A NOVEL SMART ENERGY METER WITH POWER THEFT CONTROL SYSTEM

A thesis submitted in partial fulfillment of the requirement for the degree of

BACHELOR OF TECHNOLOGY

IN

ELECTRICAL AND ELECTRONICS ENGINEERING

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CERTIFICATE

This is to certify that this project work entitled **"A NOVEL SMART ENERGY METER WITH POWER THEFT CONTROL SYSTEM "** is the bonafide work being submitted by **SIRIGIRISETTY SURYA TEJA (319126514089), SANKILI SARA EVANGELNI (319126514087), PADALA DIVYA PRAVALIKA (319126514079), K.BHASKAR PAVAN KUMAR (319126514069), PRASADA SUNIL KUMAR (3201265140L11) and T.V.K.SAMHITHA (318126514091)** of final year in partial fulfillment of the requirement for the award of the degree in Bachelor of Technology in Electrical and Electronics Engineering in ANITS (Approved by AICTE, affiliated to Andhra University and accredited by NBA, NAAC). It is a record of bonafide work carried out under the esteemed guidance of **Mr. B. SATYANARAYANA,** Assistant Professor, Dept. of EEE during academic year 2022-2023.

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With sincere regards,

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ABSTRACT

In order to modernize the existing traditional grid, advanced metering infrastructure (AMI) enables reliable and effective information exchange. Depending on the location that is important to the final customer, the Advanced Metering Infrastructure (AMI) can be divided into various sectors. Smart meters, Wide Area Communication Infrastructure, Home Area Networks, Meter Data Management System, and Operational Gateways are an integral part of AMI and they all can collect data quickly and in large volumes. Smart meters have been widely used to replace traditional analog meters in the modern smart home. It digitalizes data collecting as well as meter readings. Data can be sent wirelessly, which considerably minimizes manual labor. However, energy theft is a problem in the smart home network community. Due to the requirement of installing particular hardware for the tactics now in use, such attacks cannot be properly detected. This makes it difficult to establish energy theft detection systems due to a shortage of energy monitoring sensors. Non-smart energy and gas meters just monitor overall consumption and provide no information about power consumption data from time to time. It prevents two-way communication between the computers in the utility control center and the meter. Our project develops an energy theft detection system that alerts the user (customer) and the substation when a theft occurs by producing a buzzing sound in the home and sending a message to the substation. It provides load monitoring and power consumption data that may be made available to the user (customer) at any time when they send the specific commands.

LIST OF ABBREVIATIONS

DSMS - Data stream management system

FRTU - Feeder Remote Terminal Unit

AMR - Automatic Meter Reading

LED - Light emitting diode

GSM - Global system for Mobile communication

IDE - Integrated development environment

PLC - Programmable logic controllers

RTC - Real time clock

PIC - Peripheral interface controller

LAN - Local area network

WAN - Wide area network

PCB - Printed circuit board

NAN - Neighborhood area network

SPL - Set processor level

AREF - Analog reference

PBCCH- Physical Downlink Control Channel

UART - Universal asynchronous receiver transmitter

TX - Transmitter

RX - Receiver

BJT - Bipolar junction transistor

CMOS - Complementary metal oxide semiconductor

CHAPTER 1: INTRODUCTION

1.1: OVERVIEW OF THE PROJECT

Today's smart home inventors are focused on system development, system design, communication protocols, and forecasting tools. These advancements give home consumers with superior technologies in terms of energy monitoring, control, and reliability. For example, Demand Side Management System (DSMS) was developed to better manage and reduce power consumption in smart homes. This power conservation concept accelerated research into improved DSMS approaches such as load-shifting, dynamic price management, forecasting demand, and demand response systems.

Energy theft has been a growing problem in several countries throughout the world. Despite this, only a few preventive energy theft measures have been developed to fight the problem. Y. Zhou et al. suggested a dynamic programming approach for using probabilistic detection of energy theft in smart homes. This proposed technique necessitates the installation of a Feeder Remote Terminal Unit (FRTU) on top of a smart meter, which incurs significant expenditures for consumers.

Our project develops an energy theft detection along with load monitoring and power consumption data even without installing FRTU's and enabling two-way communication between meter and the customer. Modifying the digital meter and making it as a smart meter makes it more efficient and reliable compared to previous meters.

The System consists of hardware and software part. Hardware part consists energy meter that the users can monitor their power consumptions anytime and anywhere. As for the software part, all the program located in Arduino UNO, using C language.

In hardware part, the Automatic Meter Reading system (AMR) continuously monitors the energy meter and sends data on request of the consumer through SMS. It helps the consumer to access the accurate and updated data from the energy meter. An LED indicator is placed which blinks for 1wh pulse and also have direct pulse output connection that is compatible to the Arduino. As prototype to count the pulse, 2 units of lamps 15w each is connected to the meter through Arduino.

GSM module is used for receiving SMS from user’s mobile phone that automatically enable the controller to take further action like switching ON and OFF of electrical appliances and is also used to send data on request of the user. The microcontroller, Arduino UNO is used as it’s architecture is based on Reduced Instruction Set Computer concept which allows the processor to complete 20 million instructions per seconds operating at 20MHz. With a total of 14 digital I/O pins and 6 analog I/O pins, this is a very capable device, able to run most programs.

Real time clock is also used in this project to get the real time counting. We also added liquid crystal display (LCD), which acts as the output display to show the bill, units and GSM status on it. Power theft sensor is used for detecting energy theft and alerts the consumer (user) with a buzzer sound and sends SMS to the substation.

In software part, the program is developed in C language with the Arduino syntax in the Arduino IDE. This software is also used for loading the program code into Arduino board. Digital write input/output, GSM network, Real time clock. Arduino IDE is used to program, create, debug and upload the coding into the microcontroller (Arduino UNO). Each program needs to include the libraries of the coding such as for GSM, GSM.h library is used and other libraries are also included based on our requirement. User can also reset the bill for every month. Based on the commands the user send, the system responds to it.

1.2: OBJECTIVE OF THE PROJECT

Technology advancements have changed the goals of energy meters from simple measurement of energy units. Objectives extended much beyond merely reporting a customer's energy levels. Our primary objectives are:

1. Indication of power theft:

   When someone tries to open an energy meter, it should detect it, record the incident, and promptly notify the substation through SMS and the user with a buzzer sound.

2. Communication medium:

   There should be a communication channel not just between energy meters and utility providers, but also between the energy meter and the user. The following are some examples of communication mediums: radio frequency, ZigBee, GSM/GPRS, and PLC. There are benefits and drawbacks to each type of communication media. The best communication method must be picked based on our requirements.

3. Load control:

   Because an energy meter has a relay, a utility provider can quickly disconnect the load of any consumer by pressing a button. Not only the utility company, but also the user must be able to readily monitor the loads at any time and from anywhere through the combination of a communication channel and a relay.

4. Power Consumption:

   The user must have access to the power consumption units through a communication means at all times and from any location.

CHAPTER 2 : ENERGY METERING SYSTEMS AND CHALLENGES

2.1:- INTRODUCTION

Energy meter is a device that measures the total power consumed over a period of time. The total quantity of energy absorbed or produced within the electrical circuit is known as electrical power.

Energy meters have undergone numerous advancements over the years, including the use of better brake magnets, oil-free bearings, double jewel bearings, and magnetic bearings to increase long-term stability as well as reduce weight and size, increase load range, account for variations in power factor, voltage, and temperature, and eliminate friction.

2.2:- TYPES OF ENERGY METER AND THEIR EVOLUTION

The types of energy meter is shown in the block diagram

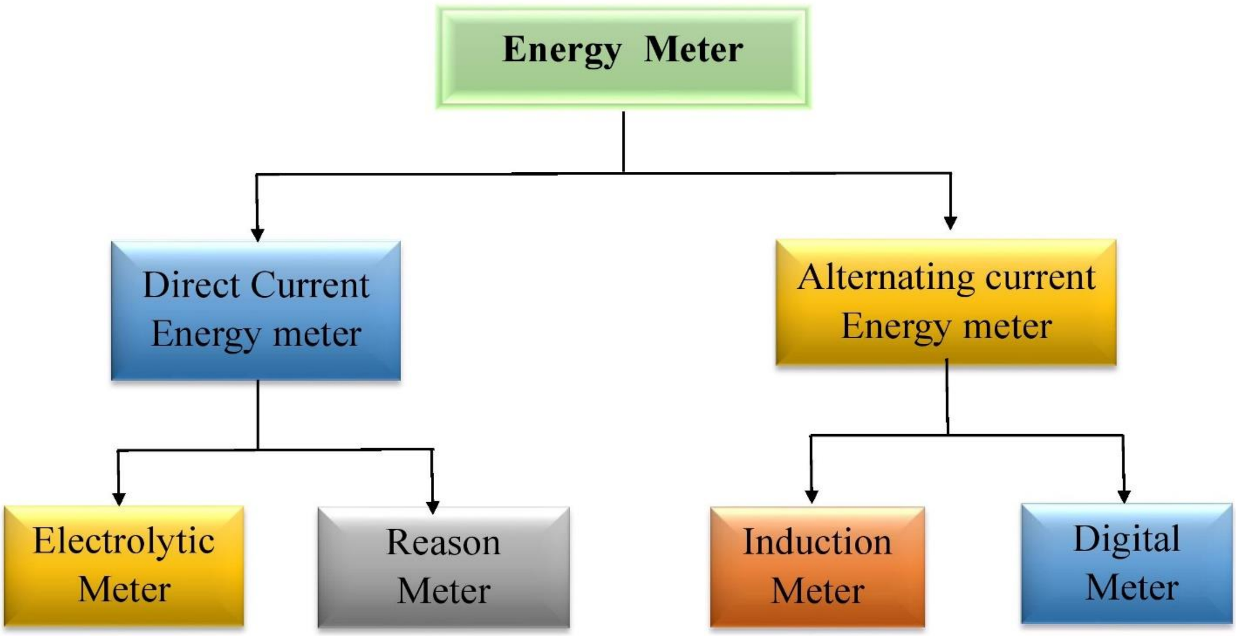


Fig 2.2 Types of Energy Meters

2.2.1:- DIRECT - CURRENT ENERGY METERS

They are mainly classified into two types

1. Electrolytic Meter
2. Reason Meter

2.2.1.1:- Electrolytic Meters

Thomas Edison first developed an electromechanical direct current (DC) meter with a direct reading register, but later came up with an electrochemical metering system that calculated total current usage using an electrolytic cell. It has an electrolytic cell that was filled at the beginning of the billing cycle with a copper strip that was properly weighed. Because of the current passing through the electrolyte, copper was deposited. At the end of the billing period, the copper strip was weighed again, and the difference represented the amount of electricity that had been used. The meter was redesigned to allow for cubic feet of gas to be used in billing. The meter was labor - intensive to read and not well received by end users(customers).

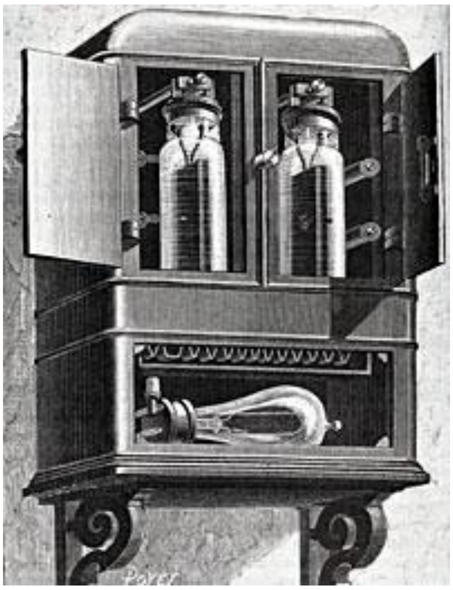


Fig 2.2.1.1 (a): Electrolytic meter

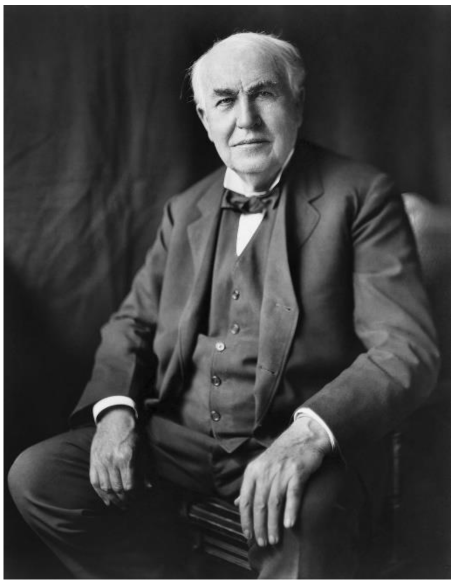


Fig 2.2.1.1 (b): Thomas Edison

2.2.1.2:- Reason Meters

The 'Reason' meter was a pioneering electrochemical meter used in the UK. A mercury reservoir was located at the top of the vertically mounted glass building that housed the meter. Electrochemical action caused the mercury to fall to the bottom of the column as current was extracted from the supply. Like all other DC meters, it kept track of ampere hours.

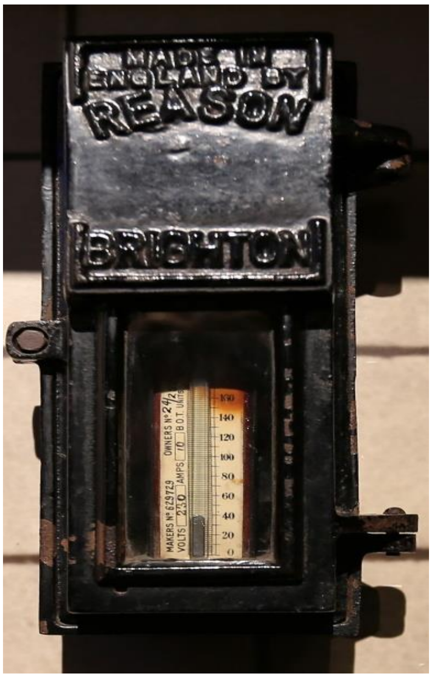


Fig 2.2.1.2:- Reason Meter

The meter becomes an open circuit when the mercury pool is exhausted. The supplier's agent would then release the meter from its mounting and flip it over, replenishing the mercury in the reservoir and the supply, for which the consumer had to pay. In reality, the customer would call the agent of the supply firm before the supply ran out and only be to pay the amount displayed on the scale. The meter was then turned backwards to zero by the agent.

2.2.2:- ALTERNATING – CURRENT ENERGY METERs

2.2.2.1: History of AC Energy Meters

At the Frankfurt Fair in the autumn of 1889, the Ganz Works displayed the first example of the AC kilowatt-hour meter made in accordance with the Hungarian Otto Blathy's patent and given his name. By the end of the same year, the manufacturer had already begun to sell the first induction kilowatt-hour meter. These first Blathy meters, or alternating-current watt-hour meters, were used. Today's AC kilowatt-hour meters operate on a similar principle to Blathy's original invention.

Around the same time, Elihu Thomson of the American General Electric company invented a recording watt meter (watt-hour meter) that used an ironless commutator motor. This meter overcame the drawbacks of the electrochemical type by operating on either alternating current or direct current.

There are mainly classified into three types:

1. Induction Meters
2. Digital Meters
3. Smart Meters

2.2.2.2:- Induction Meters

The aluminum disc can be used to calculate the load's energy usage. Between the air gap of the series and shunt electromagnet lies the disc. The pressure coil is located in the shunt magnet, and the current coil is located in the series magnet. Due to the supply voltage, the pressure coil's number of turns makes it more inductive. The pressure coil generates the magnetic field, and the current coil performs the same because of the current. Because of the short air gap, their magnetic circuit has extremely little resistance.

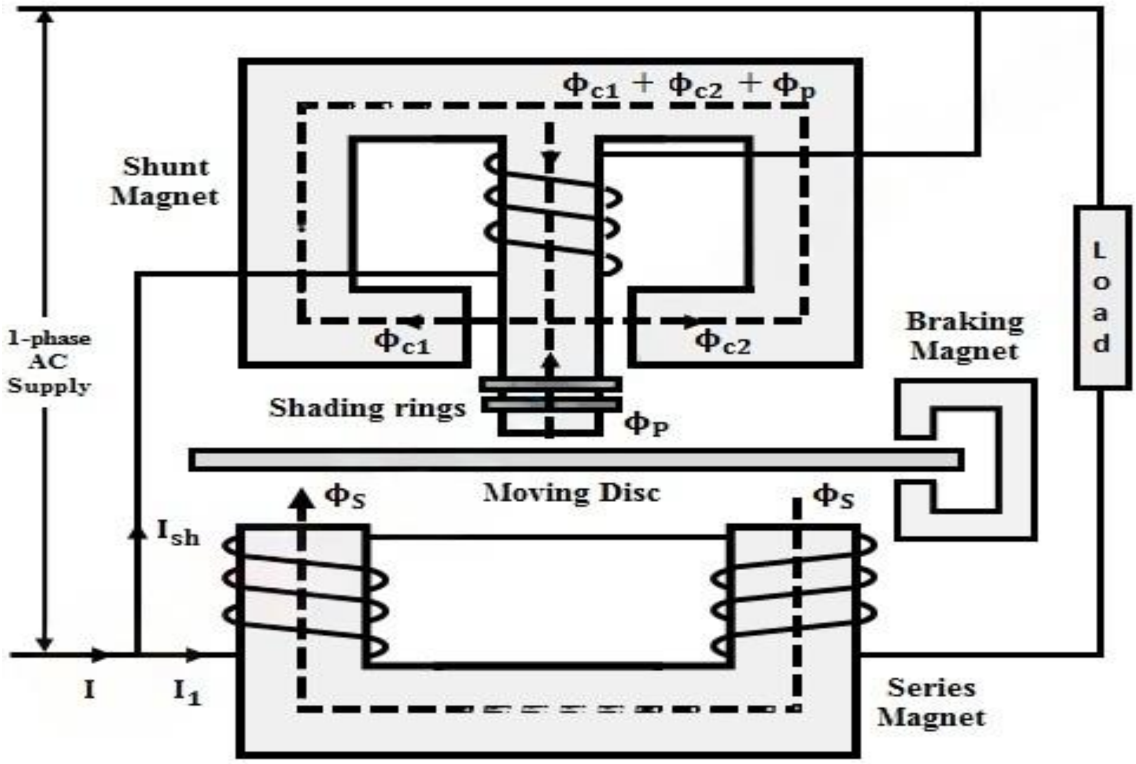


Fig 2.2.2.2 (a) Working Diagram of an Induction Meter

The supply voltage causes the current Ip to flow through the pressure coil with a 90° lag. The Ip generates two flux p, which are further separated into flux p1 and flux p2. Due to low reluctance, the majority of the flux (p1) goes through the side gap. The aluminum disc is rotated by the driving torque caused by the flux p2 that passes through the disc. The flux p has a 90° lag and is proportional to the applied voltage. Because of the alternating nature of the flux, the disc experiences an eddy current Ipe.

The load current passes through the current coil induces the flux Φs. This flux causes the eddy current Ies on the disc. The eddy current Ies interacts with the flux Φp, and the eddy current Iep interacts with Φs to produce the another torque. These torques are opposite in direction, and the net torque is the difference between these two. Then, the disc starts rotating.

The relationship between the force on the disc and the coil's current and voltage is proportional. Their rotation is controlled by the permanent magnet. The permanent magnet prevents the disc from moving and balances its power consumption. The rotation of the disc is counted by the cyclometer

Fig 2.2.2.2(b) Induction meter


Fig 2.2.2.2(c) Disk action of IM

The meter initially used a braking magnet and a cyclometric register to achieve a broad measurement range. The first meters rotated at 240 revolutions per minute, weighed 23 kg, and were mounted on a wooden platform. By 1914, the weight had dropped to 2.6 kg.

The electromechanical induction meter counts the rotations of a non-magnetic, electrically conductive metal disc that is forced to rotate at a speed proportional to the power flowing through the meter in order to work through electromagnetic induction on a single-phase AC supply. As a result, the quantity of energy used and the number of rotations are proportional. The voltage coil consumes a small and essentially constant amount of electricity, often around 2 watts, which is not seen on the meter. Similar to this, the current coil uses a small amount of power that is proportional to the square of the current that it is carrying through, which can sometimes reach a few watts at full load and is shown on the meter.

2.2.2.3:- Digital Meters

Electronic meters are another name for digital meters. On an LCD or LED display, electronic meters show the amount of energy used, and some may also send data to distant locations. Electronic meters are capable of recording additional load and supply parameters in addition to energy, including voltages, power factors, reactive power consumption, immediate and maximum rate of usage needs, and others. Additionally, they can assist with time-of-day billing by keeping track of how much electricity is utilized during peak and off-peak periods.

A power supply, a metering engine, a processing and communication engine (i.e. a microcontroller), and additional add-on modules such as a real time clock (RTC), a liquid crystal display (LCD), infrared communication ports/modules, and so on are included in the meter.

Fig 2.2.2.3(a) Digital Meter

Fig 2.2.2.3(b) Advanced Digital Meter

The digital energy meter working principal operates by continuously measuring the instantaneous voltage (volts) and current (amperes) and by finding the product of these to give instantaneous electrical power (watts) which is then integrated against time to give energy used (Joules, Kilowatt-hours etc.). Meters for smaller services (such as small residential customers) can be connected directly in-line between source and customer.

The three main design considerations for digital meters are a desired device cost, efficiency, and overall size. The cost is affected by the users' overall ability to pay, but the efficiency and size must rigorously adhere to standards. Two simple sensors are used in this situation. These sensors measure current and voltage. The voltage sensor, which is based on a potential divider network and step-down element, can detect both the phase voltage and load voltage.

The second sensor measures the current being drawn by the load at any one time and is called a current sensor. It is constructed around a current transformer and other active devices that convert measured current to voltage for processing, including voltage comparators. The output of the two sensors is then fed into a signal (or voltage) conditioner that ensures matched voltage or signal level to the control circuit. It also contains a signal multiplexer that enables sequential switching of both signals to the analogue input of the peripheral interface controller (PIC).

The voltage and current sensor signals are multiplied by means of embedded software in the PIC after the ADC converts the analogue signals to their digital equivalents. By calculating the input quality with short-circuited input and storing this value in the memory for use as the correction value device calibration, the error correction is taken in this case to be the offset correction.

C language is used to programme the PIC. So that, in addition to the multiplier circuit it models, it may use the supplied data to compute both expected charges and power consumption per hour. These are shown on the circuit's associated liquid crystal display. This is how digital meter works.

CHAPTER 3: SMART ENERGY METER: A GAME-CHANGER

3.1:- INTRODUCTION TO SMART ENERGY METERS

Since the inception of energy deregulation and market-driven pricing around the world, utilities have been looking for a way to match consumption with generation. Non-smart energy meters just monitor overall consumption and provide no information about when the energy was utilized. Smart meters measure electricity use in near real-time.

Fig 3.1 Smart Energy Meter

These devices are designed to replace traditional meters used for monitoring energy consumption in houses and businesses. Smart meters are equipped with advanced technology that allows them to communicate with energy providers and provide real-time information about energy usage. This enables energy providers to charge various fees for use based on the time of day and season. It enables more realistic cash-flow calculations for utilities. It also allows two-way communication between the meter and the computers in the utility control center. Since smart meters can be read remotely, utilities save money on labor.

3.2:- ROLE OF SMART ENERGY METER IN SMART GRID

One of the main components of the Smart grid is Smart Meter. Smart Meter carries various numbers of tasks and functions. Due its advanced task managing capability and functions, it has a wide range of advantages.

Some of the crucial tasks that the smart meters carry are:-

- Data Collection
- Communications
- Data analysis
- Decision support

The information is gathered from specific appliances and is noted at predetermined intervals of time. The data is gathered, stored in memory, and prioritized for transmission to the utility center. The utility center may send out command signals, and the smart meter can schedule and control loads based on user preferences. Smart meters can be used to automate billing.

Important functions carried out by smart meter are:-

1. Power quality measure
2. Remote controlling
3. Time of use
4. Real time communication of power usage
5. Promotes Distributed generation
6. Remote programming
7. Demand based tariff
8. Service switching

Bidirectional information flow, commonly referred to as two-way communication, is supported by smart meters. The local area network (LAN)-deployed smart meter is installed at the end user's premises to gather data on electrical usage from all appliances. Local data aggregators use NAN to gather the data from individual smart meters, and then WAN is used to transmit this data to the utility center. The smart meter at the end user's premises can also receive commands or signals from utility centers.

The smart meter should communicate the data to the utility center in a highly reliable and secured way.

Smart meters' main objective is to assure systematic energy management with the active participation of end users by coordinating utility companies in making intelligent decisions. A Smart grid will enhance the stability and reliability of power systems using AMI technologies. The most important advantages of smart meters using AMI are better outage management, increased remote monitoring on power losses and controlling them and accurate billing. Smart meters definitely have a great role in the smart grid. In addition to all the importance the smart meter holds, it is considered as most important for future energy management.

3.3 APPLICATIONS

It is critical to ensure a reliable and secure flow of digital communications, as power grid infrastructure becomes progressively digitized. Smart meters measure energy consumption and use a safe and secure network to send energy meter readings to the energy supplier. Smart Meters are used widely nowadays.

There are number of applications of smart meters which are categorized as below:-

1) Settlement and billings
2) State Estimation of Power Distribution Networks
3) Power Quality and Reliability
4) Better Customer Service
5) Forecasting Modeling and Load Analysis
6) Energy Saving
7) Balancing Power Generation and Consumption
8) Improved Efficiency and Competitive Edge

9) Security

10) Remote Monitoring to Establish Virtual Power Plant

11) Subsidiary Service Support

12) Research Support

1. Settlement and Billings include:

i. Accurate settlements – Data regarding energy consumption is up-to-date and accurate. Settlement procedures later in terms of consumption, settlement, and billing are less costly.

ii. Frequent and cheaper switching ─ metered data from a metering point at any time or within a short period can be requested by smart meters., reducing switching costs (from one retail electricity supplier).

iii. Correct and timely billing – Smart meters provide consumers with actual data on energy consumption.

iv. Prepayment – Smart meters allow advance collection from consumers. Power is only provided/supplied whilst the consumer is on credit.

v. Remotely connect, disconnect, or limit load – Remote connection and disconnection of total or partial loads, and limiting maximum capacity allowed for a metering point.

vi. Fraud detection.

vii. Tariff Setting – Tariff setting on energy consumption is based on the time of usage, the maximum demand and some other factors. Based on these factors tariff is set.

viii. State Estimation of Power Distribution Networks

ix. A large number of measurements from a model network of the physical network and its load is combined in this process. This process helps in the calculation of loss (reactive power flow) and identifies faulty measurements and input data. In addition, smart meters measure consumption at customers' end(kWh-meter.) Therefore, the loading losses are accurate in measure, overloading at transformers and lines is prevented.

2. Power Quality and Reliability:-

Due to the Smart Meters capacity to monitor power quality, customer concerns may be handled quickly and precisely. Additionally, it contributes to the maintenance of stable power quality with little variation. The location of interruptions, power drops, or other information can be used to pinpoint where improvements are needed. Based on client feedback, it also aids in enhancing energy efficiency for end users and distributed generation.

3. Better Customer Service:-

Smart meters can improve the quality of customer service and make it efficient by calling a call center agent or directly to call centers. It will allow control centers to have accurate measurements based on available data enabling faster and accurate service. New connections, load disconnection, and enhancing energy efficiency are the other customer services that are being provided.

4. Forecast Modelling and Loads Analysis

Based on data on gas, electricity, heat, and water use, load analysis is carried out. These metres do statistical analysis and forecast loads by combining profile data, weather, and outside temperatures. It is possible to estimate and forecast models based on time fluctuations, overall energy consumption, and peak demand. Energy savings efforts are evaluated using precise energy usage data.

5. Energy Saving

i. By collecting accurate and timely data from final customers, smart metres contribute to energy savings.
ii. Customers have better control over their energy consumption due to real-time information on energy consumption.

6. Improved Efficiency and Competitive Edge

Smart meters offer a competitive advantage by providing:

i. Quick metering, accurate data collection, and billing are all features that smart meters offer as a competitive edge.
ii. Analyzing consumer data usage for a new contract with retail electricity providers.
iii. The energy market is enriched by new goods and increased price elasticity. Voltage and reactive power regulation are also improved.

7. Subsidiary Service Support

Smart meters have local measurements of frequency, reactive power, and voltage level as well as remote control functions with local control outputs. It makes an effort to offer the services necessary for the transmission or distribution system to run without interruption.

8. Remote Monitoring to Establish Virtual Power Plant

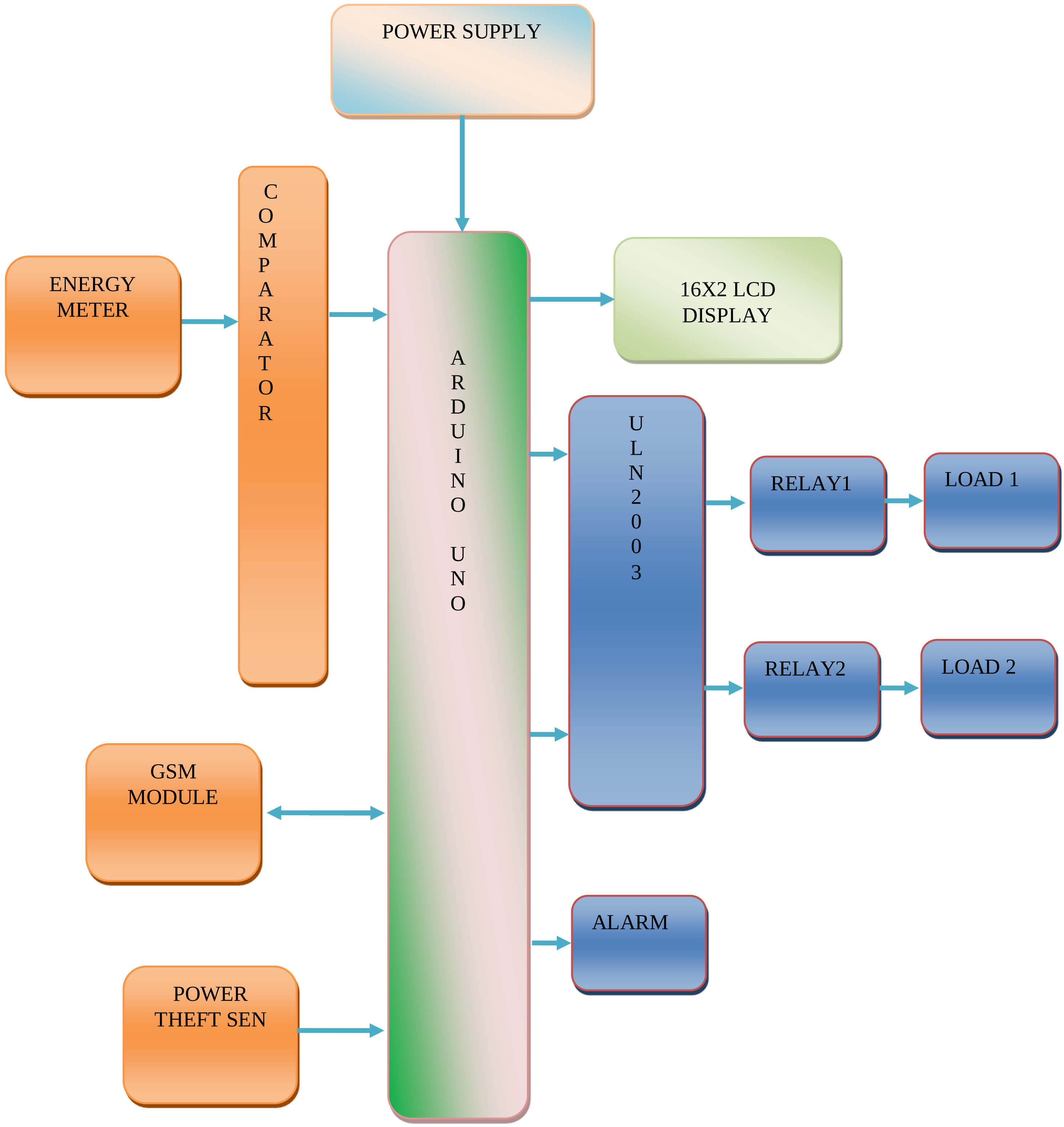
A management framework that manages several tiny generation units and other minor energy resources to function as a large power plant is known as a virtual power plant. It can be very helpful for connecting minor energy resources to the energy market and for remote monitoring and operation.

9. Security

Safety, security, and social alarm services are provided by smart meters.

CHAPTER 4: COMPONENTS AND THEIR DESCRIPTION

4.1:- BLOCK DIAGRAM



4.2:- ARDUINO

The company, initiative, and user community known as Arduino creates and produces single-board microcontrollers and microcontroller kits for the development of digital devices and interactive things that can sense and control objects in both the real world and the virtual one. The project's output is offered as open-source hardware and software that is distributed under the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL), enabling anybody to assemble Arduino boards and distribute code. Commercially, preassembled Arduino boards and DIY kits are both offered. A variety of microprocessors and controllers are used in Arduino board designs. A variety of expansion boards, breadboards (shields), and other circuits can be attached to the boards' sets of digital and analogue input/output (I/O) pins. The boards are equipped with serial communications ports, including USB on some models, and are also used to load programmes from personal computers. Typically, a dialect of elements from the programming languages C and C++ are used to programme microcontrollers.

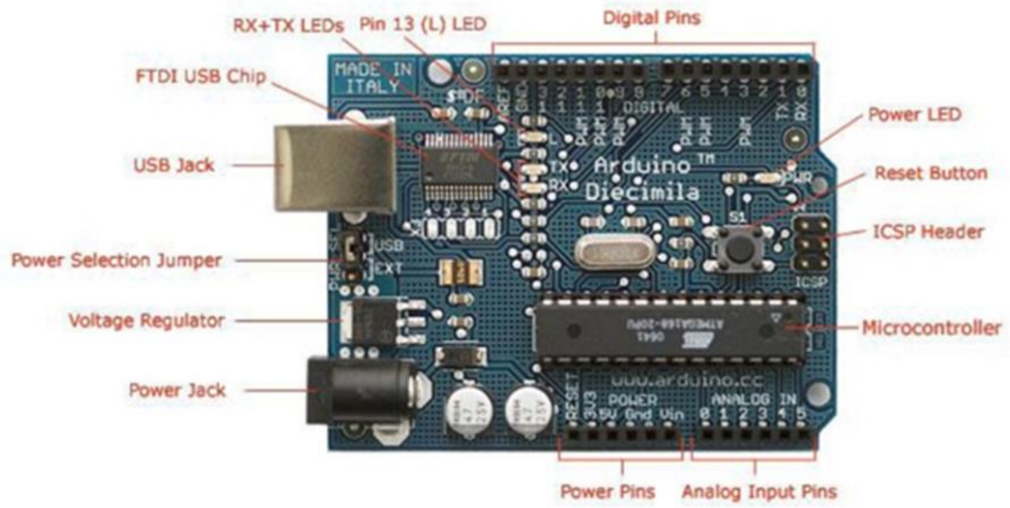


Fig 4.2 Arduino Pin Diagram

The Arduino project offers an integrated programming environment (IDE) based on the Processing language project in addition to using conventional compiler toolchains.

The Arduino project started in 2003 as a course for students at the Interaction Design Institute Ivrea in Ivrea, Italy, with the intention of giving amateurs and experts alike an affordable and straightforward way to create gadgets that interact with their surroundings by using sensors and actuators. Thermostats, motion detectors, and simple robots are typical examples of the kind of gadgets targeted at newcomers.

4.2.1: History

The Interaction Design Institute Ivrea (IDII) in Ivrea, Italy, is where the Arduino project got its start. The students were using a $100 BASIC Stamp microcontroller at the time, which was expensive for many students. As part of his master's thesis at IDII in 2003, Hernando Barragán created the Wiring development platform. Massimo Banzi and Casey Reas, who are known for their work on the Processing programming language, oversaw the project. The goal of the project was to develop simple, affordable tools for non-engineers to utilize while creating digital projects. The Wiring platform includes an ATmega168 microcontroller printed circuit board (PCB), a Processing-based integrated development environment (IDE), and library functions for simple microcontroller programming. In 2003, David Cuartielles, Massimo Banzi, and a different IDII student added support for the less expensive ATmega8 microprocessor to Wiring. They branched from the project and gave it the name Arduino rather than continuing with Wiring. The earliest members of the Arduino core team were Massimo Banzi, David Cuartielles, Tom Igoe, Gianluca Martino, and David Mellis; Barragán was not included. After the Wiring platform was finished, lighter and more cheap versions became available to the open-source community. Digital initiatives are developed by non-engineers. The Wiring platform includes an ATmega168 microcontroller printed circuit board (PCB), a Processing-based integrated development environment (IDE), and library functions for simple microcontroller programming. Midway through 2011, the New York City-based manufacturer of Arduino boards, components, and assemblies Adafruit Industries claimed that over 300,000 official Arduinos had been manufactured for sale. By 2013, users had 700,000 official boards in their possession. In October 2016, Federico Musto, the previous CEO of Arduino, purchased a 50% share in the business. Apparently, Musto "fabricated his academic record," according to Wired in April 2017. The open-source community was given access to versions. Non-engineers create digital initiatives. The Wiring platform included a printed circuit board (PCB) with an ATmega168 microcontroller, an IDE based on Processing, and library functions for easy microcontroller programming.

4.2.2: Types of Arduino

There are different types of Arduinos:-

1) Arduino UNO-

   The latest Arduino USB board is this particular model. It comes with everything else required to operate and programme the board, and it connects to the computer via a standard USB port. Shields, which are specialized daughter-boards with particular functions, can be added to it to expand it. It is similar to the Duemilanove, with the exception of the ATMega8U2 USB-to-serial chip and newly created labels to aid with input and output identification.

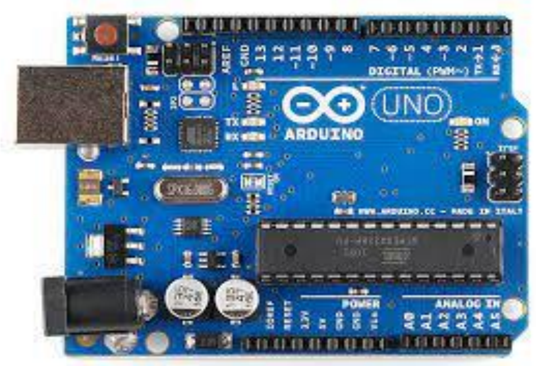


Fig 4.2.2 (a) Arduino UNO

2) Arduino Mega 2560

   An Arduino board that is larger and more powerful. Has additional digital pins, PWM pins, analogue inputs, serial ports, and so on. This is the version of the Mega that came with the Uno; it has twice the memory and uses the ATMega 8U2 for USB-to-serial communication.

Fig 4.2.2 (b) Arduino Mega 2560

3) Arduino Duemilanove

The Duemilanove automatically identifies the appropriate power supply (USB or external power), eliminating the requirement for prior boards' power selection jumper. It also includes the simplest trace for deactivating the auto-reset, as well as a solder jumper for re-enabling it.

Fig 4.2.2(c) Arduino Duemilanove

4) Arduino Diecimila

The key difference in the Arduino Diecimila is that it may be reset from the computer rather than using the reset button on the board. When supplied by an external supply, the Diecimila employs a low dropout voltage regulator, which reduces the board's power consumption. A resettable polyfuse protects the USB ports on your computer from shorts and surges. It also includes pin headers for the reset and 3.3V lines. Pin 13 has an integrated LED.

Fig 4.2.2 (d) Arduino Diecimila

5) Arduino Mini 04

Two of the pins on this Arduino Mini have changed. The third pin changed to reset and the fourth pin changed to ground instead of being disconnected. These boards bear the designation "Mini 04". There are still Arduino Serial, Arduino Serial v2.0, Nano 3.0, N 2.x, Serverino(S3V3), Arduino Stamp 02, Mini USB adapter 03, Mini USB Adapter, and Arduino Bluetooth available.

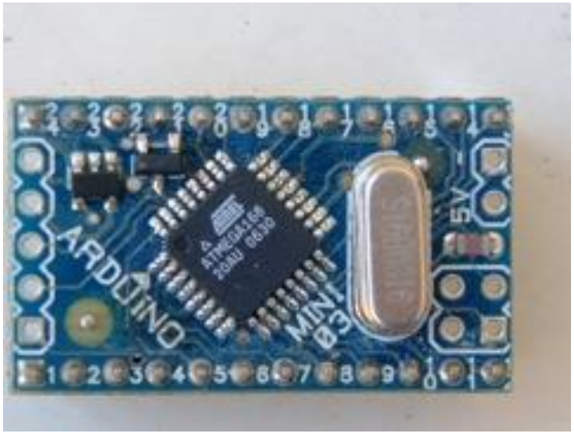


Fig 4.2.2(e) Arduino Mini 04

6) Arduino Fio**:**

A wireless node Arduino designed for application. Contains a battery charging circuit, a connector for a LiPo battery, and a header for an XBee radio.

Fig 4.2.2 (f) Arduino Fio

Arduino	Processor	Flash KiB	EEPROM KiB	SRAM KiB	Digital I/O pins	...with PWM	Analog input pins	USB Interface type	Dimensions inches	Dimensions mm
Diecimila	ATmega168	16	0.5	1	14	6	6	FTDI	2.7" x 2.1"	68.6mm x 53.3mm
Duemilanove	ATmega168/328P	16/32	0.5/1	1/2	14	6	6	FTDI	2.7" x 2.1"	68.6mm x 53.3mm
Uno	ATmega328P	32	1	2	14	6	6	ATmega8U2	2.7" x 2.1"	68.6mm x 53.3mm
Mega	ATmega1280	128	4	8	54	14	16	FTDI	4" x 2.1"	101.6mm x 53.3mm
Mega2560	ATmega2560	256	4	8	54	14	16	ATmega8U2	4" x 2.1"	101.6mm x 53.3mm
Fio	ATmega328P	32	1	2	14	6	8	None	1.6" x 1.1"	40.6mm x 27.9mm
Nano	ATmega168 or ATmega328	16/32	0.5/1	1/2	14	6	8	FTDI	1.70" x 0.73"	43mm x 18mm
LilyPad	ATmega168V or ATmega328V	16	0.5	1	14	6	6	None	2" ø	50mm ø

Fig 4.2.2(g) Different types Of ARDUINO with their Configuration

4.2.3:- Arduino UNO

Arduino Uno is a microcontroller board based on the ATmega328(datasheet). It has a 16 MHz quartz crystal, 6 analogue inputs, 14 digital input/output pins (of which 6 can be used as PWM outputs), a USB port, a power jack, an ICSP header, and a reset button. It comes with everything required to support the microcontroller; to use it, just plug in a USB cable, an AC-to-DC adapter, or a battery to power it. The FTDI USB-to-serial driver chip is not used by the Uno, which makes it different from all preceding boards.

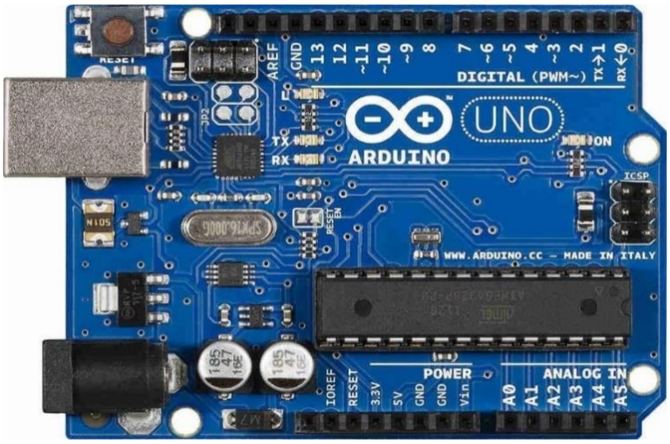


Fig 4.2.3 Arduino UNO

Instead, it has an Atmega8U2 that has been configured to act as a USB-to-serial converter. Uno is a future edition of Arduino, and its name in Italian means one. Moving forward, the Uno and version will serve as the standard versions of Arduino. The Uno is the most recent in a line of Arduino boards and serves as the platform's reference model. For a compromise with earlier models, see the index of Arduino boards.

4.2.3.1:- Components of Arduino UNO

We will cover each component in detail.

1. ATmega328 microcontroller, a single-chip member of the ATmel family. It has 8-bit processor code. Memory, an analog-to-digital converter, SPI serial ports, I/O lines, registers, a timer, internal and external interrupts, and an oscillator are all integrated into the device.
2. The In-Circuit Serial Programming (ICSP) pin enables the user to upload firmware to the Arduino board.
3. Power Indicator - LED ON status indicates that power is activated. When the power is off, the LED will not light up.
4. Digital I/O Pins - Digital pins are HIGH or LOW. Pins numbered D0-D13 are digital pins.
5. TX and RX LEDs - successful data flow is the lighting of these LEDs.
6. AREF- The Analog Reference (AREF) pin is used to provide a reference voltage to the Arduino UNO board from an external power source.
7. Reset Button - This is used to add a reset button to the connection.
8. USB - This can be used to connect the card to a computer. This is essential for programming the Arduino UNO board.
9. Crystal Oscillator - The frequency of the crystal oscillator is 16MHz, making the Arduino UNO a powerful board.
10. Voltage regulator - The voltage regulator changes the input voltage to 5V.
11. GND- ground pins. The ground pin acts as a zero-voltage contact.
12. in- This is the input voltage.

13. Analog Pins - Analogue pins are those with the letters A0 through A5. The analogue pins' purpose is to read the analogue sensor connected to them. Additionally, it can function as GPIO (General Purpose Input Output) pins.

4.2.3.2:- Specifications

Parameters-	Values-
Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage	7-9V
Digital I/O Pins	14
Analog Input Pins	6
DC Current per I/O Pin	40mA
DC Current for 3.3V Pin	50mA
Clock Speed	16MHz

4.2.3.3:- External Power

The Arduino Uno is powered by a USB connection or an external power supply. The power source is selected automatically. External (non-USB) power can come from either an AC-DC adapter (wall heater) or a battery. The adapter can be connected by connecting the middle 2.1mm positive connector to the power connector of the card. The battery wires can be connected to the GND and Vin pins of the POWER connector. The card can work with an external voltage of 6-20 volts. However, if the supply is below 7V, the 5V pin may supply less than five volts and the board may be unstable. If you use a voltage regulator above 12V, it may overheat and damage the board. The recommended voltage range is 7-12 volts.

The power cords are as follows:

• VIN, the input voltage of the Arduino board when using an external power supply (as opposed to 5 volts from USB or other regulated power supply). You can supply voltage through a pin, or if you supply voltage through an electrical connector, you can access it through this pin.

• 5V, regulated power supply used to power the microcontroller and other board components. It can either come from the OS via an internal regulator, or it can be powered via USB or another regulated 5V power supply.

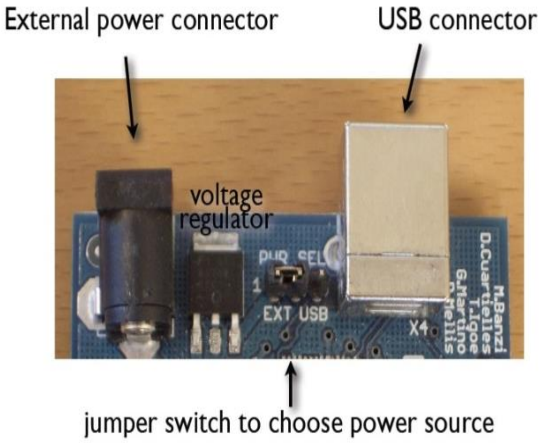


Fig 4.2.3.2(a) Power Pin

Fig 4.3.3.2(b) Power Adaptor

4.3 GSM (Global System for Mobile communication)

The SIM800L GSM/GPRS module is a miniature GSM modem. This GSM modem is a plug-and-play quad band GSM modem with a high degree of flexibility for direct and simple connection to RS232. has an integrated TCP/IP stack and supports functions including voice, data/fax, SMS, and GPRS.

Fig 4.3 SIM800L

4.3.1:- SPECIFICATIONS

4.3.1.1:- Specifications for Data

1. GPRS class 10: maximum downlink speed of 85.6 kbps
2. PBCCH support
3. Coding schemes CS 1,2,3,4
4. CSD up to 14.4 kbps
5. USSD
6. Non transparent mode
7. PPP-Stack

4.3.1.2:- Specifications for the SMS

1. MO and MT point-to-p
2. SMS cell broadcast
3. Text and PDU mode

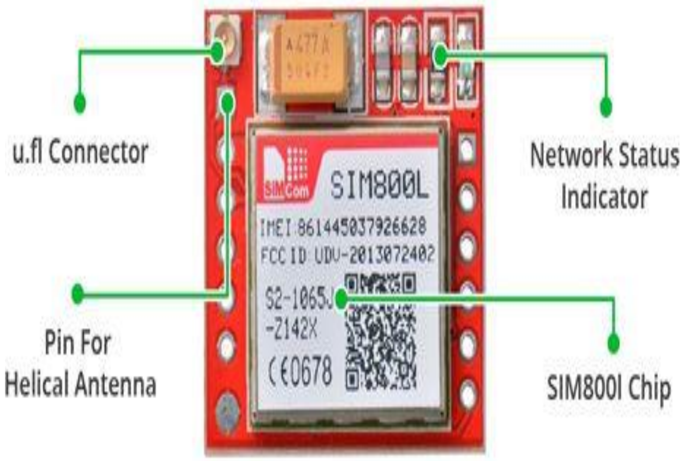


Fig 4.3.1 SIM Holder Chip

4.3.2:- Power Supply

Use AC – DC Power Adaptor with following ratings

1. DC Voltage : 12V
2. DC Current : 1A
3. Polarity : Centre +ve & Outside –ve
4. Current Consumption in normal operation 250mA, can rise up to 1Amp while transmission.

4.3.3:- HARDWARE OVERVIEW

A SIM800L GSM cellular chip from Simcom powers the module. Since the chip's operational voltage spans from 3.4V to 4.4V, direct LiPo battery supply is a perfect fit for it. It is a great option for projects with restricted area because of this. The SIM800L GSM chip's data pins, including those required for UART communication with the microcontroller, are all broken off to 0.1″ pitch headers. The module has automated baud rate detection and supports baud rates between 1200 and 115200 bps.

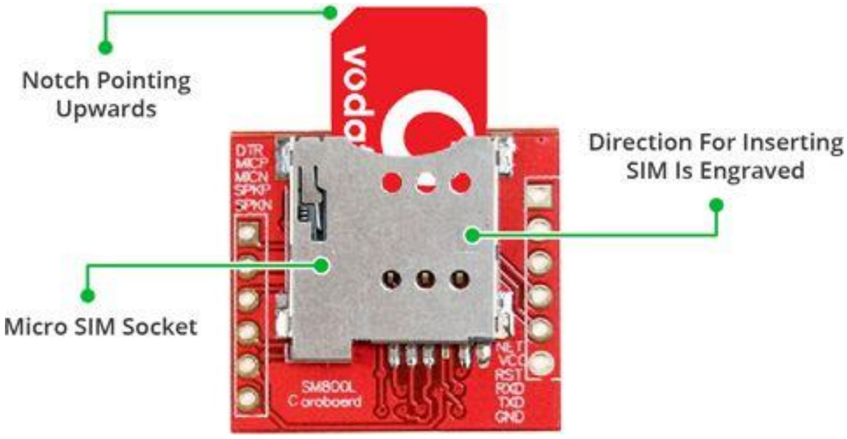


Fig 4.3.3 Pin Description

connect to the network, the module needs an outside antenna. Consequently, the module typically comes with a solderable helical antenna. If you want to keep the antenna away from the board, the board also offers a U.FL connector.

4.4:- IR TRANSMITTER AND RECEIVER

4.4.1:- INTRODUCTION TO IR SENSOR OR INFRARED SENSOR

IR technology serves a variety of functions in both daily life and other sectors. For instance, TVs employ an IR sensor to decipher the signals sent by a remote control. The key advantages of IR sensors are their low power consumption, straightforward construction, and practical functionality. The human eye is not capable of seeing IR waves. The visible and microwave portions of the electromagnetic spectrum contain IR radiation. These waves typically have wavelengths between 0.7 m and 1000 m. The three areas of the infrared spectrum are near-infrared, mid-infrared, and far-infrared. The near infrared zone has wavelengths between 0.75 and 3 m, the mid-infrared region has wavelengths between 3 and 6 m, and the far infrared sector has wavelengths more than 6 m.

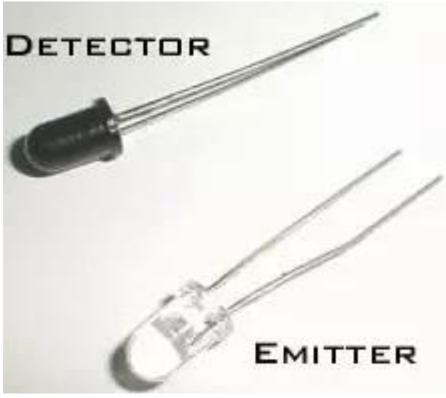


Fig 4.4.1 IR Tx and Rx

4.4.2:- DESCRIPTION

The IR TX-RX pair refers to this infrared transmitter and receiver. The IR transmitter and receiver have various colours. However, there are certain pairs that seem exactly alike or even have the opposite colours, making it impossible to tell the difference between TX and RX visually. In the event that you need to use a multimeter to tell them apart. IR-tuned pair of infrared LED and photo diode devices. These sensors can be used for robotics, pulse oximeters, and other things. This sensor can be used to detect reflective white/silver strips, obstacles, flames, and other things.

4.4.3:- TYPES OF INFRARED SENSOR

Active and passive infrared sensors are the two categories into which they fall.

4.4.3.1:- Active IR Sensor

The transmitter and receiver are both a part of this active infrared sensor. The light-emitting diode is employed as a source in most applications. A non-imaging infrared sensor is an LED, but an imaging infrared sensor is a laser diode.

These sensors operate using energy radiation that is both received and detected. Additionally, it can be processed by getting the required data using a signal processor. Reflectance and break beam sensors are the ideal illustrations of this active infrared sensor.

4.4.3.2:- Passive IR Sensor

The passive infrared sensor includes detectors only but they don't include a transmitter. These sensors use an object like a transmitter or IR source. This object emits energy and detects through infrared receivers. After that, a signal processor is used to understand the signal to obtain the required information.

The best examples of this sensor are pyroelectric detector, bolometer, thermocouple-thermopile, etc. These sensors are classified into two types like thermal IR sensor and quantum IR sensor. The thermal IR sensor doesn't depend on wavelength. The energy source used by these sensors is heated.

Thermal detectors are slow with their response and detection time. The quantum IR sensor depends on the wavelength and these sensors include high response and detection time. These sensors need regular cooling for specific measurements.

4.4.4:- WORKING:

Any movement can be detected by an IR-based security alarm circuit, which then sounds the alert. This circuit is highly helpful in houses, banks, stores, and other restricted places where a movement-alert alarm is required. This circuit's foundation is an infrared sensor, in which an infrared beam continuously falls on a photodiode. When this infrared beam breaks due to any movement, an alert is set off.

An IR LED and a photodiode make up an IR sensor; the IR LED emits IR radiation, and the photodiode picks up the radiation. When light shines on a photodiode, the voltage across it changes. A voltage comparator, such as the LM358 detects this voltage change and produces output as necessary. [Check the IR Sensor Circuit as well].

We have positioned the IR LED in front of the photodiode in this IR-based security alarm circuit so that IR light can fall directly on the photodiode. Buzzer begins to beep and IR rays stop falling on the photodiode whenever something enters this beam.

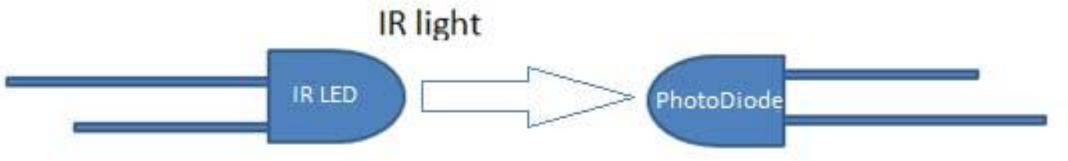


Fig 4.4.4 IR LED and Photodiode

Since the buzzer is attached to a 555 timer operating in monostable mode, the buzzer ends abruptly after a while. This type of alarm can also be constructed using laser light (like the Laser Security Alarm Circuit), however using an IR sensor has the advantage that laser light is visible while IR light is invisible. Despite the fact that both are advantageous and vary in scope.

4.4.5:- SPECIFICATIONS:

1. IR TX-RX size: 5mm diameter package
2. IR LED current rating: 30mA nominal, 600mA pulse loading at 1% duty cycle
3. IR LED wavelength: 940Nm
4. Photodiode peak response wavelength: 940nM

4.4.6:- Applications

Based on the applications, IR sensors are divided into many types. a some of the typical uses for several sensor kinds. Multiple motors' speeds can be coordinated using the speed sensor. Industrial temperature control uses the temperature sensor. The Ultrasonic sensor is used for measuring distance, whereas the PIR sensor is utilised for automatic door opening systems.

The key applications of the infrared sensors mainly include the following.

- Meteorology
- Climatology
- Photo-bio modulation
- Analysis of Water

4.5:- COMPARATOR WITH IC LM358

4.5.1:- LM358 IC

Two independent, low power, dual-channel operational amplifiers with high gain are found in the LM358. It can manage current up to 20mA per channel and DC supply voltage ranging from 3V to 32V. A dual power supply is not necessary because it is a single supply, which simplifies design and simple application use. Its single supply does not provide a negative voltage supply, which is a downside. The output won't be able to go below 0 volts as a result.

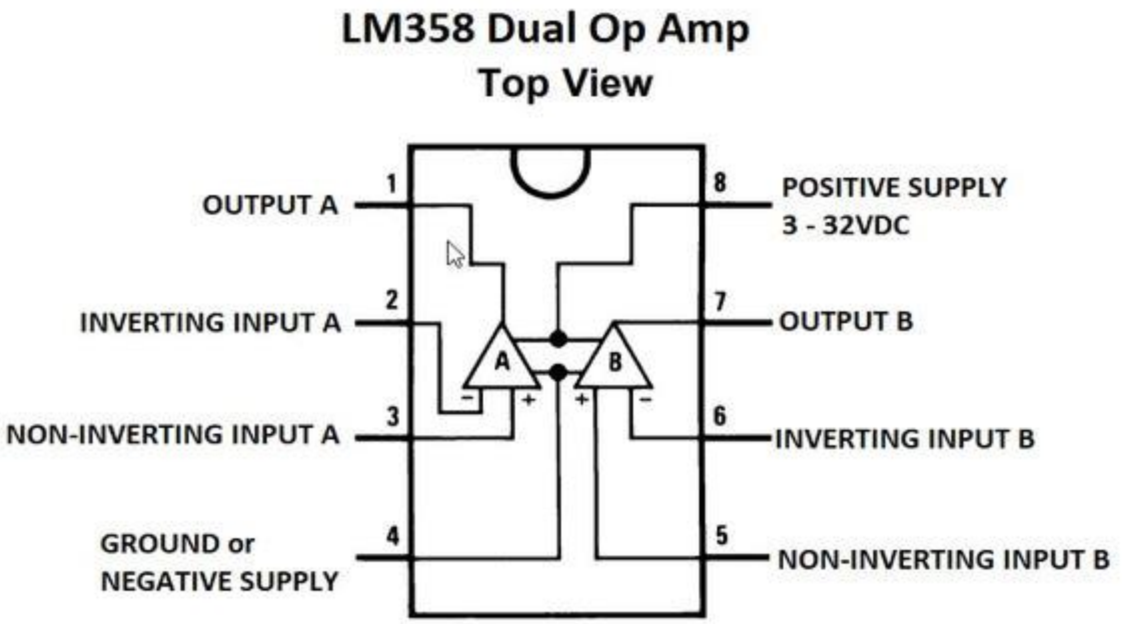


Fig 4.5.1 Pin Description of LM358

Wide supply ranges, low supply current drain, independence from supply voltage, wide unity-gain bandwidth, input common-mode voltage range including ground, low input bias, open-loop differential voltage gain, internal frequency compensation for unity gain, and many other incredible features are just a few of the amazing characteristics of the LM-358. Operational amplifier (Op-amp) circuits, transducer amplifiers, DC gain blocks, comparator circuits, active filters, current loop transmitters for 4 to 20 mA, and other applications are just a few of the uses for the LM 358.

4.5.2:- OPERATIONAL AMPLIFIER

A signal conditioner, DC amplifier, filter, and device for use with external feedback elements like capacitors and resistors between its output and input terminals are all examples of operational amplifiers, or op-amps for short. Op-amps are DC coupled high gain voltage amplifying devices. The op-amp can be employed as a differential amplifier, integrator, or summer depending on the feedback configuration it has—whether resistive, capacitive, or both.

4.5.3:- LM358 as Comparator

A comparator in electronics compares two voltages or currents and produces a digital signal that indicates which is greater. It features one binary digital output that is low when V- is greater and high when V+ is greater. It also has two analogue input terminals, V+ and V-. The LM358 comparator IC has two operational amplifiers (Op-Amp) incorporated into it, making it a single integrated circuit with two comparators. The Vcc and GND pins of the LM358 IC must be connected to a power source in order to activate the IC before using it as a comparator. The Op-Amp will then require two input voltages for comparison. The Op-Amp can now provide an output for us.

4.5.3.1:- Digital Dark Sensor Using LM358

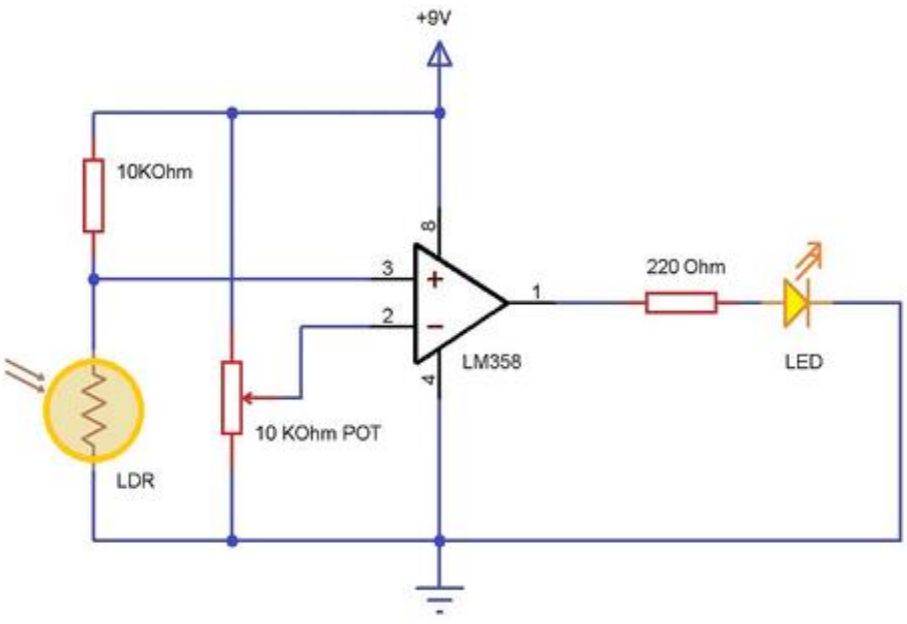


Fig 4.5.3.1 Circut Diagram Digital Dark Sensor

The resistivity of the LDR, an electrical component, changes as light is shined onto it. When no light is incident on it, the LDR offers the most resistance, providing a signal across the non-inverting terminal of the Op-amp that is used to turn on the LED when darkness is detected. When light is incident on it, the resistivity drops, and when no light is incident on it, the LDR offers the highest resistance. If the LED stays on even when no darkness is present, you can turn the 10K potentiometer preset until the LED turns OFF to adjust the circuit's sensitivity.

4.5.3.2:- 12V Battery Monitoring Circuit of Comparator

Dual Op Amp IC LM358 is used in the battery level indicator circuit to track the three critical battery levels: low, normal, and full.

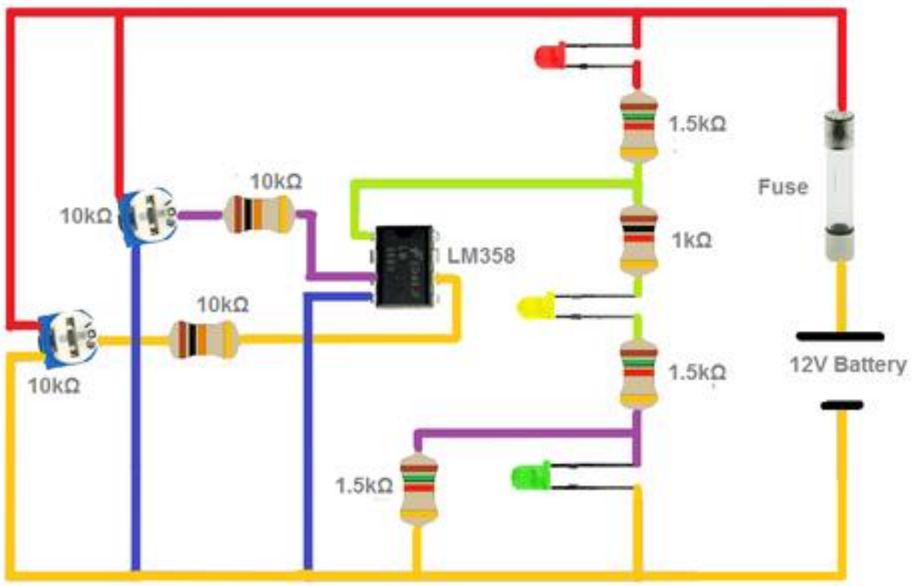


Fig 4.5.3.2 12V Battery Monitoring Circuit

The circuit keeps track of the 12V battery voltage and shows the battery's charge state, with an LED lighting up to indicate low voltage, normal voltage, or full voltage. The red/yellow and yellow/green LEDs' ON/OFF values are changed by the potentiometer. For instance, the green LED activates at 12V and the red LED at 11V. When the battery voltage is still greater than 11V and less than 12V, the yellow LED continues to glow. This circuit can be adjusted slightly to monitor voltages such as 4 volts, 6 volts, 24 volts, and others.

4.6:- LIGHT DEPENDENT RESISTOR(LDR)

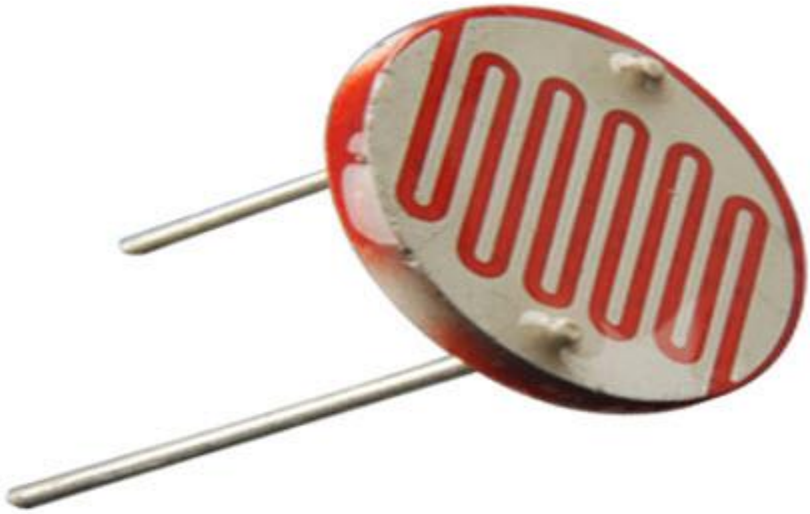


Fig 4.6 Light Dependent Resistor(LDR)

4.6.1:- LIGHT DEPENDENT RESISTOR LATENCY

The key characteristic of an LDR is latency, which is the time it takes for the components to react to changes. This property is therefore especially important when building a circuit. The LDR doesn't reach its final value for a new light level for a noticeable period of time after any changes in a light level. Because of this, the light-dependent resistor is not a superior option in situations when light values change rather quickly. When the light changes happen over a predetermined amount of time, they are more than enough.

The pace at which the resistance varies is what determines the resistance recovery rate. When the light is turned on after total darkness, the LDR typically responds in a few tens of milliseconds; however, when the light is turned out, it can take up to a second. LDR parameters are often stated as the dark resistance after a certain amount of time, such seconds, in the component's datasheet. The values that are usually cited include one for one second and another for five seconds. These numbers indicate the delay of the resistor.

4.6.2:- DESCRIPTION

LDRs, or light dependent resistors, are very helpful in circuits for light and dark sensors. This LDR has a reduction in resistance as light intensity increases. Use a light dependent resistor when a device or circuit needs to be turned on or off automatically depending on the amount of light or darkness. The metal package that houses the light detector, which has a lens and an epoxy seal, is only 12 mm in diameter.

4.6.3:- LDR Symbols:

The LDR symbol, which is mostly based on the resistor sign but displays light rays in the shape of arrows, is used in electronic circuits. This is similar to how arrows are used to represent the light falling on phototransistor and photodiode circuit symbols to represent these types of components. Below are the symbols for the LDR circuit.

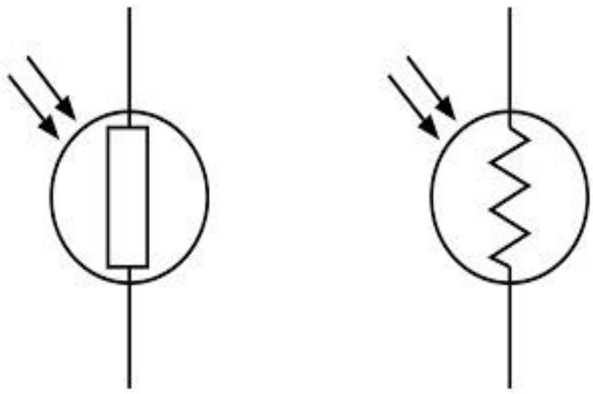


Fig 4.6.3 LDR Symbols

4.6.4:- TYPES OF LDR:

1. Intrinsic
2. Extrinsic

4.6.4.1:- INTRINSIC TYPE LDR

When incident light with sufficient energy strikes this type of photoresistor, electrons gain that energy and get excited, and some of them go to the conduction band. This type of photoresistor is made with pure semiconductor without any doping.

4.6.4.2:- EXTRINSIC TYPE LDR

This type creates a photoresistor by using a doped semiconductor, which implies that some impurities, such phosphorus, are mixed in with the semiconductor. Extrinsic light dependent resistors are often made for light with longer wavelengths and a preference for infrared.

4.6.5:- CHARACTERISTICS OF LDR

The light-dependent resistor reacts to light very quickly. When the light is greater, the resistance is lower, which indicates that the resistance value for the LDR will be drastically reduced to below 1K as the light intensity rises.

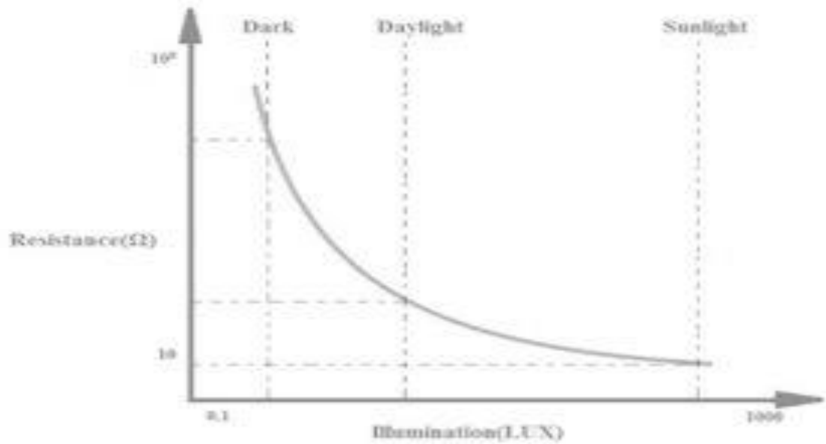


Fig 4.6.5 LDR Characteristics

When an LDR is exposed to light, the resistance increases; this is known as dark resistance. Conversely, when the resistor is exposed to darkness, the resistance decreases. Any device that absorbs light will have significantly less resistance.

The light intensity will increase and the current flow will begin to increase if a stable voltage is applied.Therefore, the characteristics between resistance and illumination for a particular LDR are shown in

the diagram below. Since LDRs are not linear devices, the wavelength of the light that strikes them causes a change in their sensitivity. Because it depends on the material employed, some types of photocells are not at all sensitive to a particular range of wavelengths.

When light enters a photocell, the resistance changes within 8 milliseconds from 8 to 12 and takes a few extra seconds to return to its initial value after the light has been turned off. Therefore, this is referred to as a resistance recovery rate. This attribute is applicable to audio compressors.

These resistors also have poor phototransistor and photodiode responsiveness. A photocell is a passive device without a PN junction that is used to convert light to electricity, whereas a photodiode is a semiconductor device with a PN junction that is used to do so.

4.6.6:- CONSTRUCTION OF LDR

The zig-zag shape of the LDR is made of photosensitive semiconductor materials such as cadmium sulphides, lead sulphides, lead selenides, indium antimonides, or cadmium selenides. As you can see in the figure, metal contacts are positioned on both ends of the LDRs to help connect them.

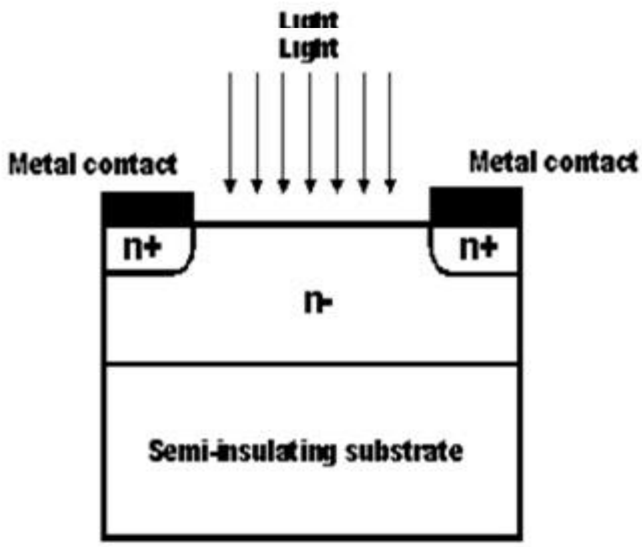


Fig 4.4.6 LDR Construction

Now the transparent coating is applied on top so that the zig-zag photosensitive material gets provided and as the transparent the LDR will be able to capture light from the outer environment for its working.

4.6.7:- WORKING

It operates under the theory of photo conductivity. Every time light shines on a photoconductive material, it absorbs the energy and the excited electrons in the valence band go to the conduction band, increasing the conductivity in proportion to the intensity of the light. Additionally, incoming light energy must be higher than band gap energy for the valence band electrons to be activated and move into the conduction band. Around 1012 ohm is the LDR's maximum resistance in the dark, and as light levels rise, this resistance falls.

4.6.8:- FEATURES

- It have High Reliability
- It have Heat Proof Construction
- It have High Power
- It have Wide spectral response
- It have Low cost
- It have Wide ambient temp range

4.6.9:- LDR SPECIFICATIONS

- Maximum power dissipation, maximum working voltage, peak wavelength, dark resistance, etc. are some of the important LDR specifications. The specs' values are listed below.

- Maximum power dissipation is 200mW
- The maximum voltage at 0 lux is 200V
- The peak wavelength is 600nm
- Minimum resistance at 10lux is 1.8kΩ
- Maximum resistance at 10lux is 4.5kΩ

- Typical resistance at100lux is 0.7kΩ
- Dark resistance after 1 sec is 0.03MΩ
- Dark resistance after 5 sec is 0.25MΩ

4.6.10 :-APPLICATOINS :

1. It is typically used to determine whether or not light is present.
2. Employed in automatic lights that turn on and off in response to light.
3. Simple smoke detector , alarm, clock with automatic light .
4. Optical circuit design .
5. Laser based security system.
6. Camera light meters.
7. Clock radios.

4.7:- RELAY DRIVER

A relay driver IC is an electro-magnetic switch that will be utilized whenever we wish to use a low voltage circuit to turn a light bulb linked to a 220V power source ON and OFF. The current required to run the relay coil is greater than that which can be supplied by various integrated circuits such as Op-Amps, etc. Relays have unique qualities and are being replaced by solid-state switches, which are more powerful than solid-state devices. Relays are distinguished by their high current capacity, ESD resistance, and drive circuit separation. Relays are components that allow a low-power circuit to regulate signals or switch high current ON and OFF while electrically isolating the controlling circuit.

The Required Components

- Zener Diode
- 6-9V Relay
- 9V Battery or DC Power Supply
- 2N2222 Transistor
- 1K Ohm Resistor
- Second Input Voltage Source

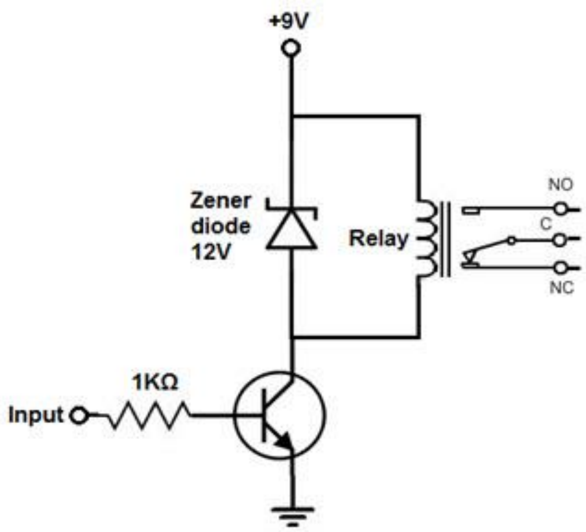


Fig 4.7 Relay Driver

4.7.1:- Driver Circuit

Only tens of MA of current can be delivered by a standard digital logic output pin. External components can demand hundreds of MA and the same voltages, including high-power LEDs, motors, speakers, light bulbs, buzzers, solenoids, and relays. A transistor-based driver circuit is used to amplify current to the necessary levels for small DC devices to be controlled. The transistor behaves like a high-current switch controlled by the lower current digital logic signal if the voltage and current levels are within the ideal range. Sometimes a discrete BJT is used in place of a MOSFET transistor, especially in older or low voltage circuits, as illustrated in the diagram below.

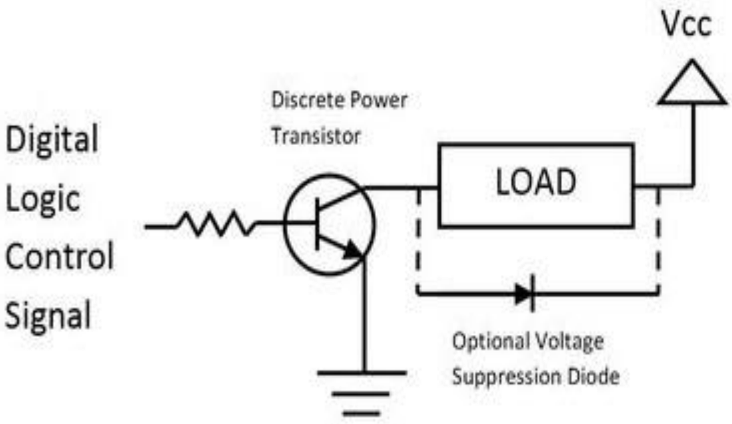
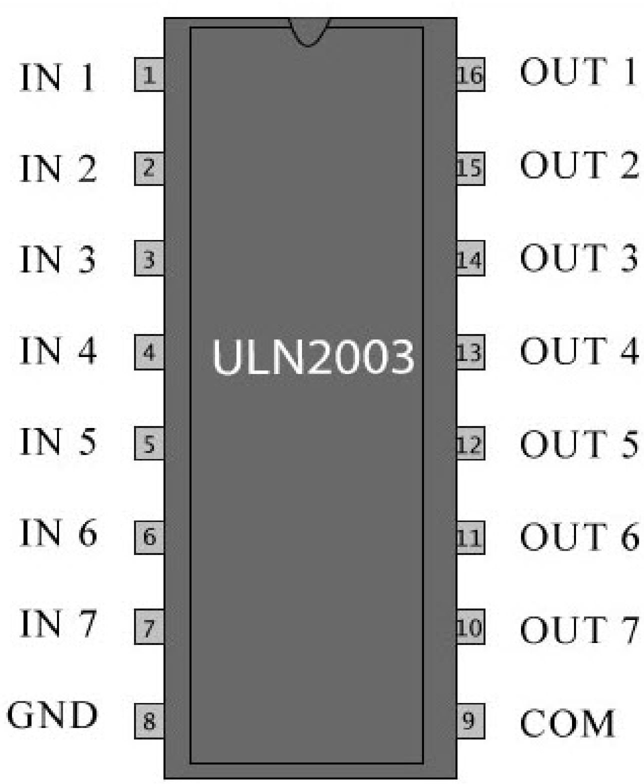


Fig 4.7.1 Driver Circuit

4.7.2:- Relay Driver IC ULN2003

The high voltage and current Darlington array ULN2003 IC relay driver consists of seven open collector Darlington pairs with common emitters. Two bipolar transistors are arranged in a pair of Darlingtons. This IC is a member of the ULN200x IC family, which has numerous variants that interact with different logic families. For use with 5V TTL and CMOS logic devices, use the ULN2003 IC. These ICs are utilised as relay drivers as well as line drivers, display drivers, and many other types of loads. Stepper motors are frequently driven by this IC. The ULN2003 pairs of Darlington are rated at 500 mA and can handle a peak current of 600 mA. For the purpose of dissipating voltage spikes while driving inductive loads, each driver also includes a suppression diode.



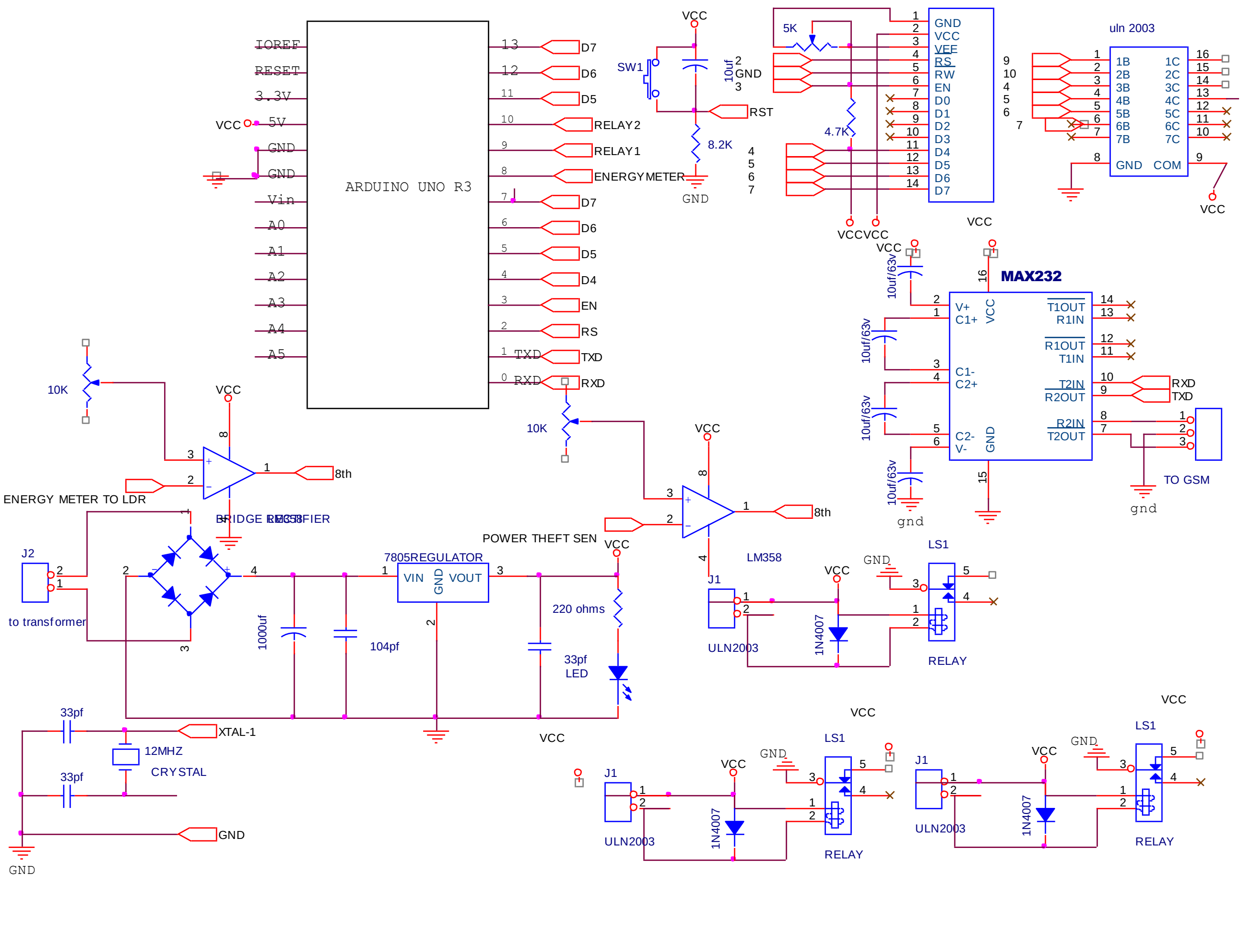
4.2.7 ULN2003

For use with a three-phase solid-state relay system, this project is created. It includes three single-phase units, with a power TRIAC and RC snubber network controlling each phase separately to enable zero-voltage switching (ZVS).

Each phase uses an opto-isolator to receive switching signals from an 8051 family microcontroller. Loads are linked in series with a set of TRIACS that are driven by an opto-isolator. To make sure that the load is switched on at zero cross of the supply waveform, the microcontroller is built to create output pulses after a zero voltage pulse.

CHAPTER 5: WORKING AND CONSTRUCTION

5.1:- WORKING OF THE HARDWARE PART



GND

Fig 5.1 Circuit Diagram of the Project

“A Novel Smart Energy Meter With Power Theft Control System” consists of hardware and software parts. Hardware consists of energy meter connect with an Arduino UNO Board so that the users can monitor their power consumption anytime and from anywhere. And coming to software parts , all the program is codded to the ARDUINO UNO by using the Arduino IDE software which was programmed in C language.

The main components present in the prototype are Energy meter, GSM module , LDR sensor, ARDUINO UNO , Comparator, Relay Driver. Firstly to run the AC static single-phase meter the input of 230V AC is given to the input terminals of the meter. The output phase terminal of the meter is connected to the load-1 and from load-1 to load-2 in parallel combustion. And output neutral terminal of the meter is connected to the output terminal of the realy-1 and realy-2. The load-2 neutral is connected to 'NC' (Naturally Continuous) terminal of the Realy-2. And neutral terminal of load-1 is connected to the 'NO' (Naturally Open) terminal of Relay-1. This relays acts as an switch for connecting and disconnecting of loads when a user command is processed via SMS to the Arduino UNO With help of GSM module.

The Arduin UNO is provided with 12v-1A input with the help of the adaptor. The GSM Module is provided with 12V and the O/P of the GSM is connected to PIN 0 and PIN 1 of Arduino UNO. The Arduino UNO is codded as the user should register with his mobile number at the time of the installation of the Energy Meter and the Arduino UNO stores the data of the user. And with the successful registration of the mobile number the user is able to control the loads with the help of commands via SMS with the registered mobile number.
*1# -- For turning ON the Load-1
*3# -- For turning ON the Load-2
*2# -- For turning OFF the Load-1
*4# -- For turning OFF the Load-2

The Units consumed by the user is known by the pulse of the LED which is present in the Energy Meter. The Pulse of the meter is recorded with the help of LDR, The output of the LDR is connected to the Comparator. The comparator is powered with 5V which is provided from the Arduino Board and the o/p of the comparator is connected to the PIN 2 and PIN 8 of the UNO board . The Arduino records the units consumed as the LED is blinked. For every blink of the LED the UNO board increment the units consumed value and it is costed 2/- per unit which was coded in the Arduino UNO board. The user can get the real time data of power consumed and the cost by sending a Command via SMS from the registered mobile number.
*S# or *s# -- For the units and cost of the power consumed

The Power Theft sensor is constructed with the help of IR Transmitter and IR Receiver. The IR Transmitter and IR Receiver are connected the input and output terminals of the energy meter which is covered by the cap and is sealed. The input of the IR-TX and IR-RX is connected to the comparator. If the user try's or attempts to break the seal and open the cap the IR-TX an IR-RX circuit breaks and an automated message is send to the substation about the Power Theft including the meter number via SMS and the Buzzer which is connected to PIN 13 of the UNO Board blows and warns the User.

5.2:- SOFTWARE PART

5.2.1:- SOFTWARE REQUIRED

The following steps to download and upload the ARDUINO IDE:

1. Download Arduino IDE

   From the official website of Arduino, get the most recent version of the Arduino IDE software. Choose software that works with the Windows, iOS, or Linux operating system that you are using. Unzip the file once it has finished downloading.

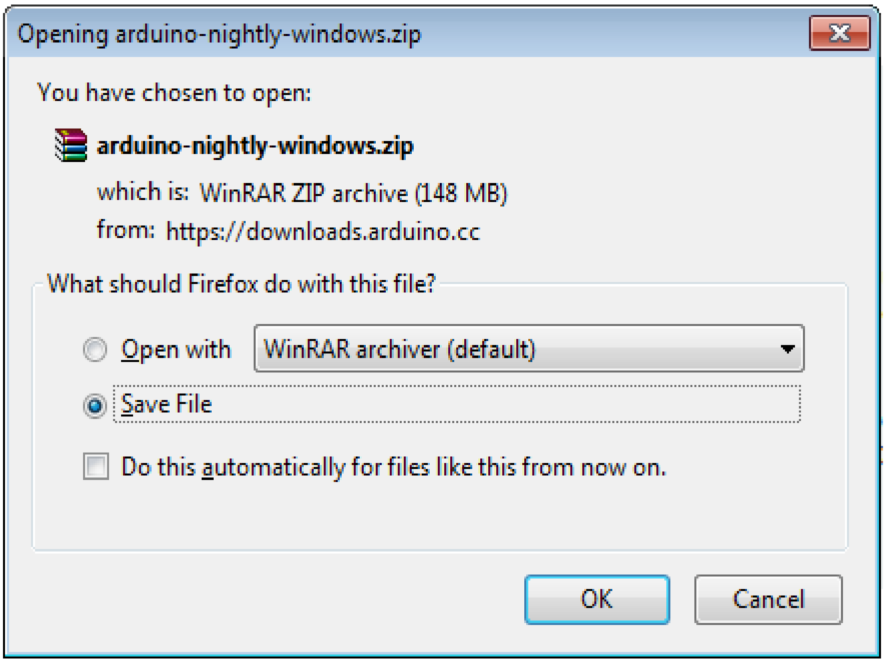


Fig 5.2.1(a) Downloading of the IDE

2. Launch Arduino IDE

   Locate the application icon with an infinity label (application.exe) after unzipping the folder. To launch the IDE, double-click the icon.

3. Create a new project

   Create a new project once the software has launched. Select "File" and then "New" to start a new project.

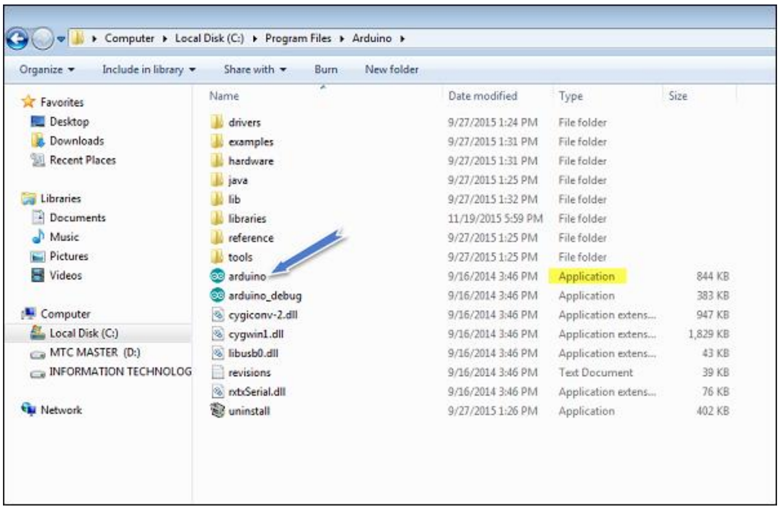


Fig 5.2.1(b) Lunching Arduino

4. Select the Arduino board

   Choose the appropriate Arduino board name that corresponds with the board connected to your computer in order to prevent any errors while uploading your programme to the board. Navigate to “Tools”, choose “Board”, and then choose your board.

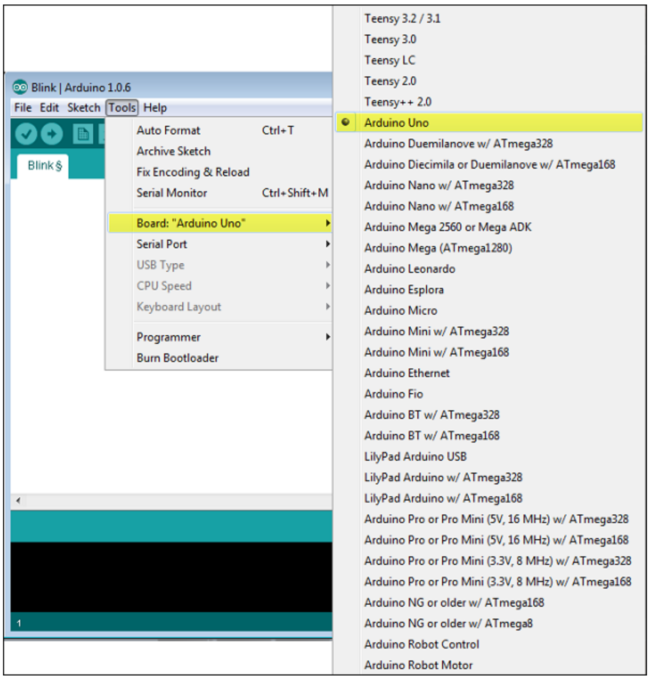


Fig 5.2.1(c) Selecting the Arduino Board

5. Select the serial port
   Choose the Arduino board's serial device. Navigate to “Tools” and select “Serial Port”.

6. Upload the program to the Arduino board
   Select "Upload" from the environment's menu. Wait for a few seconds to notice the board's RX and TX LEDs flashing. The word "Done uploading" will show up in the status bar if the upload is successful.

5.2.2:- SOURCE CODE

```
#include <LiquidCrystal.h>
#include <stdio.h>
#include <SoftwareSerial.h>
SoftwareSerial mySerial(A0, A1);
LiquidCrystal lcd(10, 11, 4, 5, 6, 7);
unsigned char rcv,count,gchr,gchr1,robos='s';
int units=0,amount=0,x=0,xx=10;
char thefts=0;
char pastnumber[11];
char lt[12],ln[13];
char igns='0',alcs='0';
char password[5];
int sti=0;
String inputString = "";         // a string to hold incoming data
boolean stringComplete = false;  // whether the string is complete
int mtr          = 2;
int ir          = 8;
int relay1       = 3;
int relay2       = 12;
int buz       = 13;
int lpgv=0,soundv=0,rtr=0;
int current1=0,current2=0,current3=0,current4=0;
unsigned int cntl=0;
```

```
int rtr1=0;
void okcheck0()
{
  unsigned char rcr;
  do{
      rcr = Serial.read();
    }while(rcr != 'K');
}
void okcheck()
{
  unsigned char rcr;
  do{
      rcr = mySerial.read();
    }while(rcr != 'K');
}
void setup()
{
 Serial.begin(9600);serialEvent();
  digitalWrite(buz,LOW);
   pinMode(relay1, OUTPUT);
   pinMode(relay2, OUTPUT);
   pinMode(buz, OUTPUT);
   pinMode(mtr, INPUT);
    pinMode(ir, INPUT);

  lcd.begin(16, 2);lcd.cursor();
  lcd.print("Energy Meter");
  delay(1500);
  gsminit();
   lcd.clear();
   lcd.setCursor(0,0);
   lcd.print("U:");//3,0
   lcd.setCursor(8,0);
   lcd.print("A:");//10,0
```

```
}
void loop()
{
  if(digitalRead(mtr) == LOW)
    {while(digitalRead(mtr) == LOW);
      units++;
      amount = (units * 2);
      lcd.setCursor(3,0);convertl(units);
      lcd.setCursor(10,0);convertl(amount);
    }
      if(digitalRead(ir) == HIGH)
      {
        digitalWrite(buz,HIGH);
     lcd.setCursor(0,1);lcd.print("power Theft occured at meter no:542046");
   Serial.write("AT+CMGS=\"");
   Serial.write("9553273978");
   Serial.write("\"\r\n"); delay(3000);
   Serial.write("Power Theft occured");//converts(units);
   delay(4000);
   delay(4000);
   Serial.write(0x1A);delay(4000);//delay(4000);
  x=1;
   lcd.setCursor(0,1);lcd.print("                ");
    digitalWrite(buz,LOW);
           }
  if(stringComplete)
    {
          if(inputString[2] == '2' && thefts == 0)
            {xx=xx+10;
             digitalWrite(relay1,HIGH);
            }
          if(inputString[2] == '1' && thefts == 0)
            {xx=xx-10;
             digitalWrite(relay1,LOW);
```

```
            }
          if(inputString[2] == '3' && thefts == 0)
            {xx=xx+10;
              digitalWrite(relay2,HIGH);
             // lcd.setCursor(4,1);lcd.print("ON ");
            }


          if(inputString[2] == '4' && thefts == 0)
            {
              xx=xx-10;
              digitalWrite(relay2,LOW);
            }
              if(inputString[2] == '5' && thefts == 0)
            {
              xx=xx+10;
             // lcd.setCursor(4,1);lcd.print("ON ");
            }
          if(inputString[2] == '6' && thefts == 0)
            {
              xx=xx-10;
            }
          if(inputString[2] == 's' || inputString[2] == 'S')
            {
  Serial.write("AT+CMGS=\"");
  Serial.write(pastnumber);
  Serial.write("\"\r\n"); delay(3000);
  Serial.write("Units:");converts(units);
  Serial.write("      Amount:");converts(amount);
  Serial.write(0x1A);delay(4000);delay(4000);
            }
    inputString = "";
    stringComplete = false;
   }
}
```

```
void serialEvent()
{
  while (Serial.available())
        {
         char inChar = (char)Serial.read();
           //sti++;
           //inputString += inChar;
          if(inChar == '*')
            {sti=1;
              inputString += inChar;
            }
          if(sti == 1)
            {
                inputString += inChar;
            }
          if(inChar == '#')
            {sti=0;
              stringComplete = true;
            }
        }
}
int readSerial(char result[])
{
  int i = 0;
  while (1)
  {
    while (Serial.available() > 0)
    {
      char inChar = Serial.read();
      if (inChar == '\n')
         {
          result[i] = '\0';
          Serial.flush();
          return 0;
```

```
        }
      if (inChar != '\r')
        {
         result[i] = inChar;
         i++;
        }
    }
  }
}

void wifiinit()
{
  Serial.write("AT\r\n");                    delay(3000);
  Serial.write("ATE0\r\n");                  okcheck();
  lcd.clear();
  lcd.print("Waiting For");
  lcd.setCursor(0,1);
  lcd.print("Connection");
  do{
     rcv = Serial.read();
    }while(rcv != 'L');

  lcd.clear();
  lcd.print("Connected");
  delay(1000);
}
void gsminit()
{
  Serial.write("AT\r\n");                    okcheck0();
  Serial.write("ATE0\r\n");                  okcheck0();
  Serial.write("AT+CMGF=1\r\n");             okcheck0();
  Serial.write("AT+CNMI=1,2,0,0\r\n");       okcheck0();
  Serial.write("AT+CSMP=17,167,0,0\r\n");    okcheck0();
  lcd.clear();
```

```
  lcd.print("SEND MSG STORE");
  lcd.setCursor(0,1);
  lcd.print("MOBILE NUMBER");
  do{
     rcv = Serial.read();
    }while(rcv != '*');
     readSerial(pastnumber);
  lcd.clear();
  lcd.print(pastnumber);
pastnumber[10]='\0';
    Serial.write("AT+CMGS=\"");
    Serial.write(pastnumber);
    Serial.write("\"\r\n"); delay(3000);
    Serial.write("Mobile no. registered\r\n");
    Serial.write(0x1A);     delay(4000);
}
int gpsgain(char result[])
{
  int i = 0;
  char rcvv;
  while (1)
  {
    while (Serial.available() > 0)
    {
      lp:
      char inChar = Serial.read();
      result[i] = inChar;
      if(result[0] == '$')
        {
          i++;
        }
      if(result[0] != '$')
        {
          i=0;
```

```
        }
      if(i == 5)
        {
         if(result[0] == '$' && result[1] == 'G' && result[2] == 'P' && result[3] == 'R' && result[4] ==
'M' && result[5] == 'C')
          {
            goto lp;
          }
         else
          {
           i=0;
          }
        }
      if(i == 46)
        {
           result[47] = '\0';
           Serial.flush();


lt[0]=result[21];lt[1]=result[22];lt[2]=result[23];lt[3]=result[24];lt[4]=result[25];lt[5]=result[26];
           lt[6]=result[27];lt[7]=result[28];lt[8]=result[29];lt[9]=result[30];lt[10]=result[31];lt[11]='\0';


ln[0]=result[33];ln[1]=result[34];ln[2]=result[35];ln[3]=result[36];ln[4]=result[37];ln[5]=result[38];

ln[6]=result[39];ln[7]=result[40];ln[8]=result[41];ln[9]=result[42];ln[10]=result[43];ln[11]=result[44
];ln[12]='\0';
           return 0;
        }
    }
  }
}

void converts(unsigned int value)
```

```
{
  unsigned int a,b,c,d,e,f,g,h;
      a=value/10000;
      b=value%10000;
      c=b/1000;
      d=b%1000;
      e=d/100;
      f=d%100;
      g=f/10;
      h=f%10;

      a=a|0x30;
      c=c|0x30;
      e=e|0x30;
      g=g|0x30;
      h=h|0x30;

   Serial.write(a);
   Serial.write(c);
   Serial.write(e);
   Serial.write(g);
   Serial.write(h);
}

void convertl(unsigned int value)
{
  unsigned int a,b,c,d,e,f,g,h;

      a=value/10000;
      b=value%10000;
      c=b/1000;
      d=b%1000;
      e=d/100;
      f=d%100;
```

```
      g=f/10;
      h=f%10;
      a=a|0x30;
      c=c|0x30;
      e=e|0x30;
      g=g|0x30;
      h=h|0x30;
   lcd.write(g);
   lcd.write(h);
}
void converts0(unsigned int value)
{
  unsigned int a,b,c,d,e,f,g,h;
      a=value/10000;
      b=value%10000;
      c=b/1000;
      d=b%1000;
      e=d/100;
      f=d%100;
      g=f/10;
      h=f%10;
      a=a|0x30;
      c=c|0x30;
      e=e|0x30;
      g=g|0x30;
      h=h|0x30;
   mySerial.write(a);
   mySerial.write(c);
   mySerial.write(e);
   mySerial.write(g);
   mySerial.write(h);
}
void convertk(unsigned int value)
{
```

```
  unsigned int a,b,c,d,e,f,g,h;
     a=value/10000;
     b=value%10000;
     c=b/1000;
     d=b%1000;
     e=d/100;
     f=d%100;
     g=f/10;
     h=f%10;
     a=a|0x30;
     c=c|0x30;
     e=e|0x30;
     g=g|0x30;
     h=h|0x30;

}
```

CHAPTER 6: RESULT

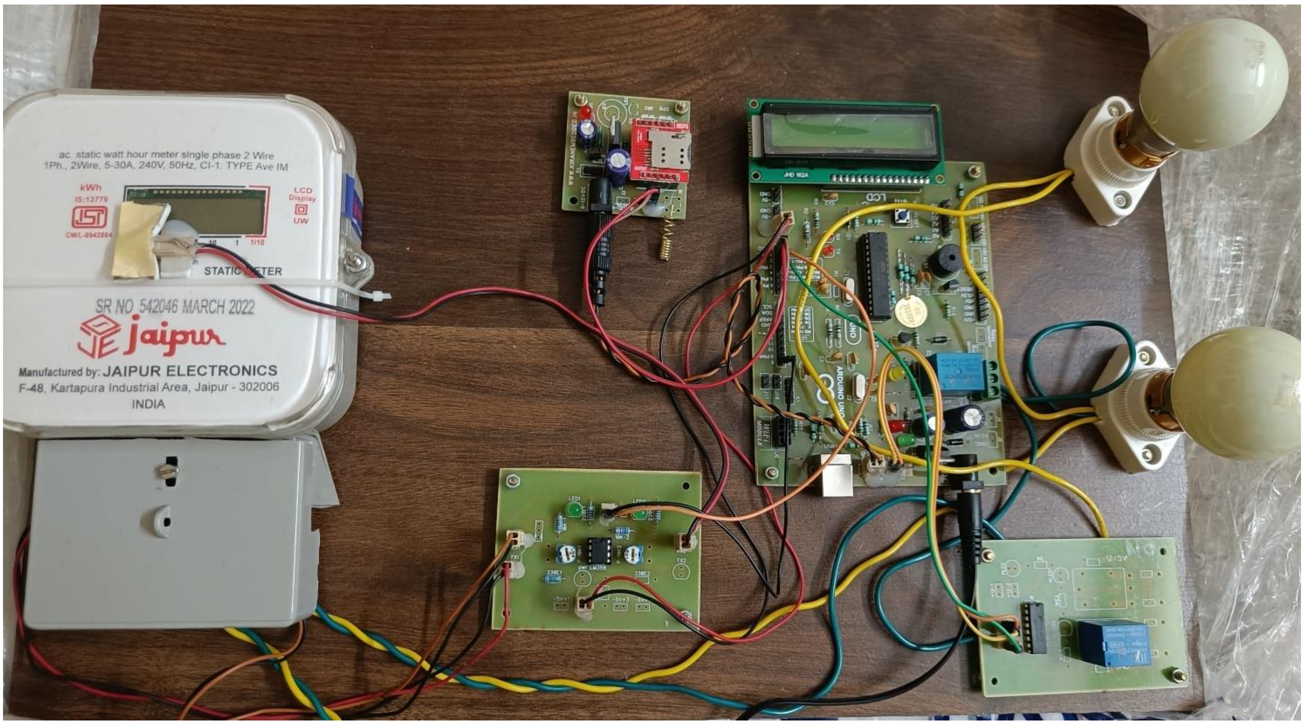


Fig 6 Project Prototype

Above figure is the hardware prototype of “A Novel Smart Energy Meter with Power Theft Control System” . The prototype consists of various components such as Arduino UNO with ATmega328 microcontroller , GSM module, Energy Meter, Comparator, Relay Driver, Loads.

Overall this hardware prototype demonstrates the smart energy meter which provides the real time data to the user about the consumed power and to inform the substation about the attempt of power theft at a particular meter via SMS .

6.1:- MOBILE NUMBER REGISTRATION

At the installation of the meter the user registers with his mobile number via SMS. If the registration is completed the user is notified that the “Mobile No is Registered” via SMS and the users Mobile number is displayed on the LCD of the Arduino UNO.

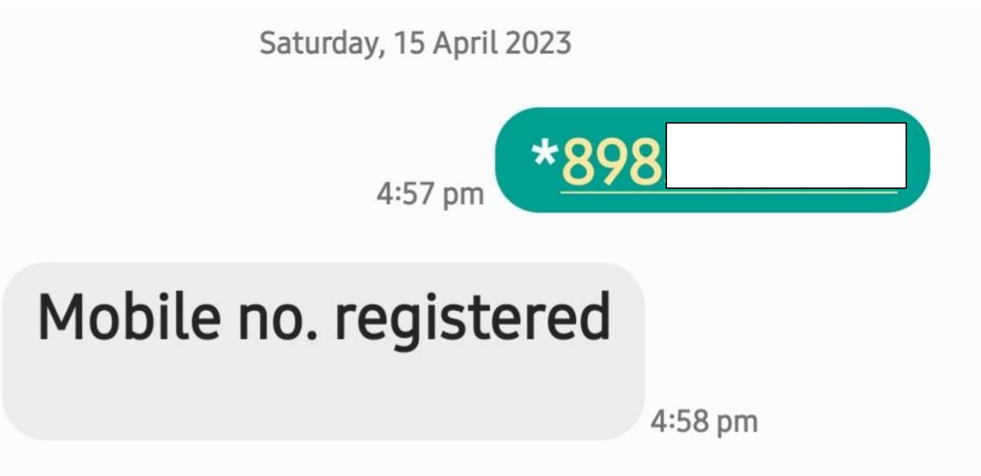


Fig 6.1(a) Registration of mobile Number

Fig 6.1(b) Display of mobile Number on LCD

6.2:- CONTROLLING OF THE LOADS

The loads can be controlled via SMS with a code Message.

*1# -- For turning ON the Load-1

*3# -- For turning ON the Load-2

Fig 6.2(a) Commands for the Turing ON of Loads

*2# -- For turning OFF the Load-1

*4# -- For turning OFF the Load-2

Fig 6.2(b) Commands for the Turing OFF of Loads

6.3:- POWER CONSUMPTION BILL

The consumer can track his daily consumption of power. The consumer is notified with the units burned and the cost .

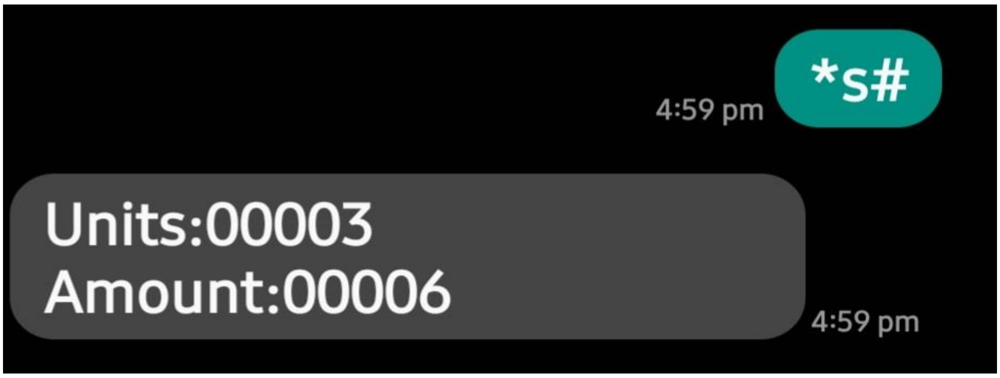


Fig 6.3 Power Consumption Bill

6.4:- POWER THEFT ALERT

If the consumer tries to attempt for the power theft the substation is notified via SMS including the Meter number

Fig 6.4:- Power Theft Notification to the substation

CONCLUSION AND FUTURE SCOPE

Energy meter is a device that measures the amount of electric energy consumed by a residence, a business, or an electrically powered device. As important as it is, present meters do have some drawbacks like power theft, lack of consumer end communication, lack of information to consumers and a way more. To overcome all these drawbacks we came up with a project that can explain the way to implement a smart meter which is used to compute consumed power, connecting and disconnecting loads, communication with end users. It allows the consumer to contact the utility service through mobile and can get to know the information about the usage of the power and price that it is going to cost. In case of power theft, we designed the meter in such a way that it alerts the substation about the theft and also consumer is alarmed. We aimed to evaluate the different steps and procedures that have been taken for obtaining the data readings, load controlling, the power calculations, Arduino coding, and the LCD which provided an attractive display of the units and price. This way a consumer is fully aware of the power consumptions and interruptions. By doing this project, we got the idea of how in general the energy meter works and the importance and advantages it holds.

Smart metering is the quickly becoming the new norm in the power and utility industry. With the capacity to harness and process more and more data, smart meters are becoming more and more advanced and efficient. Our project can be further implemented or enhanced as real time clock can be used in this project to get the real time counting and storing the bill in the EEPROM (memory section in Arduino).

With the eagerness of the government to bring in reforms to the power sector, easily availability of resources, renewed thrust on ‘aatmanirbhar’ manufacturing, and urgency to revive ailing DISCOMS, makes the switch to advanced smart metering infrastructure more viable today and is absolutely the need of the hour.

REFERENCES

JOURNAL PAPER

[1] Ashna, K. & George, S.N., "GSM based automatic energy meter reading system with instant billing", Proceedings - IEEE International Multi Conference on Automation, Computing, Control, Communication and Compressed Sensing, iMac4s, 2013, pp.65–71.

[2] De Capua, C. et al., "A smart energy meter for power grids", Conference Record - IEEE Instrumentation and Measurement TechnologyConference, 2014, pp.878–883.

[3] Dhananjayan, R. & Shanthi, E., "Smart Energy Meter with Instant Billing and Payment", 2014, pp.1397– 1403.

[4] Ghaderi, M and Boutaba, "Call Admission Control in Mobile Cellular Networks : A Comprehensive Survey", Wireless Communications and Mobile Computing, Vol. 6, No.1, 2006, pp 69-93.

[5] Jonnala, P. & Ieee, M., "Wireless Solution for Polyhouse Cultivation Using Embedded System", 2014, pp.21–25.

[6] Khan, J., "Handover management in GSM cellular system", International Journal of ComputerApplications, Vol. 8, No. 12, 2010, pp.14–24.

[7] Kumar Sehgal, V. et al, "Electronic energy meter with instant billing", Proceedings – UK Sim 4th European Modelling Symposium on Computer Modelling and Simulation, EMS, 2010, pp.27–31.