Visvesvaraya Technological University

Belgaum, Karnataka-590 018

A Project Report on

"SMART LOAD MANAGEMENT AND MONETERING OF ELECTRICITY FOR COMMUNITY"

Project Report submitted in partial fulfillment of the requirement for the award of the degree of

Bachelor of Engineering

In

Electrical & Electronics Engineering

Submitted by

KEERTHANA M	**1CR16EE035**
LIKITHA L M	**1CR16EE038**
MADHAN C	**1CR16EE039**
MANOJ A Y	**1CR16EE044**

Under the Guidance of

Mr. SUMIT MOHANTY

Assistant Professor, Department of Electrical & Electronics Engineering

CMR Institute of Technology

CMR Institute of Technology, Bengaluru-560 037

Department of Electrical & Electronics Engineering

2019-2020

CMR INSTITUTE OF TECHNOLOGY

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

AECS Layout, Bengaluru-560 037

Certificate

Certified that the project work entitled **"Smart Load Management and Monitering of Electricity for Community"** carried out by Ms.Keerthana M, USN 1CR16EE035; Ms.Likitha L M, USN 1CR16EE038; Mr.Madhan C, USN 1CR16EE039; Mr.Manoj A Y ,USN 1CR16EE044 are bonafied students of CMR Institute of Technology, Bengaluru, in partial fulfillment for the award of Bachelor of Engineering in Electrical & Electronics Engineering of the Visvesvaraya Technological University, Belgaum, during the year 2019-2020. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the Report deposited in the departmental library.

The project report has been approved as it satisfies the academic requirements in respect of Project work prescribed for the said Degree.

Signature of the Guide	*Signature of the HOD*	*Signature of the Principal*
Mr. Sumit Mohanty Assistant Professor EEE Department CMRIT, Bengaluru	Dr. K. Chitra Professor & HOD EEE Department CMRIT, Bengaluru	Dr. Sanjay Jain Principal, CMRIT, Bengaluru

External Viva

Name of the Examiners	Signature & Date
1.	
2.	

CMR INSTITUTE OF TECHNOLOY
DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING
AECS Layout, Bengaluru-560 037

DECLARATION

We, [Ms.**KEERTHANA M(1CR16EE035),**Ms. **LIKITHA L M(1CR16EE038),** Mr. **MADHAN C (1CR16EE039),** Mr. **MANOJ A Y (1CR16EE044)],** hereby declare that the report entitled **"SMART LOAD MANAGEMENT AND MONITERING OF ELECTRICITY FOR COMMUNITY"** has been carried out by us under the guidance of **Mr. SUMIT MOHANTY,** Assistant Professor, Department of Electrical & Electronics Engineering, CMR Institute of Technology, Bengaluru, in partial fulfillment of the requirement for the degree of **BACHELOR OF ENGINEERING in ELECTRICAL & ELECTRONICS ENGINEERING**, of Visveswaraya Technological University, Belagaum during the academic year 2019-20. The work done in this report is original and it has not been submitted for any other degree in any university.

Place: Bengaluru Date:

Keerthana M (1CR16EE035)

Likitha L M (1CR16EE038)

Madhan C (1CR16EE039)

Manoj A Y (1CR16EE044)

Abstract

Demand Side Management (DSM) will play a significant role in the future smart grid by managing loads in a smart way. DSM programs, realized via Home Energy Management (HEM) systems for smart cities, provide many benefits; consumers enjoy electricity price savings and utility operates at reduced peak demand. IoT can be used to make this demand side management smart by providing an interface for consumers.

The electrical energy cannot be effectively stored in bulk, it must be generated, transmitted and distributed to the consumers immediately. When the load on the power system approaches the maximum generating capacity, the electricity suppliers must increase the production to fulfil the load requirement. But the addition of generating stations requires lot of efforts. To prevent all these unwanted investments load management should be done. By doing so the produced electrical power will be utilized in an efficient way with reduced losses. In power systems, an excess load puts a stress on the generating equipment. It slows down the prime movers, associated generators and other parts of the system as they attempt to cope with the excess load. This leads to a combination of events including power swings and overloads which can cause the system becoming unstable. Some of the parts such as protection systems may interrupt the supply due to the excess current resulting from the overload.

The higher load may also lead to a lower generating and supply frequency. Even though the hydro generating systems can tolerate up to 10% frequency change, the thermal generator's operation will be affected since they are more sensitive. A five percent decrease can reduce the generated power significantly due a decrease in the energy to the turbine generator. The reduced frequency can damage the steam turbines as well as the frequency sensitive load. As such, most generator systems incorporate under-frequency relays to automatically disconnect some of the excess load.

Smart electrical load management solutions are designed to gain advanced control and minimize cost. They include applications to help reduce downtime, reduce energy costs, support capacity planning, improve efficiency and provide a view into the system as a whole, Electrical load management solutions generally helps to avoid excess demand charges by reducing peak demand , lessen the impact of utility power outages, reduce power factor penalties from the utility company, reduce the negative effects of poor power factor or high harmonic content, automatically control on-site generation and secondary systems, control an industrial electrical distribution system with minimal staff.

Acknowledgement

The satisfaction and euphoria that accompany the successful completion of any task would be incomplete without the mention of people, who are responsible for the completion of the project and who made it possible, because success is outcome of hard work and perseverance, but stead fast of all is encouraging guidance. So with gratitude we acknowledge all those whose guidance and encouragement served us to motivate towards the success of the project work.

We take great pleasure in expressing our sincere thanks to ***Dr. Sanjay Jain****,* ***Principal, CMR Institute of Technology, Bengaluru*** *for providing an excellent academic environment in the college and for his continuous motivation towards a dynamic career.*

We would like to convey our sincere gratitude to ***Dr. K Chitra****,* ***Head of Electrical and Electronics Engineering Department, CMR Institute of Technology, Bengaluru*** *for her invaluable guidance and encouragement and for providing good facilities to carry out this project work.*

We would like to express our deep sense of gratitude to ***Mr.Sumit Mohanty, Assistant Professor, Electrical and Electronics Engineering, CMR Institute of Technology, Bengaluru*** *for his/her exemplary guidance, valuable suggestions, expert advice and encouragement to pursue this project work.*

We are thankful to all the faculties and laboratory staffs of ***Electrical and Electronics Engineering Department, CMR Institute of Technology, Bengaluru*** *for helping us in all possible manners during the entire period.*

Finally, we acknowledge the people who mean a lot to us, our parents, for their inspiration, unconditional love, support, and faith for carrying out this work to the finishing line. We want to give special thanks to all our friends who went through hard times together, cheered us on, helped us a lot, and celebrated each accomplishment.

Lastly, to the ***Almighty****, for showering His Blessings and to many more, whom we didn't mention here.*

CONTENTS

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Load management is very vital in optimizing the performance of generating plants by properly managing the generated energy. During peak demand times, the energy used by the consumers are expensive compared to that used during off peak demand time. Use of IoT in load management makes the system smart and is done to help the consumer to use the loads in an efficient way by paying less bill. It allows utilities to reduce demand for electricity during peak usage times (peak shaving), which can reduce costs by eliminating the need for peaking power plants. Load management can also help us to reduce harmful emissions, since peaking plants or backup generators are often dirtier and less efficient than base load power plants. New load management technologies are constantly under development.

Since electrical energy is a form of energy that cannot be effectively stored in bulk, it must be generated, distributed, and consumed immediately. When the load on a system approaches the maximum generating capacity, network operators must either find additional supplies of energy or find ways to curtail the load, hence load management. If they are unsuccessful, the system will become unstable and blackouts can occur. Long-term load management planning may begin by building sophisticated models to describe the physical properties of the distribution network, as well as the load behaviour. A Grid assisted system would automatically switch between solar and electricity grid. Private and public sector organization and domestic users of developing countries cannot depend on utility power supply due to frequent power failures. To reduce the complexity of the existing system, a monitoring module is in co-operated into the circuit. This in turn reduces the delay produced and hazards. High power surges can severely damage the components, hence surge protection devices are installed along with the circuitry to bring in control.

The end user is informed about the power supply situation and operations of the switching techniques through IoT. This is done by a global system for mobile (GSN) module. The user present at the location is informed through a liquid crystal display and the message is displayed as “Main power is ON” and if otherwise “Main power OFF”. The importance of display system is to make it user friendly and the presence of alarm device detects failure. The circuit is designed here without the use of field programmable gate arrays (FGPA’s). Rather the timers are used to produce the delays required and switching of circuit is done accordingly. In this work, importance is given to reduce the complexity and also in reduction of components. The main importance of delay, is producing certain lag at a pre-set time to ensure the stability of voltage. Most of the large industries, educational institutions and factories for back-up power source, generators are used. In order to reduce the consumption of electricity and the man power to operate those manually, our system detects any interruptions present any and the working processes through an app. Circuit monitors were the devices installed at each transfer switch and at various locations in the paralleling of switchgear. These are used to get data and for calculating necessary parameters like power and power factor. Remote control to function based upon acquired data is allowed in a system, it is called as a SCADA system. The concern is growing on change in climate and life of fossil fuels, the renewable energy is emerging. The demand side management is applied for multiple tariff pricing model with battery storages. DSM mainly aims to avoid significant inconvenience on the consumer side. The usage of electricity has undergone major changes since 1973, starting first with increased oil prices, electricity prices, slow income growth and new technologies. The following objectives -decreasing energy consumed, cost and shifting of consumption are the parts of concern of study, when it comes to demand side management perspective.

1.1. SOLAR POWER

Solar power is the conversion of energy from sunlight into electricity, either directly using photovoltaic (PV), indirectly using concentrated solar power or a combination. Production of electricity using solar energy can be done by using two technologies namely concentrated solar power system photovoltaic.

Photovoltaic solar panels absorb sunlight as a source of energy to generate electricity. Each module is rated by its DC output power under standard test conditions and typically in the ranges from 100 to 365 Watts. The efficiency of a module determines the area of a module given the same rated output - an 8% efficient 230Watts module will have twice the area of a 16% efficient 230Watts module. There are a few commercially available solar modules that exceeds efficiency of 24%.

A Solar panel is connected to a Charge Controller, which supplies the correct amount of current to a Battery. An Inverter also connects to the battery and uses its current to produce AC for the device. When the battery is fully charged, it can be used as part of a circuit. Because any excess energy will be passed through to another 'Load'. The solar system that can provide to run a device, is designed to automatically switch between using power from a wall socket. This is for when the solar power is insufficient and could be a cheaper option. Solar thermal electricity like solar cells, solar thermal systems, also called concentrated solar power (CSP), use solar energy to produce electricity, but in an efficient way.

Most solar thermal systems use a solar collector with a mirrored surface to focus sunlight onto a receiver that heats a liquid. The super-heated liquid is used to produce steam to produce electricity in the same way as the coal plants do. There are CSP plants in California, Arizona, Nevada, Florida, Colorado and Hawaii. Some of the world's largest CSP facilities are located in California. Solar energy has great potential for the future. Solar energy is free, and it supplies are unlimited. It does not pollute or otherwise damage the environment. It cannot be controlled by any one nation or industry. If we can improve the technology to harness the sun's enormous power, we may never face energy shortages again. Using solar energy, electricity can be generated by two different technologies - concentrated solar power (CGP) systems and photovoltaic systems. For commercial, industrial, and residential applications, solar photovoltaic systems have become demanding solutions. By using photovoltaic cells, solar radiation conversion into

electricity can be achieved. The maximum efficiency, after a lot of research towards improving the efficiency of solar photovoltaic system is about 22 to 23 percent.

1.2. ELECTRICITY GRID

An Electrical Grid is an interconnected network for delivering electricity from producers to consumers. It consists of generating stations that produce electrical power high voltage transmission lines that carry power from distant sources to demand centre distribution lines that connect individual customers. The smart grid would be an enhancement of the 20th century electrical grid, using two-way communications and distributed so-called intelligent devices.

The electricity grid is a complex and incredibly important system, and one of the most impressive engineering feats of the modern era. It transmits power generated at a variety of facilities and distributes it to end users, often over long distances. It provides electricity to buildings, industrial facilities, schools, and homes. And it does so every minute of every day, year-round. The electricity grid has grown and changed immensely since its origins in the early 1880s, when energy systems were small and localized. During this time, two different types of electricity systems were being developed: the DC or direct current system and the AC or alternating current system. Competition between these two systems was fierce. Competing electric companies strung wires on the same streets in cities, while electric service for rural areas was ignored. As technology changes and better options become available, significant improvements could be made to the electricity grid, Fig.1.2. represents the electricity grid. Distributed generation systems, such as solar panels on individual homes, reduce the distance that electricity has to travel as shown in Fig.1.1, thereby increasing efficiency and saving money. Investments made by consumers such as purchasing energy-efficient appliances, constructing more energy-efficient buildings, or installing solar panels – save customers money and utilize energy more efficiently at the same time.

Fig 1.1 Solar panel

Fig 1.2 Electricity grid

1.3 RECENT POWER SCENARIO

Electricity plays a vital role in our day to day life, right from household purposes to industrial applications. It's difficult to perceive even a moment where electricity is not applicable.

Rural electrification is the process of bringing electrical power to rural and remote areas. Electricity is used not only for lighting and household purposes, but it also allows for mechanization of many farming operations, such as well-pumping, threshing, milking, and silo filling. In areas facing labour shortages, this allows for greater productivity at reduced cost.Electricity has enhanced the way of life and improved economic status. It is directly related to the economic growth and development of the nation. Later electrical grids were developed which is an interconnection of networks used to deliver electricity from producers to consumers.

1.4 ISSUES IN POWER NETWORK

Power network consists of generating stations, high voltage transmission lines, substations and distribution lines. Smart grid is a recent development with two-way communication and distribution of 'smart' devices.

This improves the quality of delivery of power to consumers immensely. Though reliable, it does have defects like Power Quality issues such as harmonics, voltage and frequency fluctuations, Storage, Protection issues, Islanding, Power theft which is one of the major issues. These power losses can be classified into two types: Technical and Non Technical losses. The technical losses are the transmission and distribution losses that can be attributed to defective or aging equipment, internal electrical resistances and malfunctioning components. The Non-Technical losses include: unauthorized tapping of distribution lines and poles, refusing to pay bills, meter tampering and bypassing meters, bribing of officials and faulty meters

1.5 INTERNET OF THINGS

Internet of Things (IoT) is an ecosystem of connected physical objects that are accessible through the internet. The 'thing' in IoT could be a person with a heart monitor or an automobile with built-in-sensors, i.e. objects that have been assigned an IP address and have the ability to collect and transfer data over a network without manual assistance or intervention. The embedded technology in the objects helps them to interact with internal states or the external environment, which in turn affects the decisions taken.

The Internet of things (IoT) comprises of network of devices, vehicles, and home appliances that contain electronics, software, actuators, and connectivity which allows these things to connect, interact and exchange data. IoT devices are a part of the larger concept of home automation, which can include lighting, heating and air conditioning,

media and security systems. Long term benefits could include energy savings by automatically ensuring lights and electronics are turned off.

Devices and objects with built in sensors are connected to an Internet of things platform, which integrates data from the different devices as shown in Fig.1.3 and applies analytics to share the most valuable information with applications built to address specific needs. These powerful IoT platforms can pinpoint exactly what information is useful and what can safely be ignored. This information can be used to detect patterns, make recommendations, and detect possible problems before they occur.

6

The information picked up by connected devices enables to make smart decisions about which components to stock up on, based on real-time information, which helps to save time and money. As far as the reach of the Internet of Things, there are more than 12 billion devices that can currently connect to the Internet, and researchers at IDC estimate that by 2020 there will be 26 times more connected things than people.

Fig 1.3 Internet of Things

1.6 SWITCHING BETWEEN SOLAR AND GRID

Switching between grid and solar is done to provide uninterrupted power supply to the consumers. So based on certain conditions the switching is done. The conditions are as follows:

- When the load demand exceeds solar capacity during day time, then the load has to be supplied by both solar as well as grid.
- During day time, if the load demand is within the solar capacity then solar alone is sufficient to supply the load.
- During night time, the load demand is supplied by grid alone.
- During peak hours, the load demand is supplied only by solar and during off peak hours it is supplied by grid or only solar depending on load demand and solar capacity.

Thus consumers enjoy electricity price savings and utility operates at reduced peak demand. IoT can be used to make this demand side management smart by providing an interface for consumers.

CHAPTER 2

PROBLEM IDENTIFICATION

A power outage is a short-term or a long-term loss of the electric power to a particular area. There are many causes of power failures in an electricity network. Examples of these causes include faults at power stations, damage to electric transmission lines, substations or other parts of the distribution system, a short circuit, or the overloading of electricity mains.

2.1. LITERATURE SURVEY

2.1.1. GRID ISSUES

Our electrical grid is old. Originally designed to last 50 years, many parts have already surpassed that. There are even parts that are about 100 years old. Yet little is being done to replace the aged parts. Part of the problem is financial. Currently, the grid needs an estimated trillion dollars' worth of repairs and upgrades. Power companies, many of them which run on a narrow margin, say they can't afford to replace aged equipment, so they keep patching it up and use it.

A. S. Anees highlighted about technical and non-technical issues. The technical issues are power quality, power fluctuations, storage, protection issues, optimal placement of renewable energy sources and the non-technical issues are lack of skilled man power and less availability of transmission line to accommodate RES.

M.Qaisar Azeem, Habib-ur-Rehman, Sheeraz Ahmed, Ajmad Khattak highlighted that An
automatic transfer switch is used to switch the load between two power supplies out of which any one supply will be connected to the load and also it makes sure that the consumers get uninterrupted power supply no matter which source is connected.

Sharma and M. Sharma stated that the solar PV systems have become highly competitive

solutions for commercial, industrial and domestic applications as a clean source of power in both grid connected and standalone mode of operation.

9

2.1.2. CHALLENGES IN SMART GRID

According to C. P. Vineetha and C. A. Babu, ome of the challenges and issues which are faced by both developed and developing countries in the implementation of smart grid. There are tremendous developments in the technology in the past decades. It is necessary to create a new infrastructure integrated.

M. H. Sazli, İ. Koşalay and G. Erdenesaikhan highlighted about power quality events have

which includes, disturbing effects on the power system do not only stem from nonlinear loads;short circuits in the system, loading and load shedding, mechanical faults etc. may also cause disturbing effects on the power quality. The fundamental reasons of the power quality analysis are electrical losses and variable costs originated from these disturbances.

2.1.3. DISTRIBUTION MANAGEMENT SYSTEM

Mohsenian-Rad, A.H, Wong V. W. S, Jatskevich, J, Schober, R & Leon-Garcia A, highlighted about autonomous demand-side management based on energy consumption scheduling for the future smart grid. DSM includes conservation and energy efficiency programs, fuel substitution programs, demand response programs, and residential or commercial load management programs.

According to L. Gan, L. Jiang, S. Low, U. Topcu and C. Zhao, demand side management is invoked to cope with a large correlated demand spike due to weather or a supply shortfall

because of faults. The reasons favor a simple and static mechanism that is sufficient to deal

with the occasional need for load control, but the reason is changing because of renewable

penetration and the deployment of a sensing.

De Almeida. A.Rosenfeld, Arthur H, highlighted about electricity which is increasingly important role in buildings and industry, due to its flexibility, efficiency of conversion and cleanliness at the point of use. However the production and transmission of electricity requires huge investments and may have undesirable environmental impacts.

2.1.4. IoT FOR SMART GRID

Yaghmaee, M. H., & Hejazi, H, proposed that in order to develop and implement smart power grid applications in a wide range of countries and the need to design smart energy metering infrastructure using IoT. The Internet of Things (IoT) technology and the development of various network connectivity sensors, it is possible to send instantaneous power consumption data to the customers.

Karg, B., & Lucia, S, highlighted about the range of wireless communication technologies,
commonly known as low power wide area network is becoming popular in the field of Internet of Things(IoT). The new IoT applications are smart buildings or smart cities, which requires large number of devices.

S. Ziegler, S. Nikoletsea, S. Krco, J. Rolim and J. Fernandes, proposed about an integral part of IoT are the desktop, tablet and cell-phones. They remain as command centre and remotes in practical implementation [22]. IoT plays a growing role in various applications such as monitoring environment, mobility and transportation, smart grid and management of waste.

2.1.5. OBSERVATION

Based on literature survey it is observed that abundant problems such as traditional grid issues,transmission and distribution losses, increased consumption of electricity and

usage of outdated technology. In keeping view of these factors, an energy conserving can be designed.

2.1.6 LITERATURE REVIEW

1. Mohamed Muzammil Mohamed Mufassirin (Dec. 2016)

This paper presents the work to provide an implementation methodology for electricity theft detection and controlling which allows violators to be detected at a remote location.

2. Soham Chatterjee, Vaidheeswaran Archana, Karthik Suresh, Rohit Saha, Raghav Gupta and Fenil Doshi (2017)

In this paper, a solution to power theft using advanced metering infrastructure and intelligent algorithms has been proposed. The proposed solution profiles users based on their half hour wise power consumption data and locality. Irregularities in power usages are detected using a state-of-the art artificially intelligent algorithm: Recurrent Neural Networks.

3. Pravin Shikalgar, Prasad Yadav, Hemant Pawar (Jan. 2015)

Paper deals with identification of online theft that prevails on distribution line. Here used smart grid technology to identify theft online. Smart grid means an effective two-way communication between sending and receiving end. Here used microcontroller based system to detect power theft .Taking consideration grid & resident designing intelligent program which is main concept of paper.

4. N Kunan, Poornima BK (May 2017)

In this project we are using smart power meter which are fitted on both at the transmission and load side. These meters are capable of measuring power sent over the load sand power consumed by the load over the time respectively. Both the parameters are sent to the base station wirelessly. Whenever there is a mismatch above the tolerance level parameters, then power theft is detected. The system will trigger the alarm to intimate to the concern authority so that they take necessary legal action and prevent power theft in the future.

5. R. E. Ogu and G. A. Chukwudebe (2017)

This paper presents the development of a cost effective electricity theft detection and prevention system using the Internet of Things(IoT) technology. A Passive Infrared Sensor is employed as the sensory element to detect when the sensitive part of a meter is opened by a human being. The Thingspeak.com IoT Analytic platform is employed to create a webpage so that the status of the meter can be visualized on the Internet by the power company.

6. Ou Qing-Hai, Wang Zheng, Zhen Yan, LI Xiang-Zhen, and Zhou Si (2013)

The Internet of Things (IoT) technology plays an important role in the construction of the smart grid. This paper first introduces the latest progress of IoT technology and the architecture of the power IoT, and then proposes a status monitoring and early warning system for the power distribution network based on the IoT technology. The key technologies and the functions of the system as well as its application in the power distribution network are also described in this paper.

7. Saritha I G, Sowmyashree M S , Thejaswini S, Surekha R Gondkar(Jan. 2014)

This paper determines the greatest opportunity for energy savings by continuously monitoring and controlling power theft from the electric meter by taking readings from it . This system prevents the illegal usage of electricity, which can be solved automatically without any human control .The implementation of this system will save large amount of electricity.

8. Bharathi R, Madhushree M. E., Priyanka Kumari (Sept. 2017)

In this paper we present a newly designed digital meter based on a very cheap distributed components like microcontroller architecture and current sensors. This system doesn’t require placing other cables and along with this we are using WIFI to communicate with the servers and users. By measuring current and voltage, we can analyze energy consumption, make the world smarter place and make better decisions using Internet of Things.

9. Dr. S. Sayyad , Choudhari Roshani , Tribhuvan Prashant , Salvi Sagar , Amte Anuradha (May 2018)

In this paper we propose an automated system design, which automates the electricity meter reading by incorporating the IoT (Internet of Things) technology in electricity energy meter. In current electricity metering system, meter tampering can be done easily for the purpose of electricity theft. In proposed system, Theft Detection unit connected to energy meter will identify theft attempts and notify to the server side on immediate basis so that further action could be taken. This automated system provides accuracy in billing and also enables the consumers to do power optimization by providing electricity consumption information on frequent basis through android application.

10. Xisheng An, Peng Lu, Niansheng Wei, Gang Hong(2017)

This paper presents a GPRS based power cable grounding wire anti-theft monitoring device system, which includes a camera module, a sensor module , a micro processing system module, and a data monitoring center module, a mobile terminal module. Our design utilize two kinds of methods for detecting and reporting comprehensive image, it can effectively solve the problem of power and cable grounding wire box theft problem, timely follow-up grounded cable theft events, prevent the occurrence of electric field of high voltage transmission line fault, improve the reliability of the safe operation of power grid.

11. J. Sathish Kuma, Dhiren R. Patel (Mar. 2014)

This paper introduces Internet of Things (IoTs), which offers capabilities to identify and connect worldwide physical objects into a unified system. As a part of IoTs, serious concerns are raised over access of personal information pertaining to device and individual privacy.

2.2 OBJECTIVES OF THE PROJECT

The objective of this paper is to analyze, by using MatLab simulations and considering different grid configurations, how electricity theft results in power quality issues, specifically voltage drop in steady state. Additionally, it is shown how the steady state voltage drop can result in economic penalties for the electric utility when the proper voltage exceeds the network operational standards.

Based on the various drawbacks of each work that was presented, the proposed model is designed to overcome most of the same.

- Detect the power theft in distribution system.
- Identify the severity (magnitude) of the power theft.
- Develop control module to protect the healthy zone from theft zone.
- Intimate the theft details to the authorized personnel using GSM module.

- Monitor the status of distribution lines using IoT.
- To investigate the development of smart grid technology to ensure reliable electricity infrastructure.
- To integrate and co-ordinate numerous entities of the grid with an easy to learn and

  flexible open source programming hardware.
- To design tests ensuring peak demand requirements are assured without relying on external power supplies.
- To enhance the quality of major components of electricity grid by prioritising and drawing a distinction among their operations.
- To impart a structured and systematic sequenced loop having the ability of good operating speeds.

2.3. FLOW CHART OF THE PROJECT

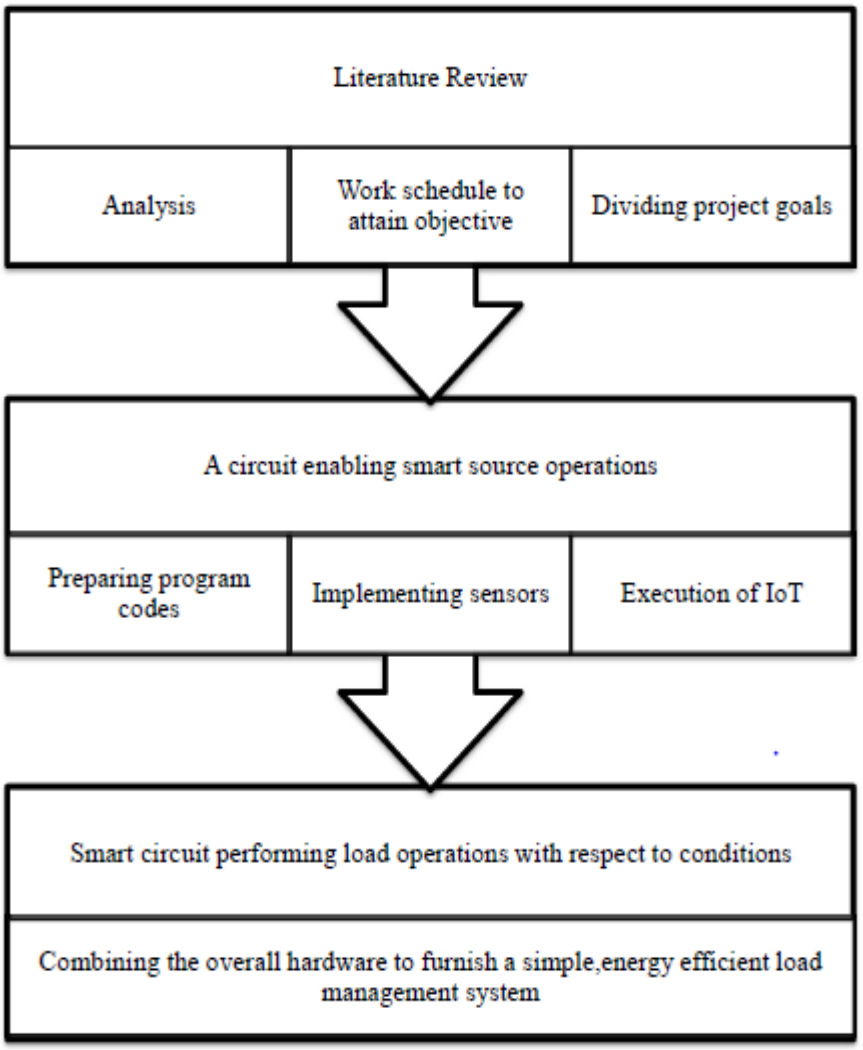

Fig 2.1 Flow chart of the Project

CHAPTER 3

PROPOSED MODEL

Fig 3.1 depicts the block diagram of the proposed model, the various blocks are in accordance with the requirement of solutions for each issue that may occur in a power system , remote location theft detection is made possible here with the use of wireless communication. The blocks and their functions are shown in the description below.

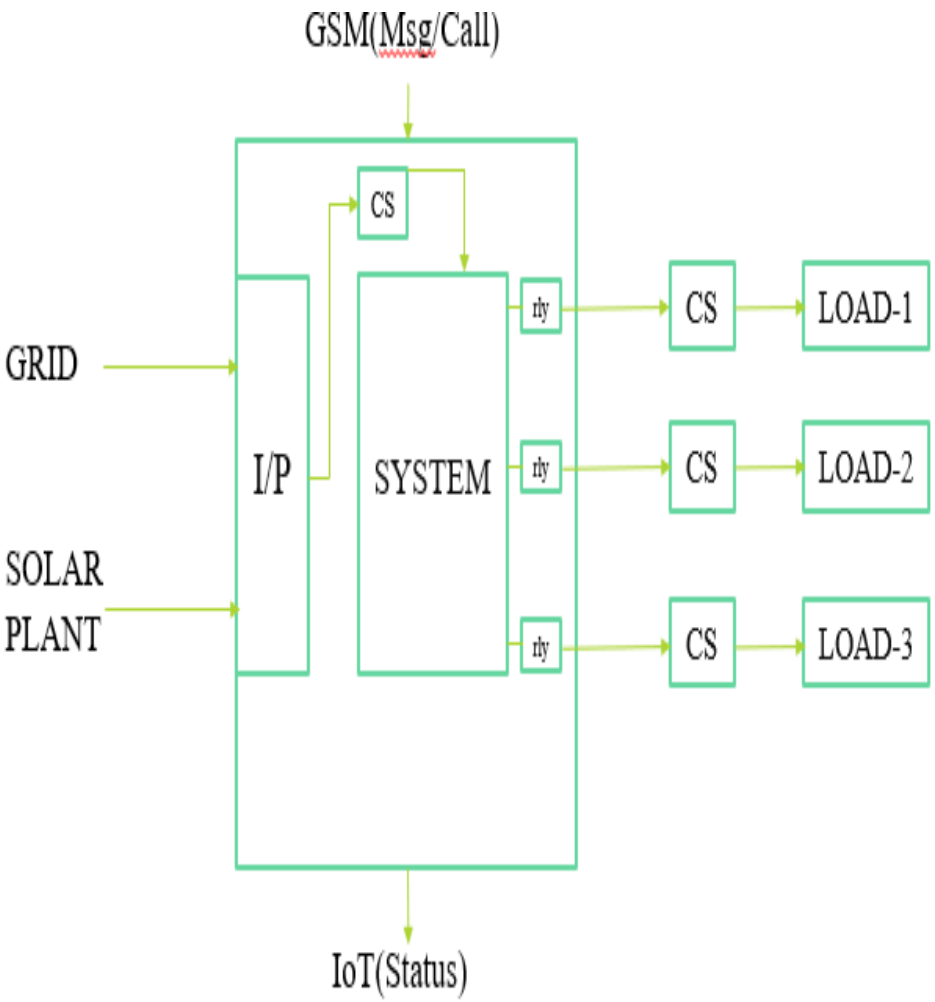

Fig 3.1:Block diagram

3.1 SOURCE SIDE MODEL

The Switching at source side is done by the relays present. The operations is controlled by a micro controller. Varied conditions are embedded in its program so that proper supply can be taken as sensors are kept both temperature and indication whether its day or night can be detected using LDR sensor. LCD1 shows the temperature of the surrounding and LDR value which indicates day/night along with which source the entire system is connected to. This model can be further expanded based on requirements for domestic, industrial and commercial establishments.

3.2 LOAD SIDE MODEL

Imposing relays as well as sensors on load side allows selection of load as relay performs switching process and sensor detects current flow through each load. GSM module is used in order to send or receive communication viabilities, it comes as an aid for a user who is at the remote location. Turning ON/OFF operations of the loads can be done by sending a message to the SIM number present in the GSM module. This interface at the consumer side specifies which supply is being available in excess and which is being used. LCD2 displays which load is connected to the system and the current consumed by that particular load. The sole purpose of using GSM module in this project is the idea of implementing IoT in our project. This enables us to control turning ON/OFF operations during working state of the plant. Also if any fault occurs in some region, quick action can be taken. To nullify such occurrences, IoT is very useful. Relays are used on both the sides, source as well as load side. It make sure which source will be providing supply.

3.3 DESCRIPTION OF MAJOR COMPONENTS

1. Current Sensor

A **current sensor** is a device that detects electric current in a wire, converts current to an easily measured output voltage, and generates a signal proportional to the measured current. Two current sensors of same rating are used on both source and load side to

measure the current flowing through them. These current signals are given to the controller.

2. Arduino Controller

Arduino is an easy to use open-source platform. Arduino boards are capable of reading inputs, turning it into output and display it online. Signals are sent to the GSM module and relay module through Wi-Fi for further actions.

3. NodeMCU Controller

NodeMCU is an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi, and hardware which is based on the ESP-12 module. In this model, the currents obtained from the sensors are compared and if some tapping is done in between the transmission line the difference in the values of current indicates power theft has occurred. Hence suitable action is taken through the controller. Signals are sent to the GSM module and relay module through Wi-Fi for further actions.

Either NodeMCU or Arduino can be used as the controller in the proposed system. The control action can be same as the Arduino.

4. Relay Module and GSM Module

The relay module is an electrically operated switch that allows turning on or off a circuit using voltage and current. The relay protects each circuit from each other in a power system

According to the signal obtained from the Arduino or NodeMCU controller the **relay module** takes action by interrupting the supply to the load whenever theft is detected.

The General Packet Radio Service (GPRS) is a data extension of the mobile telephony standard GS**M. It** allows mobile subscribers to benefit from high-speed transmission rates and run data applications from their mobile terminals. It facilitates instant connections where information can be sent or received immediately. No dial-up modem connection is necessary.

5. IoT (ThingSpeak monitoring)

ThingSpeak being an open source platform enables the users to access information from anywhere. ThingSpeak provides an online text editor to perform data analysis and visualization using MATLAB. With ThingSpeak, sensor-logging applications, location-tracking applications and a social network of things with status updates can be created.

It serves as the data collector which collects data from edge node devices and also enables the data to be pulled into a software environment for historical analysis of data. The output signal from the Arduino controller is sent to ThingSpeak through wireless transmission.

6. Switching circuit

The switching circuit is a Multiplexer(IC 4052). It's a Dual 4-Channel Analog Multiplexer. This circuit helps to switch between each sensor input with a time delay of Ms..

CHAPTER 4

HARDWARE DESCRIPTION

4.1. ARDUINO UNO

The Arduino UNO is an open-source microcontroller board based on the Microchip ATmega328p microcontroller and developed by arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards(shields) and other circuits. The board has 14 Digital pins, 6 Analog pins, and programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable. It can be powered by a USB cable or by an external 9 volt battery, though it accepts voltages between 7 and 20 volts. It is shown in Fig.4.1. And is also similar to the Arduino Nano and Leonardo. The hardware reference design is distributed under a Creative Commons Attribution Share-Alike 2.5 license and is available on the Arduino website. Layout and production files for some versions of the hardware are also available. "Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0.

The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform. The ATmega328 on the Arduino Uno comes pre-programmed with a boot loader that allows uploading new code to it without the use of an external hardware programmer.

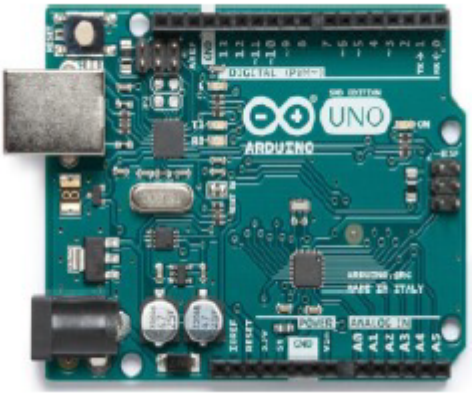

Fig.4.1.Arduino UNO board

4.2. RELAY

A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays, shown in Fig.4.2. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits as amplifiers: they repeated the signal coming in from one circuit and re-transmitted it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations. The essential component of any relay is its contact system. Current conducting elements are made up of beryllium bronze or phosphor bronze so that they provide current supply as well as contact pressure

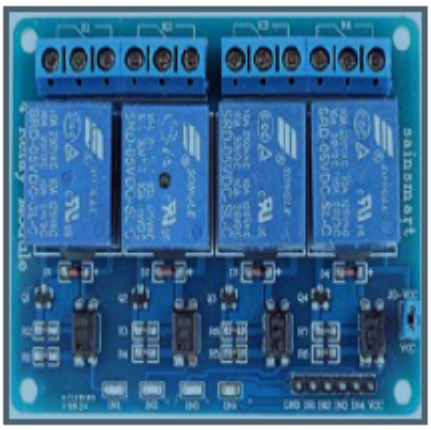

Fig.4.2.Relay

4.3. DHT 11 (TEMPERATURE SENSOR)

DHT11 is a Humidity and Temperature Sensor, which generates calibrated digital output, shown in Fig.4.3. DHT11 can be interfaced with any microcontroller like Arduino, Raspberry Pi, etc. and get instantaneous results. DHT11 is a low cost humidity and temperature sensor which provides high reliability and long term stability. In this project, we will build a circuit to interface Arduino with DHT11 Temperature and Humidity Sensor. One of the main applications of connecting DTH11 sensor with Arduino is weather monitoring

Fig.4.3.DHT11 sensor

4.4. LIGHT DEPENDENT RESISTOR (LDR)

LDR is a light-controlled variable resistor. The resistance of a LDR decreases with increase in incident light intensity, in other words it exhibits photoconductivity. It is shown in Fig.4.4. A LDR can be applied in light-sensitive detector circuits, and light-activated and dark-activated switching circuits.

Fig.4.4.LDR sensor

4.5. GSM MODULE

GSM/GPRS module is used to establish communication between a computer and a GSMGPRS system. Global System for Mobile communication (GSM) is an architecture used for mobile communication in most of the countries. Global Packet Radio Service (GPRS) is an extension of GSM that enables higher data transmission rate. GSM/GPRS module consists of a GSM/GPRS modem assembled together with power supply circuit and communication interfaces (like RS-232, USB, etc) for computer. GSM/GPRS MODEM is a class of wireless MODEM devices that are designed for communication of a computer with the GSM and GPRS network. It requires aSIM (Subscriber Identity Module) card just like mobile phones to activate communication with the network. Also they have IMEI (International Mobile Equipment Identity) number similar to mobile phones for their identification.

A GSM/GPRS MODEM can perform the following operations:

1. Receive, send or delete SMS messages in a SIM.
2. Read, add, search phonebook entries of the SIM.
3. Make, Receive, or reject a voice call.

GSM system was developed as a digital system using time division multiple access (TDMA) technique for communication purpose. A GSM digitizes and reduces the data, then sends it down through a channel with two different streams of client data, each in its own particular time slot. The digital system has an ability to carry 64 kbps to 120 Mbps of data rates. There are various cell sizes in a GSM system such as macro, micro, Pico and umbrella cells. Each cell varies as per the implementation domain. There are five different cell sizes in a GSM network macro, micro, Pico and umbrella cells. The coverage area of each cell varies according to the implementation environment.

GSM ARCHITECTURE:

A GSM network consists of the following components:

- A Mobile Station: It is the mobile phone which consists of the transceiver, the display and the processor and is controlled by a SIM card operating over the network.
- Base Station Subsystem: It acts as an interface between the mobile station and the network subsystem. It consists of the Base Transceiver Station which contains the radio transceivers and handles the protocols for communication with mobiles. It also consists of the Base Station Controller which controls the Base Transceiver station and acts as an interface between the mobile station and mobile switching centre.
- Network Subsystem: It provides the basic network connection to the mobile stations. The basic part of the Network Subsystem is the Mobile Service Switching Centre which provides access to different networks like ISDN, PSTN

etc. It also consists of the Home Location Register and the Visitor Location Register which provides the call routing and roaming capabilities of GSM.

It also contains the Equipment Identity Register which maintains an account of all the mobile equipment's wherein each mobile is identified by its own IMEI number. IMEI stands for International Mobile Equipment Identity.

Fig.4.5. Extended GSM module

4.6. LCD DISPLAY

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD.A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character

to be displayed on the LCD. Click to learn more about internal structure of a LCD.LCDs are used in a wide range of applications, including LCD televisions, computer monitors, instrument panels, aircraft cockpit displays, and indoor and outdoor signage.

26

Small LCD screens are common in portable consumer devices such as digital cameras, watches, calculators, and mobile telephones, including smartphones. LCD screens are available in a wider range of screen sizes than CRT and plasma displays, with LCD screens available in sizes ranging from tiny digital watches to very large television receivers. LCDs are slowly being replaced by OLEDs, which can be easily made into different shapes, and have a lower response time, wider colour gamut, virtually infinite colour contrast and viewing angles, lower weight for a given display size and a slimmer profile and potentially lower power
consumption (as the display is only "on" where needed and there is no backlight).

LCD PIN DESCRIPTION:

Pin No	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; through a variable resistor	V_{EE}
4	Selects command register when low; and data register when high	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight Vcc (5V)	Led+
16	Backlight Ground (0V)	Led-

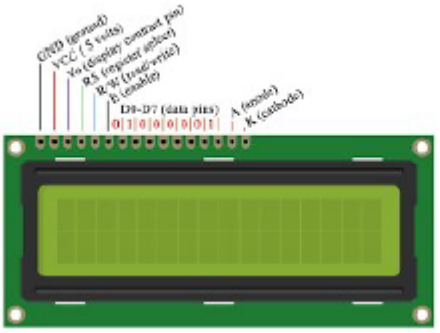

Fig.4.6. 16x2 LCD Display

4.7. CURRENT SENSOR

A current sensor is a device that detects electric current in a wire, and generates a signal proportional to that current. The generated signal could be analog voltage or current or even a digital output. The generated signal can be then used to display the measured current in an ammeter, or can be stored for further analysis in a data acquisition system, or can be used for the purpose of control

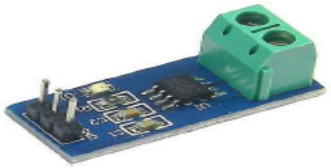

Fig.4.7.ACS712 current sensor

4.8. BREAD BOARD AND JUMPER WIRES

A breadboard is a construction base for prototyping of electronics and jumper wires are wires used for connecting all the sensors to arduino. It is shown in Fig.4.8.

Fig.4.8.jumper wires

4.9 NODEMCU CONTROLLER

NodeMCU is an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The term "NodeMCU" by default refers to the firmware rather than the development kits. The firmware uses the Lua scripting language. It is based on the eLua project, and built on the Espressif Non-OS SDK for ESP8266. It uses many open source projects, such as lua-cjson and SPIFFS.

4.9.1 HISTORY

NodeMCU was created shortly after the ESP8266 came out. On December 30, 2013, Espressif Systems began production of the ESP8266. The ESP8266 is a Wi-Fi SoC integrated with a Tensilica Xtensa LX106 core, widely used in IoT applications. NodeMCU started on 13 Oct 2014, when Hong committed the first file of nodemcu-firmware to GitHub. Two months later, the project expanded to include an open-hardware platform when developer Huang R committed the gerber file of an ESP8266 board, named devkit v0.9. Later that month, Tuan PM ported MQTT client library from Contiki to the ESP8266 SoC platform, and committed to NodeMCU project, then NodeMCU was able to support the MQTT IoT protocol, using Lua to access the MQTT broker. Another important update was made on 30 Jan 2015, when Devsaurus ported the u8glib[14] to NodeMCU project, enabling NodeMCU to easily drive LCD, Screen, OLED, even VGA displays.

In summer 2015 the creators abandoned the firmware project and a group of independent contributors took over. By summer 2016 the NodeMCU included more than 40 different modules. Due to resource constraints users need to select the modules relevant for their project and build a firmware tailored to their needs.

Fig: 4.9.1 NodeMCU

CHAPTER 5

SOFTWARE DESCRIPTION

5.1 Development of Arduino Module

The following sub sections describes the software implementation of the proposed model.

5.1.1 About Arduino Software

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language and the Arduino Software IDE based on Processing.

Its simple and accessible user experience, Arduino has been used in thousands of different projects and applications. The Arduino software is easy-to-use for beginners, yet flexible enough for advanced users. It runs on Mac, Windows, and Linux. Teachers and students use it to build low cost scientific instruments, to prove chemistry and physics principles, or to get started with programming and robotics. Designers and architects build interactive prototypes, musicians and artists use it for installations and to experiment with new musical instruments. Makers, of course, use it to build many of the projects exhibited at the Maker Faire, for example. Arduino is a key tool to learn new things. Anyone - children, hobbyists, artists, programmers - can start tinkering just following the step by step instructions of a kit, or sharing ideas online with other members of the Arduino community.

CHAPTER 6

HARDWARE IMPLEMENTATION

6.1 Introduction

The following sections depict the hardware implementation of the proposed model, the components used, their connections and working. The implementation is done for without theft load and with theft load. Taking resistive circuit as load in a real time situation, the implementation of theft and no theft is simulated in the following sections.

6.2 Verification of theft circuit (without theft)

Currents at the source side and load side are measured using current sensors. Sensors used for this problem definition is ACS712 with capacity up to 20A. In Fig.6.1 the line load is shown where three distribution lines from a single source line is shown.

The load at the end of the line represents the theft load which can be turned on with the help of a simple DPST switch. In the ‘without theft’ situation, all the three distribution lines are turned on, with the theft load off as shown below.

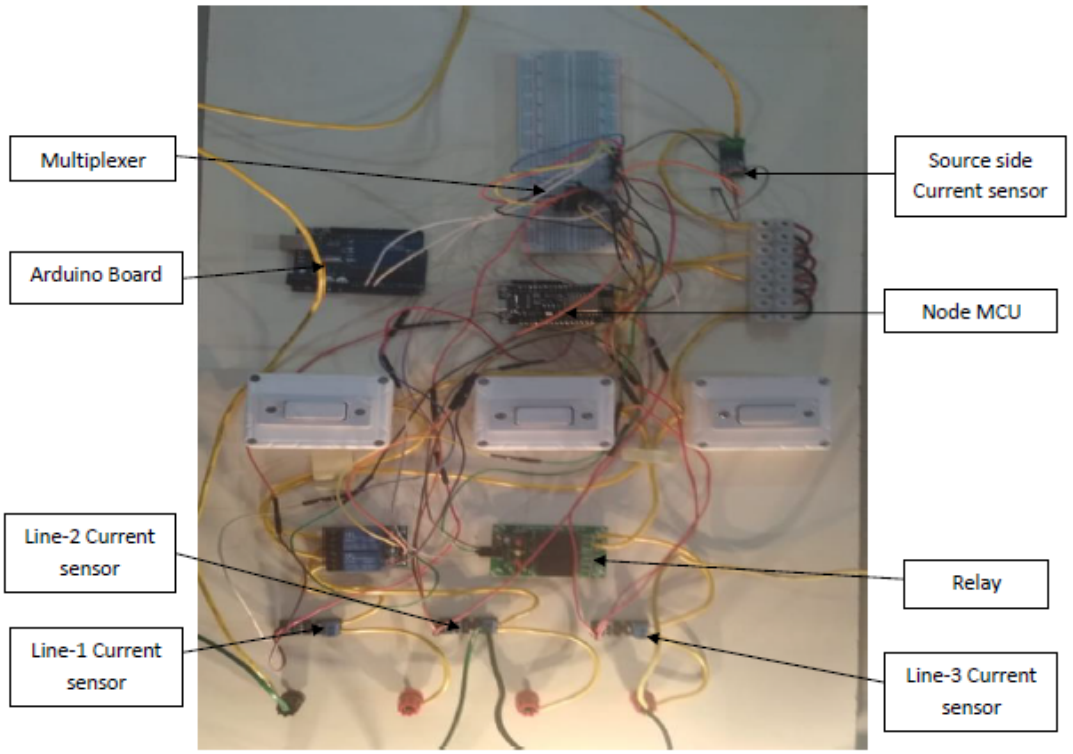

Fig: 6.1 Sensing currents without theft

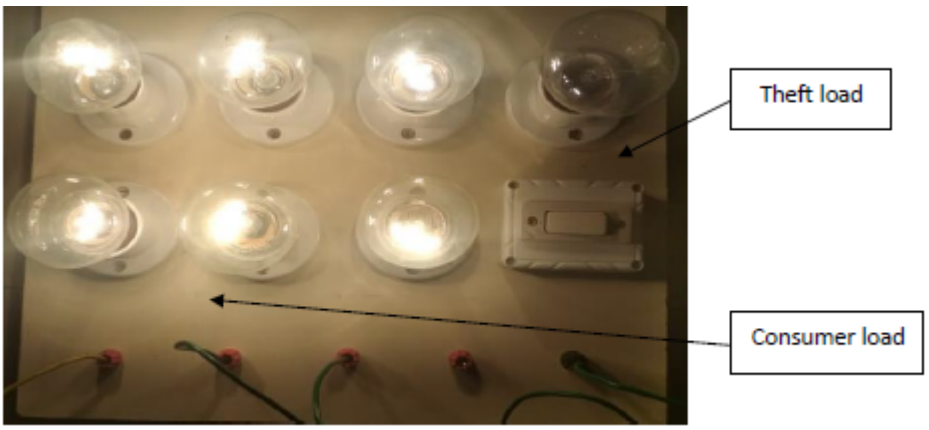

Fig: 6.2 Loads without theft (all 3 lines)

The above Fig.6.2 shows the model of the control panel. The currents of the three distribution line loads are sensed by three different sensors, with the source having its own sensor too.

The three DPST switches are used to switch on each of the lines individually. The current values of the three lines and the source are transmitted to the NodeMCU controller through MUX and the values are displayed on the serial monitor of NodeMCU or on ThingSpeak channel.

6.3 Verification of theft circuit (with theft)

The below Fig.6.3 depicts a scenario when the theft load (a lamp load is used here) is switched on with the help of a simple DPST switch. The theft is simulated for a single line as shown below, with the other two lines switched off for better understanding of the circuit.

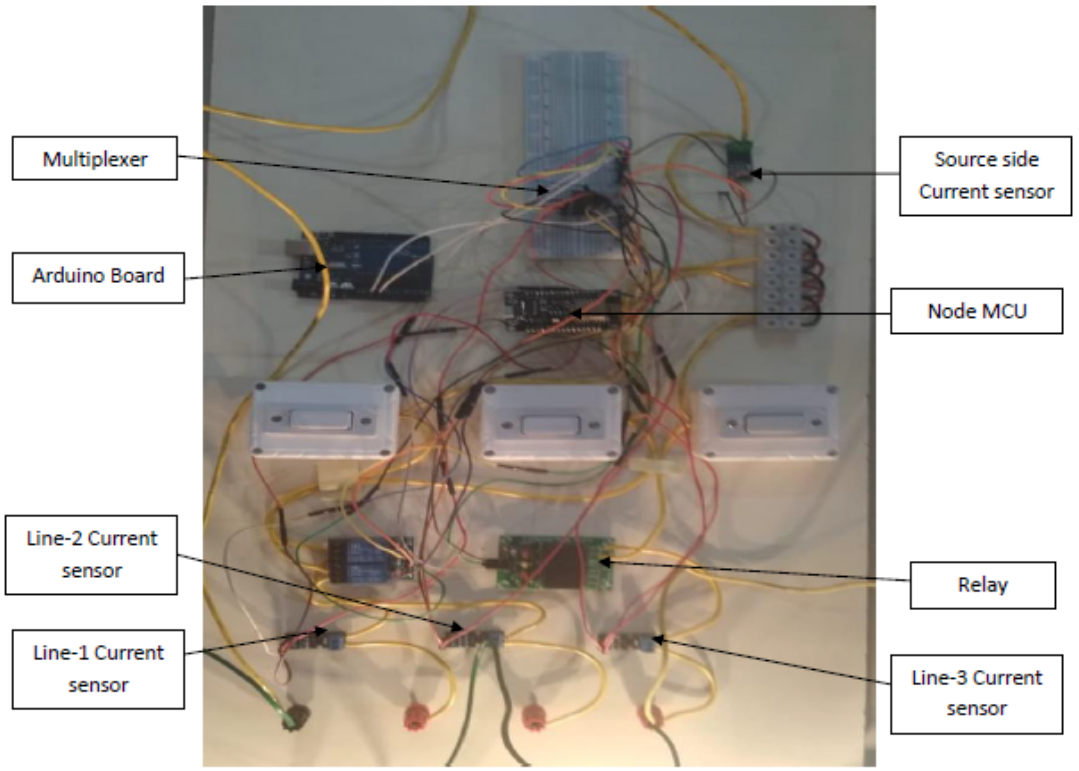

Fig: 6.3 Sensing currents with theft

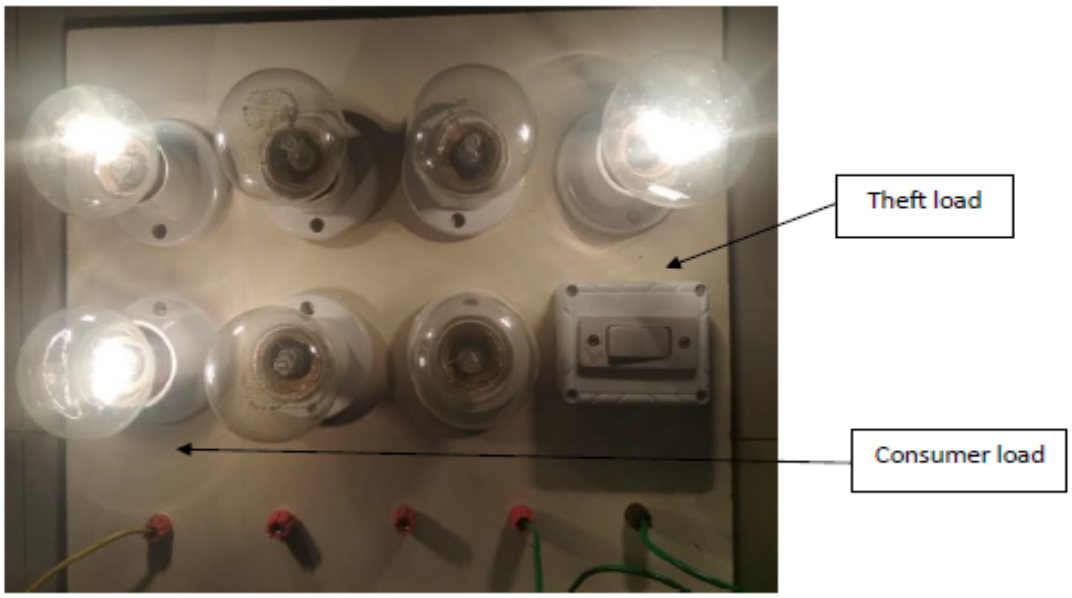

Fig: 6.4 Loads with theft (Line-1)

The Fig.6.4 shows the model of the control panel. The currents of the three distribution line loads are sensed by three different sensors, with the source having its own sensor too. The three DPST switches are used to switch on each of the lines individually. Here only one line is switched on and the effect of theft in the power lines can be seen in the serial monitor of NodeMCU or ThingSpeak channel.

6.4. VERIFICATION OF OVERALL MODEL

Thus, from the above sections i.e., verification of load circuit without theft and with theft conditions have been simulated and the results shown, inferences drawn and conclusions made are described in the following section.

6.5. SOURCE MANAGEMENT

Arduino UNO is used as the main processor part at the internal circuitry. They can be programmed and debugged according to the design needs and specifications. The multiple pins pave the way for connecting required relays as well as sensors. Using a software called as Fritz the schematic diagram can be drawn. The software includes all the sensors

such as LDR, DS3231, DHT11 etc. and controllers such as Arduino UNO, Arduino MEGA bread board and jumper wires.

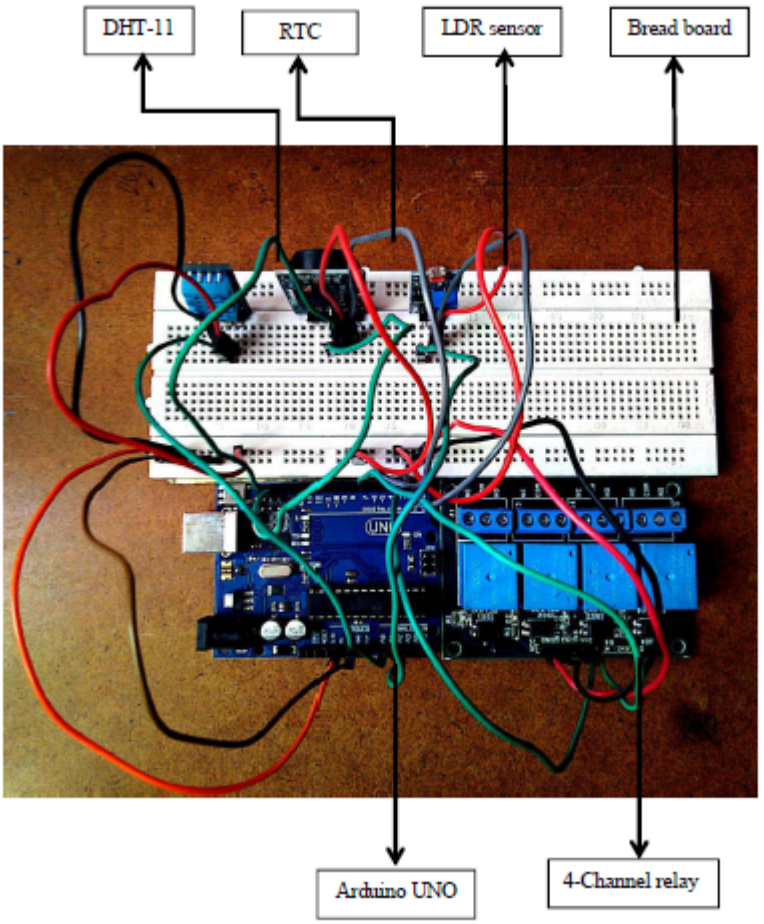

Fig.6.5.Practical Implementation of source management

In the sketch present above timer, DHT11, LDR sensors respectively are connected across the board with the relay performing the switching action. All these components are embedded and placed on an electrical compatible bread board. The relay is used to make or break a circuit and it is being operated by the arduino controller. The controller works using the program dumped in it. The other sensors used are also controlled by arduino. The sketch is shown in Fig.6.5.

After sensing their respective function, the output will be shown in the serial monitor of the

arduino software. Using the arduino software the arduino board can be programmed and reprogrammed infinite number of times according to the need. Combining of two to three

programs also can be done according to the ports available in the arduino board. The practical circuit is shown in Fig.6.5. and was tested under conditions and it was observed that relay switching was appropriate and sensors gave correct indication during varied cases.

6.6. LOAD MANAGEMENT

After analysing the changes to be done, modified circuit was designed and the connections

were made as follows:Fig.6.6.

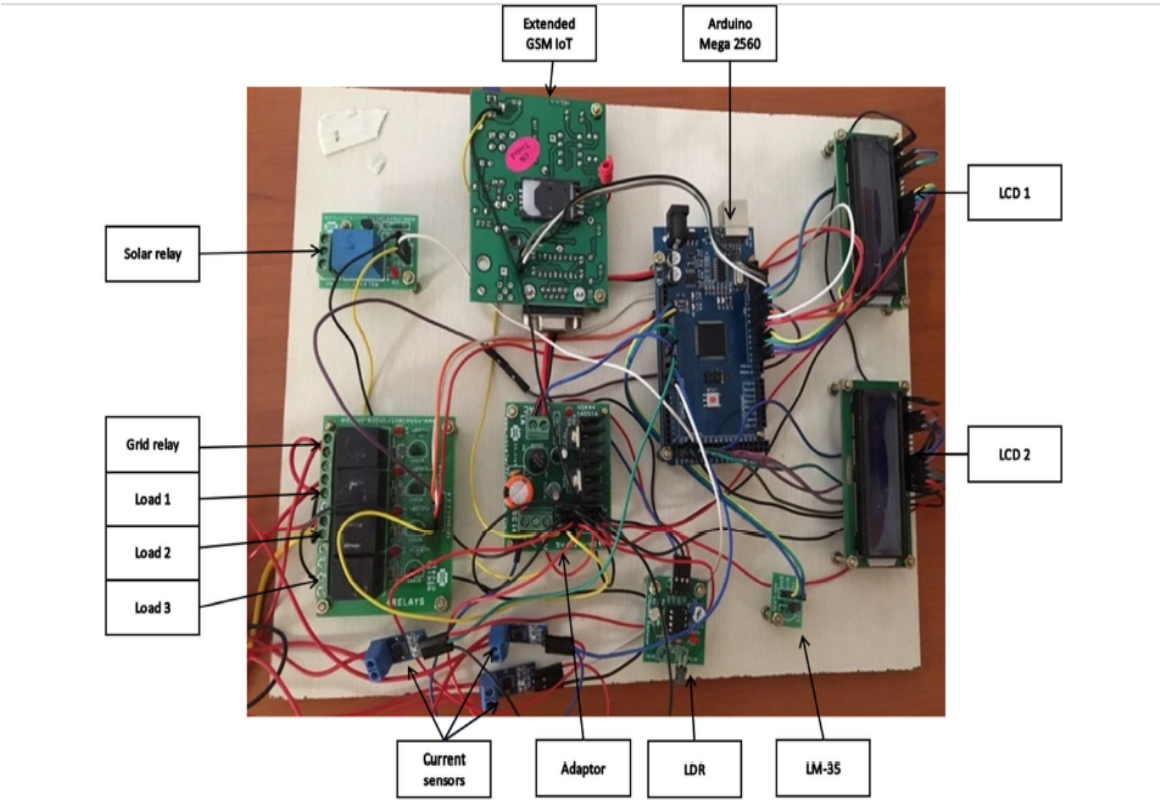

Fig.6.6.Hardware implementation of Load management

From source side implementation we found that, Arduino UNO could not accommodate more number of pins, because of which we could not interface the required sensors. Therefore, we opted Arduino MEGA 2560. At the site of circuit, the switching and ongoing process associated with it is displayed on LCD1. Similarly the load connected to the system, the current consumed by that particular load and the source connected is displayed on LCD 2. Three current sensors are employed in series with the loads and load operation is controlled by relay as well as GSM module. Whenever the consumer wants to turn OFF or turn ON the loads, he/she can do from a remote location just by sending messages i.e, L1_ON or L1_OFF. The same is possible for other two loads also. Adaptor is used to power the controller and GSM module. Whenever the current exceeds the solar

capacity, power to the load is supplied by both so solar, grid relays respectively are turned ON.

REFERENCES

[1] M. Qaisar Azeem, Habib-ur-Rehman, Sheeraz Ahmed, Ajmad Khattak “Design and Analysis of switching in Automatic transfer switch for load transfer”, 2016 International Conference on Open source Systems and Technologies.

[2] Afram Abdul, Abdul Atisam Farooq, “A Low cost Generator Auto Transfer Switch (ATS)controller for 2-3KVA household Generators”, VOL 2, Issue 2,September 2012.

[3] C. P. Vineetha and C. A. Babu, "Smart grid challenges, issues and solutions," 2014 International Conference on Intelligent Green Building and Smart Grid (IGBSG), Taipei, 2014,pp. 1-4.

[4] M. H. Sazli, İ. Koşalay and G. Erdenesaikhan, "A brief review of power quality issues in smart grid and a simple user friendly software," 2018 6th International Istanbul Smart Grids and Cities Congress and Fair (ICSG), Istanbul, 2018, pp. 54-58. doi:10.1109/SGCF.2018.8408941.

[5] Steimer, P. K. (2008). Power Electronics, a Key Technology for Energy Efficiency and Renewables. 2008 IEEE Energy 2030 Conference. doi:10.1109/energy.2008.4781022.

[6] Sharma and M. Sharma, "Power & energy optimization in solar photovoltaic and concentrated solar power systems," 2017 IEEE PES Asia-Pacific Power and Energy Engineering Conference (APPEEC), Bangalore, 2017, pp. 1-6. doi:10.1109/APPEEC.2017.8308973.

[7] E. Romero-Cadaval and Q. C. Zhong, “Grid connected photovoltaic plants: An alternative energy Source, replacing conventional sources" IEEE Ind. Electron. Mag., vol. 9, no. 1, pp. 18-32, Mar. 2015.

[8] A. Reinders and A. Freundlich, Photovoltaic solar energy: from fundamentals to applications, Hoboken, NJ, USA: Wiley, 2017.

[9] D. Sharma, A. Talwariya, A. Pandey and P. Singh, "Shrouded problems of solar power plant and recommendations," 2017 Innovations in Power and Advanced Computing Technologies (i-PACT), Vellore, 2017, pp. 1-5. doi: 10.1109/IPACT.2017.8245160.

[10] Aniele Menniti, Anna Pinnarelli, Nicola Sorrentino, P.Vizza, Alessandro Burgio, Giovanni Brusco, Mario Motta “A real life application of an Efficient Management

Management method for a local energy system in the presence of energy storage systems", pp1-5, 12-15, June2018.

[11] Pravin Chopade, Dr.Serap Karagol, Dr.Marwan Bikdash, Dr Ibraheem Khatib, Dr.Numan Dogan, "Noval Smart Grid and SCADA system interdependency network for future's clean,sustainable and Green energy", pp 1-3, October 2013.

[12] Kaddari, M., El Mouden, M., Hajjaji, A., & Semlali, A. (2018). Reducing energy consumption by energy management and energy audits in the pumping stations. 2018 Renewable Energies, Power Systems & Green Inclusive Economy (REPS-GIE). doi:10.1109/repsgie.2018.8488820.

[13] D.Leslie, A. Hlushko, S. Abughazaleh and F. Garza, "Tailoring SCADA systems for standby power applications," in IEEE Computer Applications in Power, vol. 7, no. 2, pp. 20-23, April 1994. doi: 10.1109/67.273782.

[14] A.Daneels, W.Salter, "WHAT IS SCADA?" International Conference on Accelerator and Large Experimental Physics Control Systems, 1999, Trieste, Italy.

[15] Teng F, Aunedi M, Pudjianto D, "Benefits of Demand-Side response in providing frequency response service in the future GB Power system", FRONTIERS IN THE ENERGY RESEARCH JOURNAL, ISSN: 2296-598X, 2015.

[16] M.M. Mohamed Mufassirin, A. L. Hanees and M.S. Shafana, "Energy theft detection and controlling system model using wireless communication media," in 5th Annual Science Research Sessions, 2016.

[17] Soham Chatterjee, Vaidheeswaran Archana, Karthik Suresh, Rohit Saha, Raghav Gupta and Fenil Doshi, "Detection of Non-Technical Losses using Advanced Metering Infrastructure and Deep Recurrent Neural Networks," IEEE, 2017.

[18] Pravin Shikalgar, Prasad Yadav, Hemant Pawar, "Power Theft Identification Using Smart Grid Technology," International Journal on Recent and Innovation Trends in Computing and Communication, vol.1, no.6, pp. 2321-8169, 2015.

[19] N Kunan, Poornima BK, "IoT Based Power Theft Detection and Monitoring System," in IJIREEICE, vol.5, no.5, pp. 2321 – 2004, 2017.

[20] R. E. Ogu and G. A. Chukwudebe, "Development of a Cost-Effective Electricity Theft

Detection and Prevention System based on IoT Technology," in 2017 IEEE 3rd International Conference on Electro-Technology for National Development (NIGERCON), 2017.

[21] Ou Qing-Hai, Wang Zheng, Zhen Yan, LI Xiang-Zhen, and Zhou Si, “Status Monitoring and Early Warning System for Power Distribution Network Based on IoT Technology,” in 3rd International Conference on Computer Science and Network Technology, 2013.

[22] Saritha I G , Sowmyashree M S , Thejaswini S, Surekha R Gondkar, “Wireless Power Theft Monitoring And Controlling Unit for Substation”, in IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) vol. 9, no.1, pp.10-14, 2014.

POWER THEFT MONITORING AND CONTROL USING IoT