in spark over and flash over between phase and ground at the weakest point in the network, breakdown of gaseous/solid/ liquid insulation, failure of transformers and rotating machines.

Ideal characteristics of an over voltage protection circuit

1. Prevent the excess voltage from being applied to the components.
2. The protection circuit should not interfere with the normal function of the system or circuit. The protection circuit should not load the power supply and cause related voltage drops.
3. The protection circuit should be able to distinguish between normal voltage fluctuations and harmful over-voltage.
4. Be fast enough to respond to transient events that can damage the power supply and downstream components.
5. The OVP method should not to have false trips or undetected real over-voltage conditions. This can be a nuisance in the case of false trips and also dangerous if it is unable to see the real over-voltage conditions.

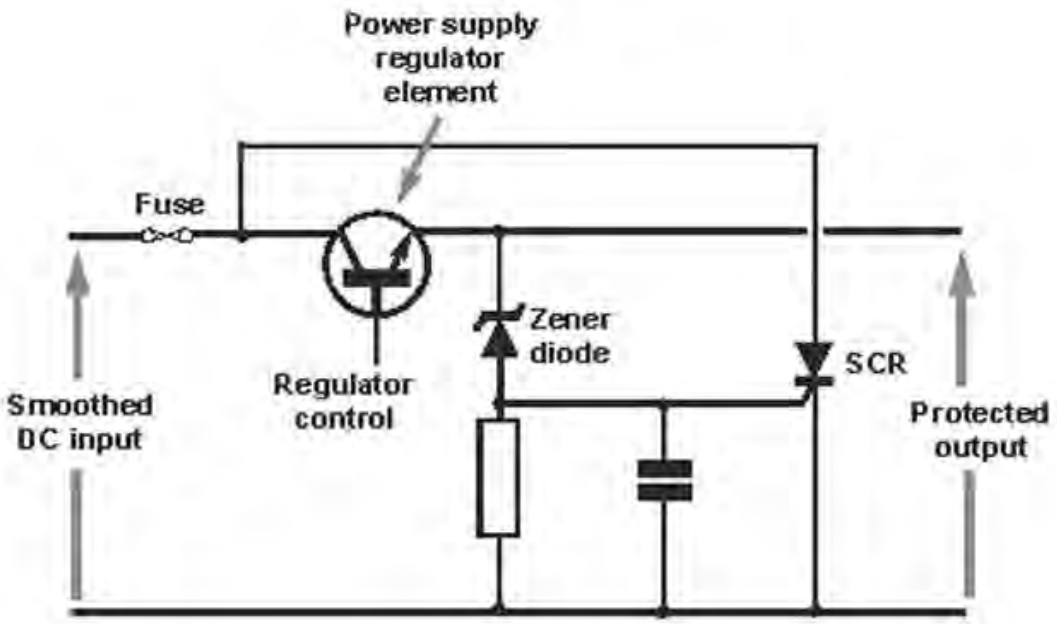
   The over voltage protection circuit may be constructed using discrete components, integrated circuits, mechanical devices such as relays, etc. These can either connected internally or externally depending on the circuits involved.

   There are various protection circuit designs, each with its merits, mode of operation, sensitivity, ability, and reliability. The protection can either clamp off the excess voltage, or completely shut down the power supply.

A crowbar over-voltage protection circuit

A crowbar circuit provides one of the simplest, cheap and effective over-voltage protection methods. This is usually connected between the regulated output and the protected circuit or load. The series regulating transistor controls the output current and voltage while the crowbar consists protects the load when the voltage exceeds a preset value. A basic circuit consists of:

- Silicon controlled rectifier (SCR)
- Zener diode
- Resistor
- Capacitor



Over-voltage protection crowbar circuit

During the normal operation, the zener diode is reverse biased and does not conduct, all the current through the series transistor appears at the output. Once the voltage rises and goes beyond the zener breakdown voltage, the diode breaks down and starts conducting. The current develops a voltage across the resistor which then triggers the SCR. This places a short circuit across the output and all the current is sank into the ground. This caused the fuse to open and removes the voltage from the series transistor and the protected circuit.

The zener diode selected must be slightly above the output voltage. The capacitor prevents the triggering of the SCR by short spikes.

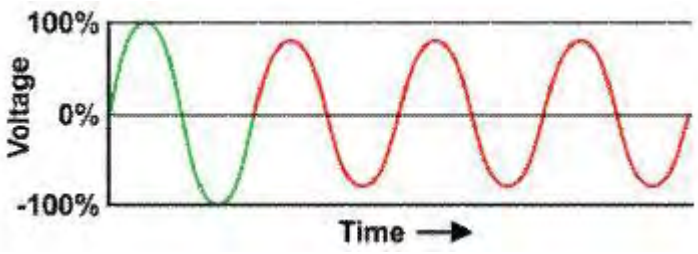
The simple circuit is widely used due to its effectiveness; however it has some limitations, such as Zener diode being not adjustable while the best tolerance for the diode is 5%.

The SCR firing voltage must also be designed to be far above the power supply's output voltage to prevent erroneous firing by short spikes such as those generated when powering RF circuits.

Under Voltage

Under Voltage is the decrease in AC RMS voltage at power frequency to less than 90% of the network nominal voltage and for duration longer than one minute. According to IEEE 1159/1995, decreased voltage will range from 80% to 90% of the nominal voltage and for duration longer than one minute.

Under Voltage Impacts:



Under voltage causes many problems with the that required steady state voltage especially modern load so it causes malfunction, miss operation and in some times full operation stoppage.

Voltage Sag Impacts:

Voltage sag causes many problems like:

(1) Malfunction of information technology equipment which called microprocessor based control systems (PLC, ASD, PCs……etc.) that may lead to process stoppage.

(2) Tripping of contactors and electromagnetic relays.

(3) Disconnection and less efficiency in rotating machines.

Features:

We have in this project has some features to ensure safe guards of electrical systems as-

1) Security access with administrative privilege;
2) Real time actual usage data;
3) Usage history preserves in memory and online domain server;
4) Control access from wide range through GSM module;
5) Instant SMS provide facility;
6) Automatic turn ON/OFF facility;
7) Protection for both voltage and current overflow;
8) Advantages and transparency in electrical billing.

1. Security access with administrative privilege:

   This device is security protected with specific login access compatibility. Specific personnel with pre saved password can only access the system. The device will function only when it has fixed personnel operator.

2. Real time actual usage data:

   Due to fault of meter or tampered meter there is always a variation in usage data provided by analog meter and actual usage. This digital smart system screens the real usage of consumer through electric calculation function.

3. Online Backup:

   This particular device protects usage data history and preserves all information. With a pre designated portal, all the information are kept preserved. So there is no margin for data to lose. The domain keeps and updates all the information signals sent by the GSM module.

4. Remote accessibility:

   The system is mounted with a GSM module which provides remote access privilege. The authorized user(s) can access from wide and far ranges through air communication. This particular feature gives the device mobility to engage even when consumer is distant from the device.

5. SMS facility:

   During fault occurs or device starts or turns off there is a SMS sent to the pre designated cellular number. The number is pre inserted in the Arduino code. So, the user is always updated with the device even when it is out of sight.

6. Automation:

   This device is an automated designed device. The device is turned ON automatically during the fault occurring time period and after a certain time it is turns OFF automatically. There is tough manual option but this automation certainly enhances the device.

7. Protection for both voltage and current:

   This device provides protection and security for both current and voltage. It alarms in conditions for both over and under and fault situations. The consumer is always safe from any kind of electrical mismatch or mishap. The voltage sensor detects the pre inserted voltage limitation range and the current controller does the same for current.

8. Transparency in electrical billing:

   The device acts as a watchdog for both the consumer and power distribution system. It keeps and updates real time electrical usage and uploads time to time in the domain. The website provides unit wise monthly bill then. The consumer after getting monthly bill from the distributor can easily cross check. This very facility also provides antitheft privilege for the distribution side.

Advantages:

In this automated device there are some independent facilities which differs and advances the system from analog and other digital protection systems. They are as follows-

1) Reliable and cheap;
2) Independent and fast in terms of operation;
3) Totally automated;
4) Consumer can compare between government provided bills and device oriented one;
5) Administrator access privilege;
6) Secured and advanced;
7) Consumer can keep data about usage and preserve in online;
8) Distant access compatibility;
9) Will create awareness and knowledge over electrical terms among consumers.

Thesis Organization:

Forward parts of this report is organized as follows; Chapter two is about hardware components those are used in this entire project. The title of the chapter is “Hardware Components”. Next, chapter three focuses on simulation of the entire protection system. After that, the following chapter will be focusing on system Design, working methodology. Then, chapter five discusses future works and the report concludes.

Chapter 03

Hardware Components

Circuit Components

- Bridge Rectifier
- Capacitor
- 220-12V Step Down Transformer
- Zener Diode
- Arduino UNO
- Resistors
- LCD Display
- Regulator
- Relay
- Voltage Sensor
- Current Controller
- Diode
- Potentiometer
- BJT 547
- GSM Sim808
- Opto Coupler
- AC to DC converter (12V-6V)

Arduino:

Arduino is an open-source project that made microcontroller-based packs for building computerized gadgets and interactive objects that can detect and control physical devices. The venture depends on microcontroller board plans. These systems give sets of computerized and analog input/output (I/O) pins that can interface to different extension sheets (named shields) and different circuits. The sheets highlight serial correspondence interfaces, including Universal Serial Bus (USB) on a few models, for leading programs from PCs. For programming the microcontrollers, the Arduino extend gives an integrated development environment (IDE) in light of a programming dialect named Processing, which likewise underpins the dialects C and C++.

An Arduino board comprises of an Atmel 8-, 16-or 32-bit AVR microcontroller with corresponding parts that encourage programming and joining into different circuits. An important part of the Arduino is its standard connectors, which let clients associate the CPU board to an assortment of tradable extra modules named shields.The reason of using Arduino is to control the circuit. In our project, Arduino plays a vital role. The reason behind this is, in our project voltage measurement, perfect tripping time, give notification to the user on time is very important. To control these things in parallel way, Arduino is important. In this project, we are willing to use Arduino UNO to fulfill all our necessity. The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller. We can easily

connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

We could have used microcontroller. This would fulfill our all demand. But there are some drawbacks using microcontroller. The main superiority of using Arduino is it has a vast amount of library which microcontroller don't have. Besides as we are thinking of making something that does not cost much. Arduino UNO is cheaper than microcontroller so if we think economically Arduino UNO is good for us. Microcontroller will make the device that we are trying to build quite big on the other hand Arduino UNO is small. For these reasons we chose to work with Arduino UNO.

Bridge Rectifier:

We used this rectifier as the supply is of ac so we need to convert the AC to DC. We can use full wave also but it is has more losses than this rectifier as we don't use center tap in this rectifier as it forms continuous flow of direct current. We will use four diodes in this rectifier and one capacitor parallel to this acts as filtering of the ac currents from dc currents. It requires four diodes instead of two, but avoids the need for a center tapped transformer. During the positive half cycle of the secondary voltage, diodes D1 and D3 are conducting and D2 and D4 are no conducting. Therefore, current flows through the secondary winding, diode D1 and D3, resistor RL. During the negative half cycle of the secondary voltage, the diodes D2 &D4 conduct and diodes D1 and D3 do not conduct. Then current flows through the secondary winding, diode D2 D4 and Resistor RL. In both cases current passes through the load resistor in the same direction

A bridge rectifier, is a group of rectifiers (4 in a single phase) wired so that each half of an AC current is passed to respective positive and negative lines of a DC output. It provides full wave rectification of AC into DC.

With the availabilities of low-cost, highly reliable and small-sized silicon diodes bridge rectifier is becoming more and more popular in comparison to center-tap and half-wave rectifier. It has many advantages over a center-tap and half-wave rectifier, as given below. The rectification efficiency of full-wave rectifier is double of that of a half-wave 12 rectifier. The ripple voltage is low and of higher frequency in case of full-wave rectifier so simple filtering circuit is required. Higher output voltage, higher output power and higher Transformer Utilization Factor (TUF) in case of a full-wave rectifier. In a full-wave rectifier, there is no problem due to dc saturation of the core because the dc current in the two halves of the two halves of the transformer secondary flow in opposite directions. No center tap is required in the transformer secondary so in case of a bridge rectifier the transformer required is simpler. If stepping up or stepping down of voltage is not required, transformer can be eliminated even. The PIV is one half that of center-tap rectifier. Hence bridge rectifier is highly suited for high voltage applications. Transformer utilization factor, in case of a bridge rectifier, is higher than that of a center-tap rectifier. For a given power output, power transformer of smaller size can be used in case of the bridge rectifier because current in both (primary and secondary) windings of the supply transformer flow for the entire ac cycle.

It will cost 0.4$ globally.

Capacitor:

Capacitors store and release electrical charge. They are used for filtering power supply lines, tuning resonant circuits, and for blocking DC voltages while passing AC signals, among numerous other uses. 470micro farads: 15 0.1 micro capacitor.

AC capacitors will cost 0.5$ per piece.

Zener Diode:

We used diodes in this project near the low voltage and high voltage near low voltage we use 6.0v and near high voltage 6.8v diode. As this diodes are used as break down voltage constructions: The Zener diode's operation depends on the heavy doping of its p-n junction. The depletion region formed in the diode is very thin (<1 μm) and the electric field is consequently very high (about 500 kV/m) even for a small reverse bias voltage of about 5 V, allowing electrons to tunnel from the valence band of the p-type material to the conduction band of the n-type material. In the atomic scale, this tunneling corresponds to the transport of valence band electrons into the empty conduction band states; as a result of the reduced barrier between these bands and high electric fields that are induced due to the relatively high levels of doping on both sides. The breakdown voltage can be controlled quite accurately in the doping process. While tolerances within 0.05% are available, the most widely used tolerances are 5% and 10%. Breakdown voltage for commonly available Zener diodes can vary widely from 1.2 volts to 200 volts.

6.8V Zener diode costs 0.1$ per piece.

Transformer:

Transformers are also used extensively in electronic products to step-down the supply voltage to a level suitable for the low voltage circuits they contain. The transformer also electrically isolates the end user from contact with the supply voltage. We have used a 220V to 12V ac transformer.

Relay:

When an electric current is passed through the coil it generates a magnetic field that activates the, and the armature consequent movement of the movable contact(s) either makes or breaks (depending upon construction) a connection with a fixed contact. If the set of contacts was closed when the relay was de-energized, then the movement opens the contacts and breaks the connection, and vice versa if the contacts were open. When the current to the coil is switched off, the armature is returned by a force, approximately half as strong as the magnetic force, to its relaxed position. Usually this force is provided by a spring, but gravity is also used commonly in industrial motor starters. Most relays are manufactured to operate quickly. In a low-voltage application this reduces noise; in a high voltage or current application it reduces arcing.

When the coil is energized with direct current, a diode is often placed across the coil to dissipate the energy from the collapsing magnetic field at deactivation, which would otherwise generate a voltage spike dangerous to semiconductor circuit components. Some automotive relays include a diode inside the relay case. Alternatively, a contact protection network consisting of a capacitor and resistor in series (snubber circuit) may absorb the surge. If the coil is designed to be energized with alternating current (AC), a

small copper "shading ring" can be crimped to the end of the solenoid, creating a small out-of-phase current which increases the minimum pull on the armature during the AC cycle.

A solid-state relay uses a thyristor or other solid-state switching device, activated by the control signal, to switch the controlled load, instead of a solenoid. An optocoupler (a light-emitting diode (LED) coupled with a photo transistor) can be used to isolate control and controlled circuits.

GSM Sim808:

SIM808 module is a total Quad-Band GSM/GPRS module which joins GPS innovation for satellite route. The conservative outline which incorporated GPRS and GPS in a SMT bundle will essentially spare both time and expenses for clients to create GPS empowered applications. Including an industry-standard interface and GPS work, it enables variable advantages for be followed flawlessly at any area and at whatever time with flag scope.

The SIM808 module has to be connected to Uno as follows:

- Vcc to 5V
- Gnd to Gnd
- RXD to digital pin 10
- TXD to digital pin 9

This system has a supply voltage range of 3.4V ~ 5V.

BJT:

A bipolar intersection transistor (bipolar transistor or BJT) is a kind of transistor that utilizations both electron and opening charge transporters. Conversely, unipolar transistors, for example, field-impact transistors, just utilize one sort of charge bearer. For their operation, BJTs utilize two intersections between two semiconductor sorts, n-sort and p-sort.

BJTs are made in two sorts, NPN and PNP, and are accessible as individual segments, or created in coordinated circuits, regularly in extensive numbers. The essential capacity of a BJT is to open up current. This enables BJTs to be utilized as intensifiers or switches, giving them wide relevance in electronic gear, including PCs, TVs, cell phones, sound enhancers, mechanical control, and radio transmitters.

In this particular circuit configuration we have used BJT547.

Potentiometer:

A potentiometer is a three-terminal resistor with a sliding or turning contact that structures a flexible voltage divider. If just two terminals are utilized, one end and the wiper, it goes about as a variable resistor or rheostat.

The measuring instrument called a potentiometer is basically a voltage divider utilized for measuring electric potential (voltage); the segment is a usage of a similar standard, thus its name.

Potentiometers are usually used to control electrical gadgets, for example, volume controls on sound hardware. Potentiometers worked by a system can be utilized as position transducers, for instance, in a joystick. Potentiometers are once in a while used to straightforwardly control huge power (more than a watt), since the power scattered in the potentiometer would be practically identical to the power in the controlled load.

We used potentiometer to convert 6V to 5V for Arduino use.

Opto Coupler:

In hardware, an opto-isolator, likewise called an optocoupler, photocoupler, or optical isolator, is a part that exchanges electrical flags between two confined circuits by utilizing light. Opto-isolators keep high voltages from influencing the framework getting the signal. Commercially accessible opto-isolators withstand contribution to-yield voltages up to 10 kV.

A typical kind of opto-isolator comprises of a LED and a phototransistor in a similar misty bundle. Different sorts of source-sensor mixes incorporate LED-photodiode, LED-LASCR, and light photo resistor sets. Normally opto-isolators exchange computerized (on-off) signs, however a few methods enable them to be utilized with simple signs.

An opto-isolator contains a source of light, quite often a close infrared light-emanating diode (LED) that believes electrical information motion into light, a shut optical channel and a photo sensor, which distinguishes approaching light and either creates electric vitality straightforwardly, or regulates electric current spilling out of an outside power supply. The sensor can be a photo resistor, a photodiode, a phototransistor, a silicon-controlled rectifier (SCR) or a triac. Since LEDs can detect light notwithstanding producing it, development of symmetrical, bidirectional opto-isolators is conceivable. An optocoupled strong state hand-off contains a photodiode opto-isolator which drives a power switch, more often than not a reciprocal combine of MOSFETs. An opened optical switch contains a wellspring of light and a sensor, yet its optical channel is open, permitting tweak of light by outer items discouraging the way of light or reflecting light into the sensor.

AC to DC Converter:

An AC to DC converter or widely known as rectifier, is an electrical gadget that rotates current (AC), which intermittently inverts bearing, to direct present (DC), which streams in just a single direction. Rectifiers have many utilizations, yet are regularly discovered filling in as parts of DC power supplies and high-voltage coordinate current power transmission systems. Because of the exchanging way of the info AC sine wave, the procedure of amendment alone creates a DC current that, however unidirectional, comprises of beats of current. Numerous uses of rectifiers, for example, control supplies for radio, TV and PC gear, require a relentless consistent DC current.

The transformer in this experiment was AC, so needed a rectifier to make it DC.

Voltage Sensor:

A voltage sensor will be ready to decide and even screen and measure the voltage supply. It is then ready to take those estimations and transform them into a flag that one will at that point have the capacity to peruse. The flag will regularly go into a specific electronic gadget for recording, yet once in a while, an eyewitness will be available to physically read the sensor yield.

We have fixed higher voltage to 235V and lower voltage to 200V, elsewise sensor will sense.

Current Controller:

Current controlling is the practice in electrical or electronic circuits of forcing a furthest point of confinement on the present that might be conveyed to a load with the motivation behind securing the circuit producing or transmitting the current from destructive impacts because of a short out or comparative issue in the load.

Diode:

A diode is a two-terminal electronic part that conducts fundamentally in one direction; it has low imperviousness to the current in one heading, and high resistance in the other. A semiconductor diode, the most well-known sort today, is a crystalline bit of semiconductor material with a p–n intersection associated with two electrical terminals. The most regular capacity of a diode is to enable an electric current to go in one heading (called the diode's forward bearing), while at the same time blocking current the other way (the reverse biasing).

LCD Display:

A liquid-crystal display (LCD) is a flat-panel display or optical device that uses the light-modulating properties of liquid crystals. LCD’s don't radiate light straightforwardly, rather utilizing a backdrop illumination or reflector to deliver pictures in shading or monochrome. LCDs are used in a wide range of applications including computer monitors, televisions, instrument panels, aircraft cockpit

displays, and indoor and outdoor signage. Small LCD screens are common in portable consumer devices such as digital cameras, watches, calculators, and mobile telephones, including smartphones.

Bread Board:

A present day solderless breadboard attachment comprises of a punctured square of plastic with various tin plated phosphor bronze or nickel silver amalgam spring cuts under the holes. The clasps are regularly called tie focuses or contact focuses. The quantity of tie focuses is regularly given in the determination of the breadboard. The edge of the board has male and female scores so sheets can be cut together to shape an extensive breadboard.

Chapter 04

Software Simulation

All electrical devices can bear voltage up to certain limits. For example your home fan normal operating voltage is 220 volt AC. If voltage input to fan become greater than or less than about 20% of normal operating voltage of fan it many burn fan and in case of less voltage fan excessive current may flow which in turn cause short circuit in your home wiring. To avoid all these issues this project is designed which automatically turn on and turn off main power supply in case of issue in AC main power supply and on one need to control it manually. Microcontroller is embedded into this system to make it smart enough to handle all the issues intelligently and to provide control signals to turn on and off AC main power supply.

Following things are the main components of this project for simulation. Function of each component used in this project will be described briefly with picture.

Voltage Sensor:

Voltage sensor is used to measure voltage of AC main power supply. Voltage sensor is used difference amplifier to step down voltage level from 220 volt AC to 2.8 volt AC or 311 volt peak of AC voltage to 3.96 volt of peak voltage of sine wave. Difference amplifier is used as a signal conditioning circuit to convert high voltage of AC main supply into low voltage which Arduino Uno can easily read. Because analog to digital converter cannot read voltage more than 5 volt and voltage more than 5 volt will eventually damage Arduino. So difference amplifier as a signal conditioning circuit is used to step down voltage by adjusting the gain of difference amplifier.

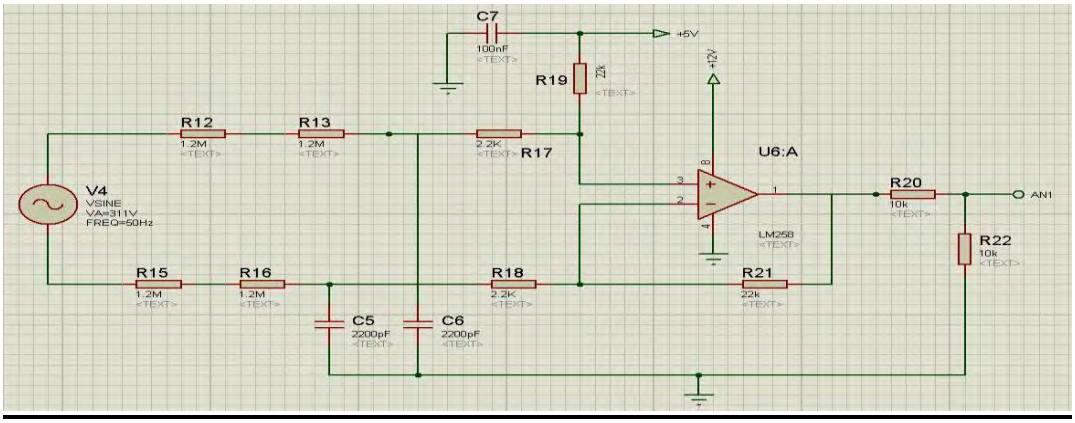


Fig: Difference Amplifier

High speed relay:

Relay is used to turn on and turn off main power supply. Relay get control signal from Arduino Uno through a transistor. Diode is use in parallel with coil pin of relay to avoid sparking in case of back EMF (Electromagnetic Force). For relay to turn on, 12 volt DC is needed.

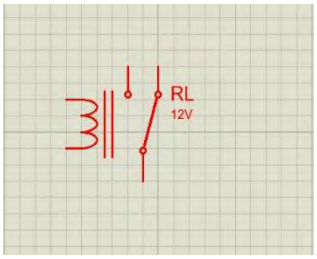


Fig: Relay

Liquid Crystal Display:

LCD is used to display value of voltage and status of your power supply. If AC voltage of main power supply is greater or less than 20% of normal operating voltage, LCD display "fault occur". Otherwise LCD display "No fault". LCD also displays value of AC main voltage supply. For simulation we used LM016L which is a 16x2 display.

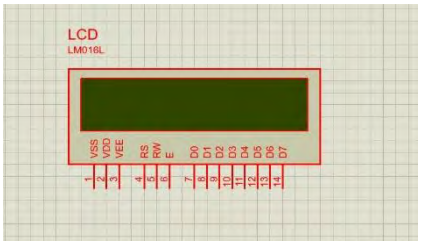


Fig: LCD Display

Voltage regulators:

As the name implies, voltage regulators are used to regulate voltages especially when low voltage is needed from high voltage. We used two regulators. 7805 and 7812. 7805

is used to get regulated 5 volts which is supply voltage for Arduino and 7812 is used to get regulated 12 volts which is supply voltage for relay. 220 to 12 volt step down transformer and rectifier full bridge is used to produce DC voltage which is input for the both voltage regulators.

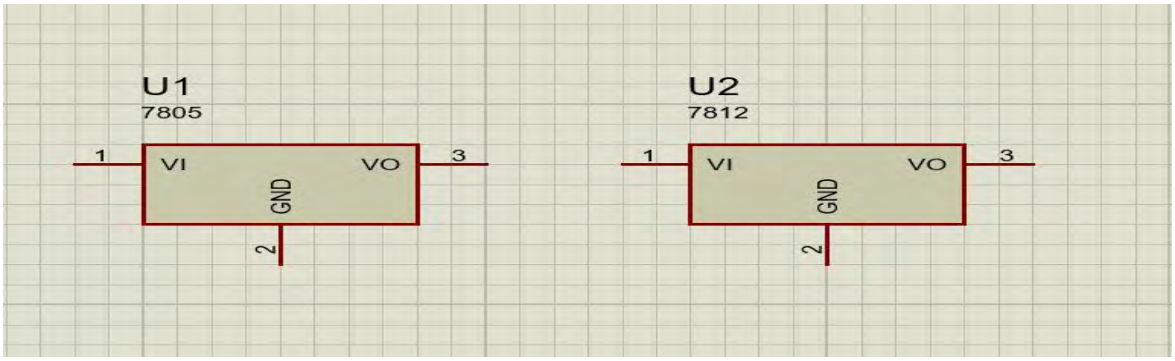


Fig: 7805 and 7812 Voltage Regulators

Arduino Uno:

Arduino Uno is use to make this project intelligent and smart. ADC of Arduino is used to measure analog AC voltage. Control signals is used to turn on or off transistor which control the relay. Arduino reads the analog value of voltage and display it on LCD. Actually embedding Arduino Uno make this project intelligent and smart enough so that it can take control actions automatically in case of under and over voltage. It can also automatically turn on or off power supply without having need of any person.

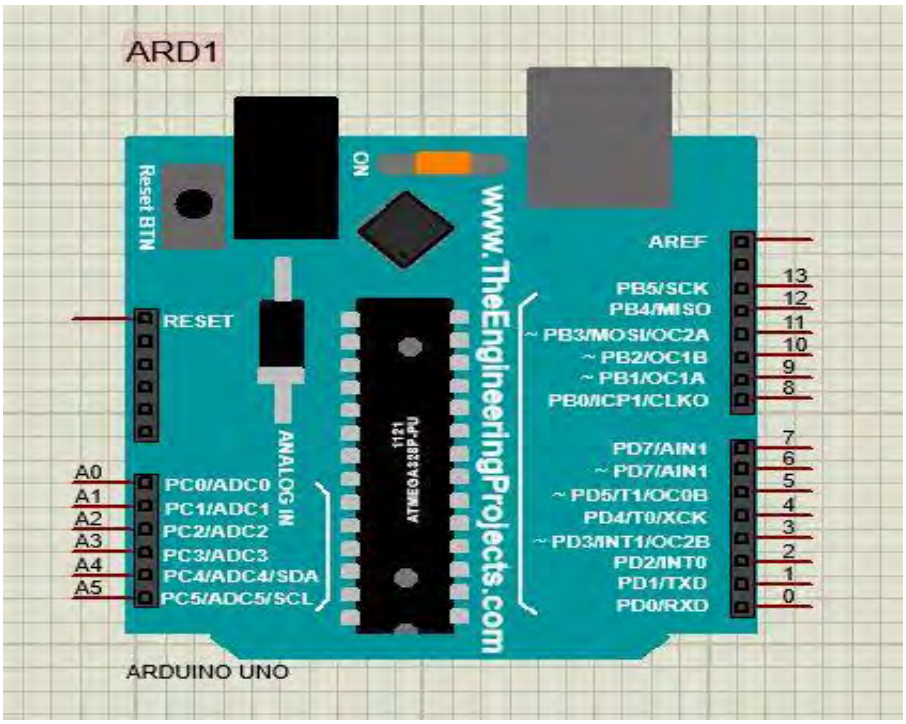


Fig: Arduino Uno

This diagram will show when voltage is 220 volt AC or less than of normal operating voltage, the LED is on and relay is working and the LCD Display will show that there is no fault in the line. Because relay is used as normally closed mode.

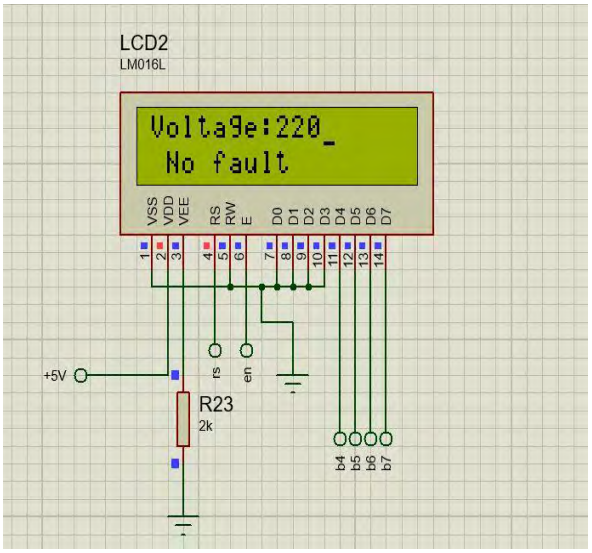


Fig: Relay is on and RED LED is blinking.

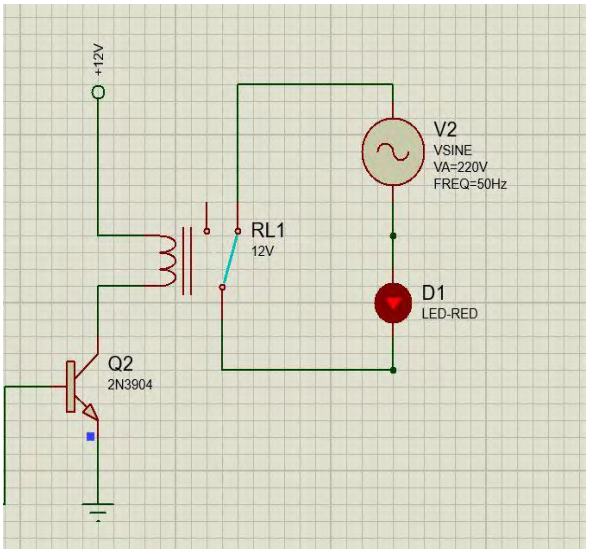


Fig: "NO FAULT" when Normal voltage is passing

But when voltage become greater than or less than normal operating voltage it will turn off relay in minimum possible time and relay in return turn off main AC power to ensure safety of devices.

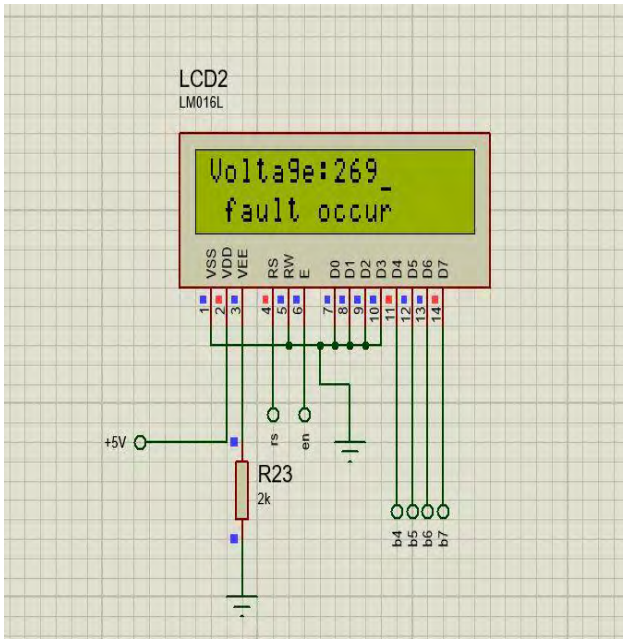


Fig: "FAULT OCCUR" when high voltage is passing

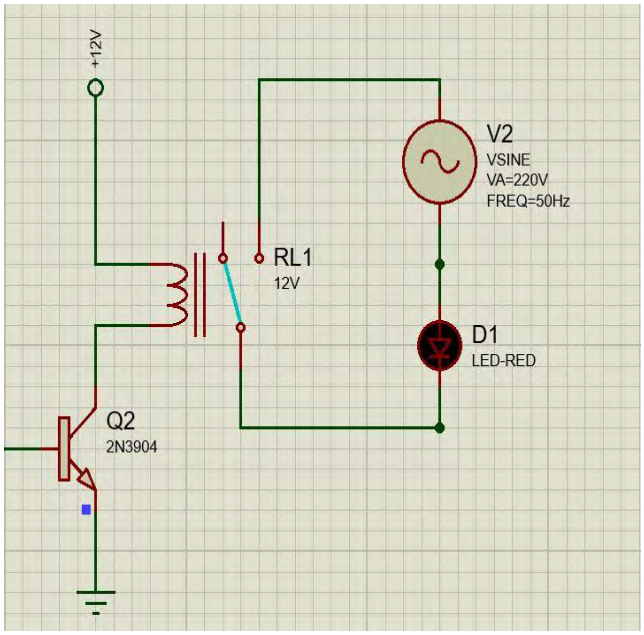
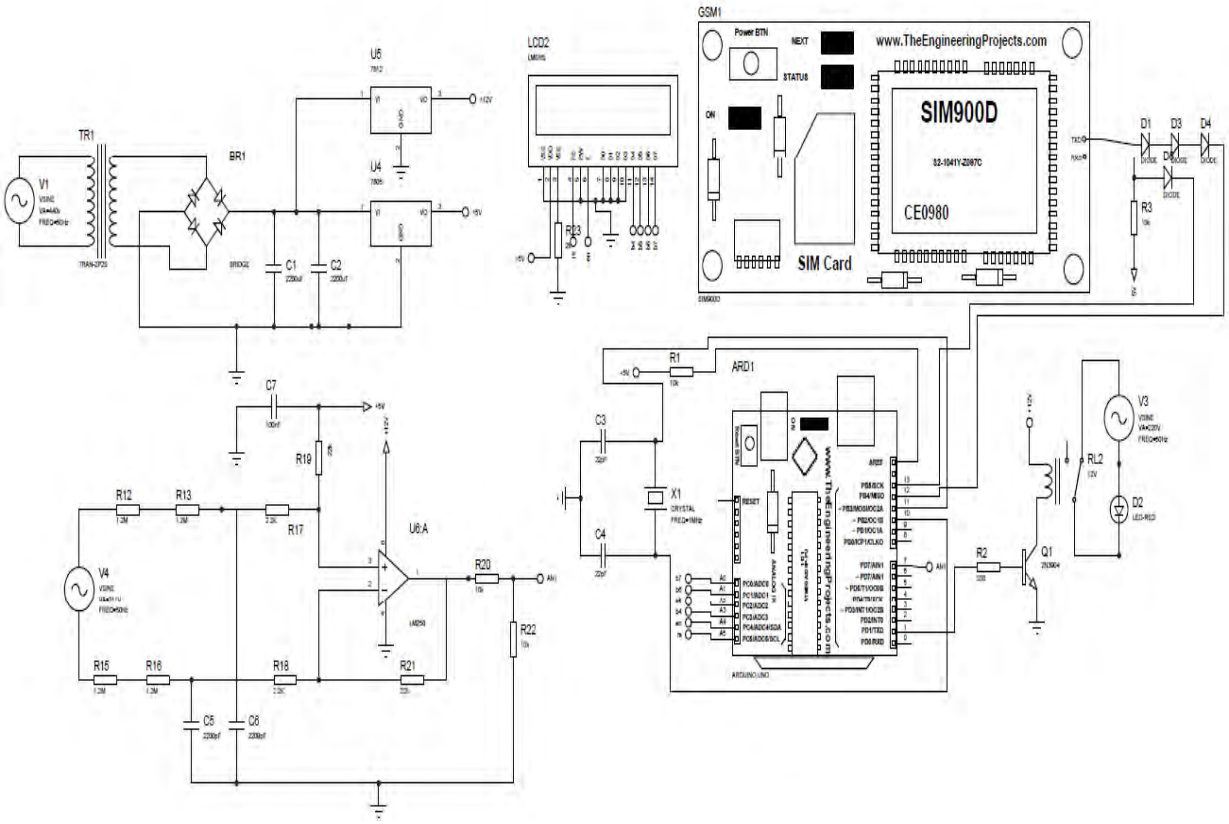


Fig: Relay is Off and LED has stopped blinking

Complete Circuit Diagram along with GSM Module

We have added SIM900 GSM Module along with the rest of the circuit. To this to work we need to practically make this circuit with the GSM. Which we did. In the later part of this paper you will find out the practical implementation of this Schematic diagram.



Protection System:

In a complete electric system there must have safety gauges and protection systems.

Switchgear is such a system that allows electrical circuit to function with safety. Switchgear is a mix of electrical separate switches, wires or circuit breakers used to control, ensure and confine electrical hardware. Changes are sheltered to open under ordinary load current, while defensive gadgets are protected to open under fault current.

Switchgear consists of CT, PT, isolator, busbar etc. The fundamental purposes of switchgear are as follows-

1) Switch load currents;
2) Make onto a fault;
3) Carry fault current without blowing itself up;
4) Break normal and fault current.

Relays are widely used safety component around the globe. Relays are the devices, which monitor the conditions of a circuit and give instructions to open a circuit under unhealthy conditions.

Electromechanical and static relays are mostly used relays.

Methodology

This project is designed which automatically turn on and turn off main supply in case of issue in AC main power supply and no one need to control in manually. It is designed to ensure protection of home devices like fan, televisions, refrigerator and all other things we need to protect in case of under and over voltage in main supply. This device has three parts by which it is said to the safeguard given there occurs any irregularities in AC supply. GSM module, Arduino controlling and Networking these are the three parts of this device.

GSM Module

In this device, GSM is mainly used for communication purpose. We made our device in such a way that no extra hand is needed to turn this thing after it first turned on. It can be turned on and off through mobile phone call.

At first when it is introduced with the AC main supply, the device will turn on and a message will be sent to the user's registered sim that the "Device Restarted".

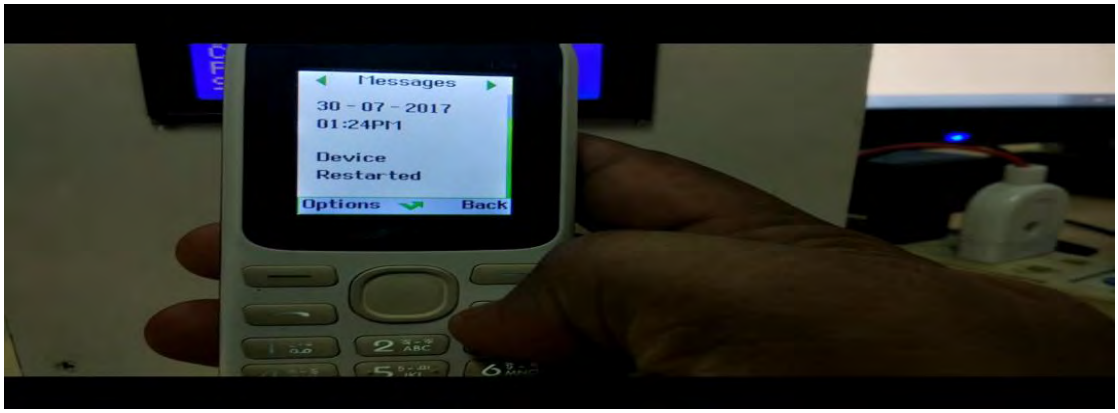


Fig: "Device Restarted"

But the status of this device will still remain “off”. As the status is still off the device will not be measuring the current and the power of load even though the load is connected with the device.

Fig: “Device Restarted” but Status is “OFF”

Now the registered user has to call the device to make change the status of the device from “turn off” to “turn on”. After ringing three times the call will automatically end and the status of the device will switch to “Turn on”. A confirmation message will be sent to the user’s cell that “Device Switched On, Volt: Normal”. The message will say “Volt: Normal” if the voltage is normal.

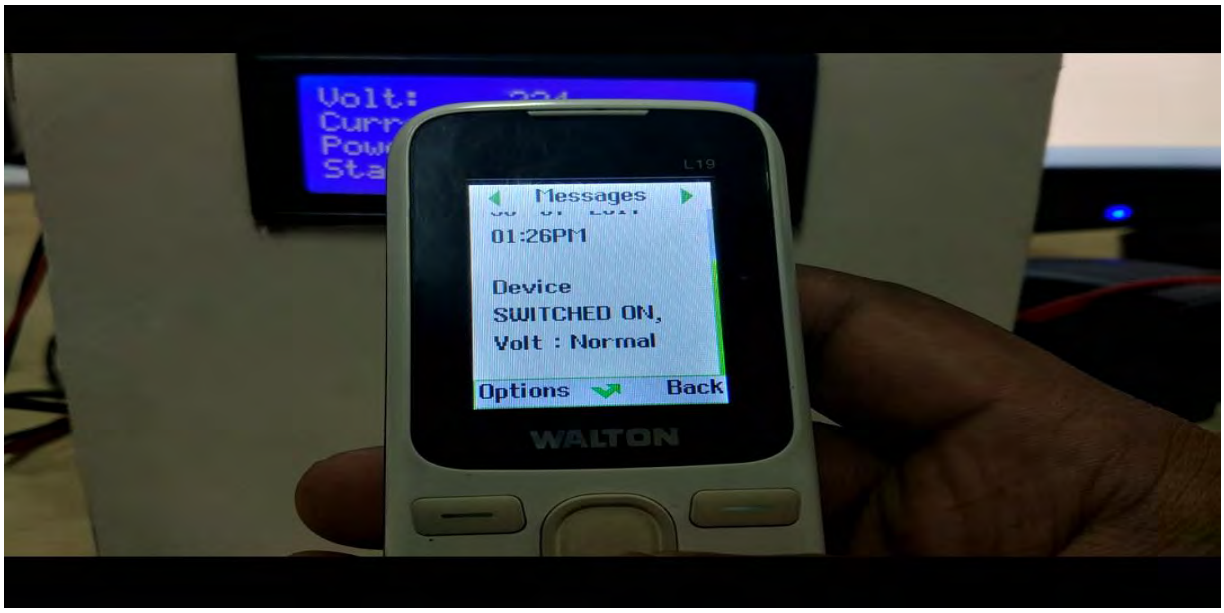


Fig: Device Status turned “ON”

As the device status is now “on”, we can now measure the current and power of the connected load. The device has a display that will show the voltage is currently flowing through the device, current and the power of the connected load. We have connected a multi meter to the AC Supply to see whether the voltage reading is actually right or wrong.

Fig: Status “On”, Volt: 222 V, Current: 0.76Amp, Power: 0.17 KW

The device will turn off automatically whenever there occurs a under voltage or over voltage in AC supply. If the voltage is below 200 volt, a message will be sent to the user's cell phone that "Volt limit Lacked, Switched OFF". If the voltage is over 250 volt, a message will be sent to the user that "Volt limit exceed, Switched OFF" and this is how the user will be notified about the status of the device from anywhere.

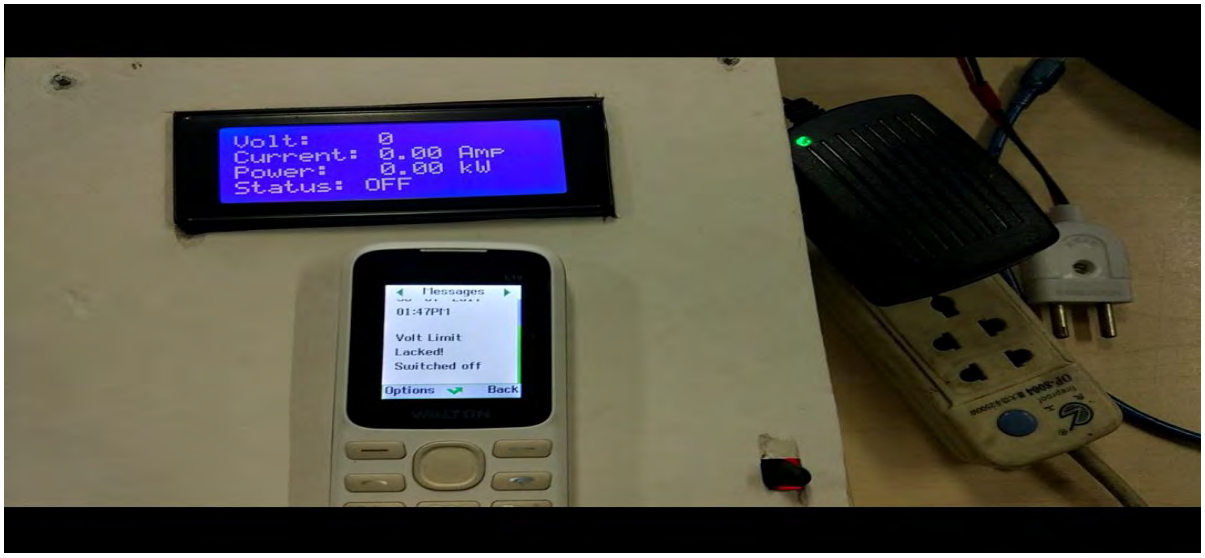


Fig: "Volt limit Lacked, Switched OFF"

If the user wishes to turn off the device without turning it off from the main supply rather from far away from the device, he just need to call the device. After two rings, the device status will switch from “ON” to “OFF” automatically.

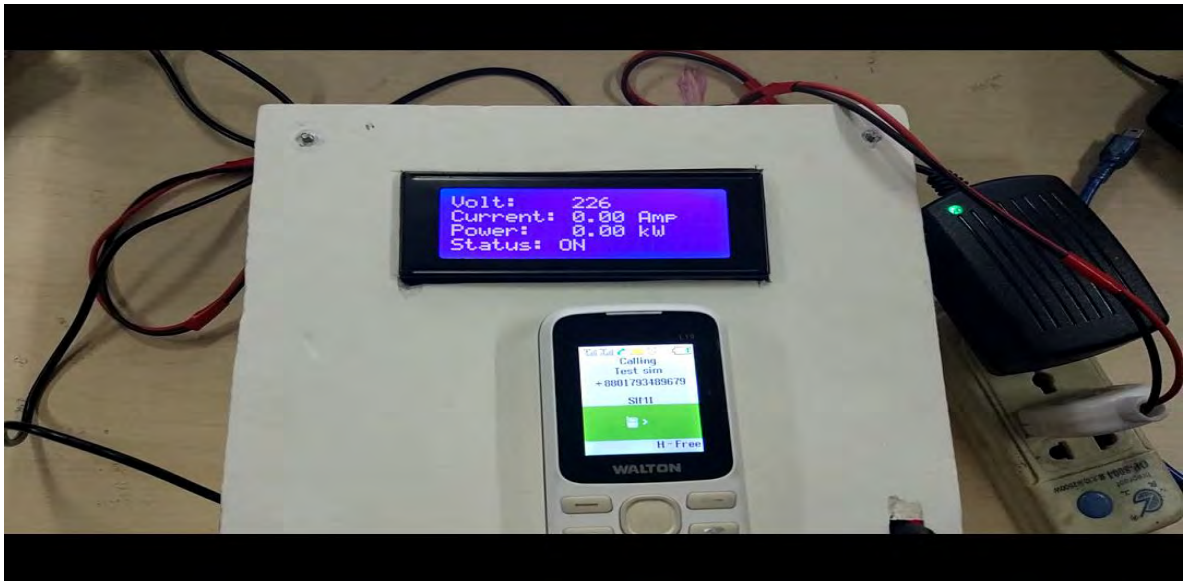


Fig: Calling the device again to turn the status of the device “OFF”

If someone whose cell phone number is not registered with the device calls the device, the device will not turn on no matter how many times the person calls the device. That means only and only authorized personnel has the authority to turn the device status from “off” to “on”.

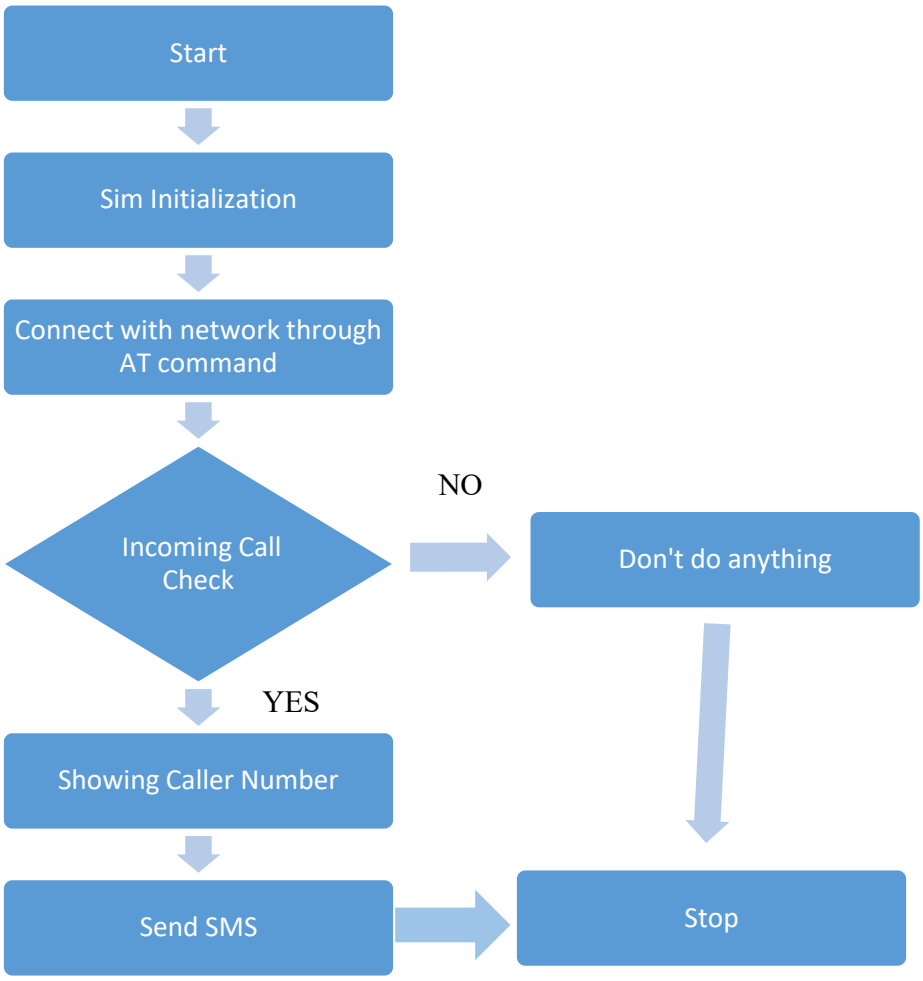
Electric Meter

SN	Voltage	Current	Power	Status
1	12	1.2	120	ON
2	12	1.2	120	ON
3	220	1.2	120	ON
4	12	1.2	120	ON
5	220	1.01	90	ON
6	225	0	0	ON
7	0	0	0	OFF
8	0	0	0	OFF
9	0	0	0	OFF
10	228	0	0	OFF

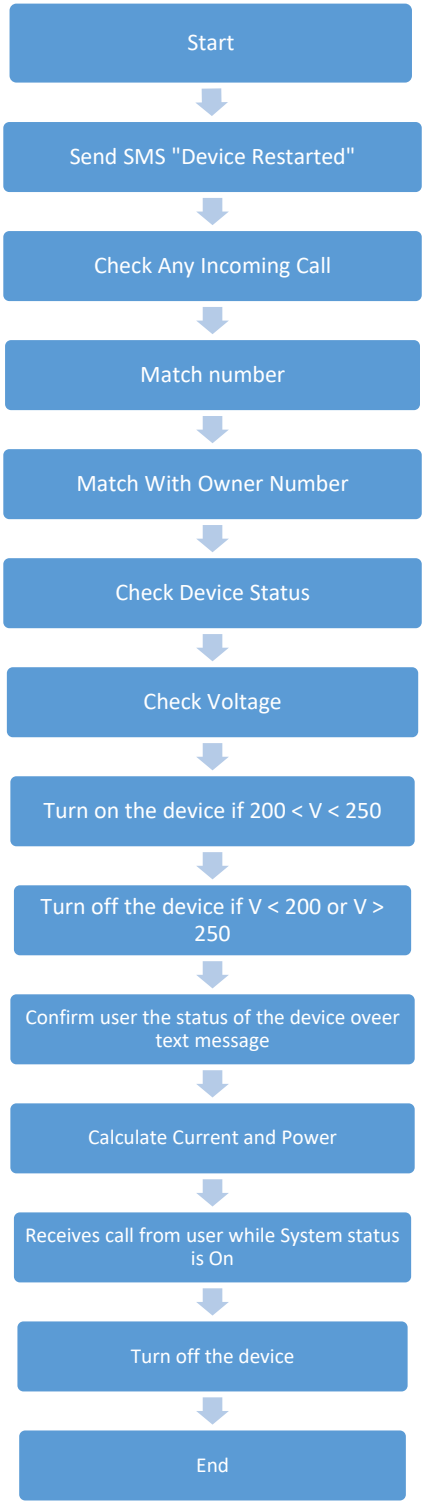
Fig- Real time web data analysis various loads

We have connected different loads across smart meter and results displayed on screen which directly goes to website. In SN 1,2,3,4 we have connected electric fan and laptop and in SN 5 we connected mobile phone charger. The device showed the load current along with active voltages. For SN 6-10, we disconnected the load and no current flowed. The device calculates power simultaneously.

GSM Workflow



Arduino Workflow



Chapter 5

Future Work & Conclusion

To take this project further, we are planning to add couple of features.

Three Phase System Protection:

What we have made here, will only protect the single phase connection. But in future we are planning make such device which will not only protect single phase connection but also protect three phase connection as well.

We will be making a device which will be relatively low in cost. We will be including a library firmware which will calculate all energy measurement parameters including active and reactive power and energy, RMS current and voltage, power factor, line frequency, fundamental and THD readings. For better communication, we will add communications modules for wireless communications standards such as ZigBee, Wi-Fi, Wireless M-Bus. Both 2.4 GHz and Sub-1 GHz. It has to have a display to show all the important data so we will be including a Built-in 160-segment display. It will be powered from three-phase line voltage so there will be no of extra power to turn this device on.

Introducing Gas Meter

A Gas Meter is specialized flow meter which is used to measure the volume of fuel gases such as natural gas and propane. Bangladesh is the seventh largest producer of natural gas in Asia. Due to huge amount of misuse our Gas reserve is decreasing day by day. If consumers supposed to pay their Gas Bill like electricity bill then they might be more concern about their usage. The only way to stop misuse of gas is Gas Meter. For that there is no need to use a spate meter for Gas measurement. One Smart meter can handle both Gas and Electric Meter.

Security Lock for Admin Access

As we want to make our device more reliable so that any person from the outside could not be able to do any change. To make it work, we are planning to make an application supported in Android platform.

A system administrator writes a device admin application that enforces remote/local device security policies. These policies could be hard-coded into the app, or the application could dynamically fetch policies from a third-party server.

The application is installed on users' devices. Android does not currently have an automated provisioning solution. Some of the ways a sysadmin might distribute the application to users are as follows:

- Google Play.
- Enabling installation from another store.

- Distributing the application through other means, such as email or websites.

The system prompts the user to enable the device admin application. How and when this happens depends on how the application is implemented. Once users enable the device admin application, they are subject to its policies. Complying with those policies typically confers benefits, such as access to sensitive systems and data.

If users do not enable the device admin app, it remains on the device, but in an inactive state. Users will not be subject to its policies, and they will conversely not get any of the application's benefits—for example, they may not be able to sync data.

If a user fails to comply with the policies (for example, if a user sets a password that violates the guidelines), it is up to the application to decide how to handle this. However, typically this will result in the user not being able to sync data.

If a device attempts to connect to a server that requires policies not supported in the Device Administration API, the connection will not be allowed. The Device Administration API does not currently allow partial provisioning. In other words, if a device (for example, a legacy device) does not support all of the stated policies, there is no way to allow the device to connect.

If a device contains multiple enabled admin applications, the strictest policy is enforced. There is no way to target a particular admin application.

Artificial Intelligence Operating System

The ability of a system to calculate, reason, perceive relationships and analogies, learn from experience, store and retrieve information from memory, solve problems, comprehend complex ideas, use natural language fluently, classify, generalize, and adapt new situations. Goals of AI

- **To Create Expert Systems** − the systems which exhibit intelligent behavior, learn, demonstrate, explain, and advice its users.

- **To Implement Human Intelligence in Machines** − Creating systems that understand, think, learn, and behave like humans.

There are many types of intelligence system. Among them some of the system we can implement in our device for a better and advance response. Those are,

Linguistic intelligenc	The ability to speak, recognize, and use mechanis of phonology (speech sounds), syntax (gramm and semantics (meaning).	Narrators, Orators
Logical-mathematica intelligence	The ability of use and understand relationships in absence of action or objects. Understanding comp and abstract ideas.	Mathematicians, Scientists

These two are the most compatible with our current system. Merging these two with our current system will make the system fully automatic machine with automation.

Conclusion

The main objective of this project was to introduce both way communications through internet using this device. This meter will ensure a more secure and transparent billing and monitoring system. Users will get more clear bills and real-time usage availability will rise concern about wasting electricity. This will bring benefit to both consumers and country. This meter designed in a different way from the exiting meter. Distributors will be able to have more control over the distribution system and the country will get a more advance and smart power distribution system. Moreover, the electricity stealing will reduce and government will be able to get more revenue and less loss. In short, to introduce a smart and advance grid to developing countries like Bangladesh, this device will be the first step of a new era in case of Power Management and Distribution.

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Appendix

```
/************************************************
 This is the code for Arduino Nano which includes:
 1. Energy meter code
 2. SD card code
 3. Meter display code
 4. Transmission to other arduino code
************************************************/
// these libraries have been used
#include <SoftwareSerial.h>

#include <DFRobot_sim808.h>
#define PHONE_NUMBER "+8801521200841"
#define MESSAGE_LENGTH 20
#define MESSAGE_1  "LIGHT SWITCHED ON"
#define MESSAGE_2  "LIGHT SWITCHED OFF"
char gprsBuffer[64];
char *s = NULL;
int c=0;
int i=0;
int z = 0;
#define led       13
```

```
#define PIN_TX    7
#define PIN_RX    8
SoftwareSerial mySerial(PIN_TX,PIN_RX);
DFRobot_SIM808 sim808(&mySerial);//Connect RX,TX,PWR,
//DFRobot_SIM808 sim808(&Serial);
bool push = false;
void setup() {
  mySerial.begin(9600);
  Serial.begin(9600);
  pinMode(led, OUTPUT);
  digitalWrite(led, LOW);

  //******** Initialize sim808 module *************
  while(!sim808.init()) {
      Serial.print("Sim808 init error\r\n");
      delay(1000);
  }
  delay(1000);
  Serial.println("Init Success, please call or send SMS message to me!");
}

void loop() {
```

```
  //******** Wait serial data *************
  if(sim808.readable()){
    sim808_read_buffer(gprsBuffer,32,DEFAULT_TIMEOUT);
    //Serial.print(gprsBuffer);

  //************** Detect the current state of the telephone or SMS
************************
    while(NULL != strstr(gprsBuffer,"RING")) {
       mySerial.print("AT+CLIP=1\r");
       Serial.println(gprsBuffer);
      // if(NULL != strstr(gprsBuffer,"+CLIP: \"+8801672326796")) {
         if(NULL != strstr(gprsBuffer,"+CLIP: \"+8801627283739")) {

       Serial.println("YOOO");

         i++;
         if(i>2){
           mySerial.print("ATH");
          break;
       }
    }
    else {break;}
```

```
   delay(2000);
   }

  sim808_clean_buffer(gprsBuffer,32);
}
if(i>2){
 mySerial.print("ATH");
 //delay(2000);
 push=true;
 c++;
 i=0;
}

if (c % 2 == 0) {
// delay(5000);
 digitalWrite(led, LOW);


} else {
// delay(5000);
 digitalWrite(led, HIGH);
```

```
}
 if(push==true && c % 2==0){


  Serial.println("SMS SENDING 2");
 // delay(5000);
 while(z<5000){
  mySerial.print("ATH");
  z++;
  Serial.println(z);
  if(z>4999){
    Serial.println("SMS SENDING 2 complete");
    z=0;
    break;


  }
 }
   sim808.sendSMS(PHONE_NUMBER,MESSAGE_2);
  // delay(1000);
  z=0;
  push=false;
  }
```

```
   else if(push==true && c % 2!=0){



    Serial.println("SMS SENDING 1");
   // delay(5000);
   while(z<5000){
    mySerial.print("ATH");
    z++;
     Serial.println(z);
    if(z>4999){
      Serial.println("SMS SENDING 1 complete");
      z=0;
      break;
    }
   }
    sim808.sendSMS(PHONE_NUMBER,MESSAGE_1);
   // delay(1000);
   z=0;
    push=false;
    }
z=0;
 }
```