University of Mumbai

Energy Meter with Load Control using GSM

Submitted in partial fulfillment of requirements

for the degree of

Bachelors in Technology

by

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Batch 2017 -2021

Certificate

This is to certify that the dissertation report entitled **Energy Meter with Load control using GSM** is a bona fide record of the dissertation work done by Bharatan Ramkumar, Ashirwad Bhide and Nikhil Naredla in the year 2020-21 under the guidance of Dr. Sudha Gupta of Department of Electronics Engineering in partial fulfillment of requirement for the Bachelors in Technology degree in Electronics Engineering of University of Mumbai.

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This project is approved for the award of Bachelors in Technology Degree in Electronics Engineering of University of Mumbai.

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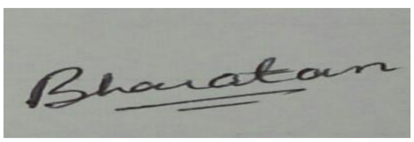
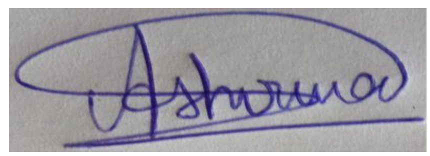
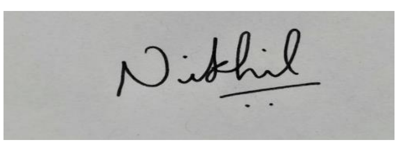
 **Signature of the Student** **Roll No. 1712066**	 **Signature of the Student** **Roll No. 1712067**
 **Signature of the Student** **Roll No. 1712077**	

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My family and friends

Abstract

This study is about creating a smart energy meter that can monitor electrical energy usage and deliver usage statistics to mobile phones over the air. This metering method was entirely analogue in the beginning. It has now turned digital as a result of rapid technology advancements. It still required a large human team to visit the site and record the data. The above-mentioned two procedures have a number of limitations, including erroneous results and a long repair time, as well as defective readings. The other technique gives us slightly precise readings, but its major flaw is that the readings cannot be delivered to the point of billing. By fully automating the energy meter, the GSM technology used here solves all of the above-mentioned limitations. i.e., meter readings are automatically sensed and noted, and those units are transferred to the point of billing through GSM module on a regular basis, with matching bills generated and provided to the user at the appropriate time. It saves time, decreases the need for human labour, and provides reliable readings. This system is an alternative to traditional methods of collecting energy meter reading and allows the energy provider to access current energy meters remotely. They can keep track of the readings without having to go to the person's home.

Keywords: *Electrical energy usage, energy meter, GSM technology*

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Chapter 1
Introduction

This chapter will give a brief explanation about smart energy meter and it's need, along with the scope, problem definition and objectives of the project.

1.1 Background

Electrical metering device technology has advanced significantly since its start more than a century ago. Many advances have resulted in size and weight reductions, as well as improvements in features and specifications, since the initial huge meter with hefty magnets and coils. The meter's resolution and accuracy have improved significantly over time. The digital meter, which was introduced in the latter half of the twentieth century, revolutionized the way electrical parameters are measured. Due to features such as ease of reading, greater resolution, and sturdy construction, the digital meter has conquered the entire spectrum of measuring devices, starting with Voltmeters and Ammeters. The emergence of the Electronic Energy Meter in the mid-1980s was particularly significant. Because of the vast differences in energy production and use, energy consumption and distribution has recently become a hot topic of debate. In this regard, energy customers face numerous issues as a result of frequent power outages; another major cause of power outages is wealthy people's unrestricted energy usage. In this regard, some constraints should be placed on the energy consumption of all the energy consumers, and the energy supply companies should execute policies that implement Smart Energy Meters throughout the household sector to avoid power outages and distribute energy fairly to all locations. As a result, there is a pressing need to consider this issue, and a solution must be found.

1.2 Motivation

The main motivation for developing our smart energy meter is to be able to track energy consumption in real time. We can see how much we've consumed and how much it cost us at any time, which is very useful for both power consumption and financial management. Smart meter can also do other functions remotely, such as turning on and off the electricity supply without the need for a field technician, measuring the power quality at your location, and notifying your electricity distributor when the power goes out.

1.3 Objectives

Allow you to use a broader range of services, such as battery storage. On a regular basis, provide you with precise information on your energy usage. This information can assist you in better understanding and adjusting your usage, as well as locating the best offer for you. Assist electricity retailers in providing you with better and more creative goods and services, such as energy management apps and online access to data about your electricity usage. Allow electricity providers to more rapidly detect outages and check the quality of your power. This will help to cut down on the number and duration of power disruptions. The suggested smart energy meter with advanced prepaid billing system is a gadget that makes electricity billing more user-friendly and readable for the average person, as well as providing a slew of other benefits.

• Energy conservation is important.

• The user can recharge as many units as they need (prepaid system).

• Significant time and energy savings for the electricity department.

• The energy meter is controlled automatically.

• Energy meter storage based on non-volatile memory.

• Introduces Prepaid Billing, which will help consumers become more aware of their energy usage while also being more cost-effective.

• Billing system automation eliminates the need for human intervention, making it more accurate.

• It provides time-of-day billing, which discourages consumers from using electricity during peak hours, lowering energy generation costs.

• To encourage consumers to keep track of their energy usage.

Chapter 2

Literature Survey

This chapter presents the summary of the literature survey performed by us on smart energy meter GSM technologies.

1. GPRS-based design of an electric energy meter for long-distance data information transfers

Based on the current electric energy meter with the well-functioned ARM kernel microprocessor, it not only finishes the power data measuring and processing, but also realizes the TCP/IP by cutting. With the popularization of the internet in China as GPRS service improved increasingly, electric energy meter transmits data information and controlling command remotely and wirelessly. Electric energy meters could be connected to the internet using the GPRS service by using an ARM kernel microprocessor to control the GPRS module. Because it is handled by the C/OS-2 operating system, the whole system is stable and reliable. This is especially true in some rural regions where the cable network has yet to gain traction.

2. Automatic reading of power meters through GSM network

The creation of a GSM automatic power meter reading system entails the installation of GSM digital power meters in every consumer unit, as well as the installation of an electrical EB connection system on the energy provider's side. The GSM digital power meter is a single phase IEC61036std compliant digital KILOWATT power meter with embedded GSM modem that uses the GSM network to relay its power usage reading back to the energy provider wirelessly via a short messaging system. An EB link system is used by the power provider to manage all received SMS meter readings, compute the billing cost, update the database, and send the billing notification to the appropriate consumer through SMS or email. The GAPMR system was designed as a functional prototype to show the effectiveness of autonomous meter reading billing and notification using GSM networks.

3. Instant billing using an electronic meter

It shows the design of a basic low-cost wireless GSM energy meter and the web interface that goes with it for automatic invoicing and data management on a global scale. The suggested technology replaces traditional meter reading methods and allows the energy provider to access an existing energy meter remotely. A GSM-based wireless connection module is integrated with each entity's electronic energy meter to provide remote access to electricity usage. The billing point is a PC with a GSM receiver on the other end that contains the database. The billing point receives live meter readings from the GSM-enabled energy meter on a regular basis, and these details are updated in a central database# and the.NET Framework Users can access the developed web page details from anywhere in the world with correct authentication. After analyzing these data, the customer receives a message with the total monthly consumption and owing bill.

4. A digital energy meter that may be read wirelessly.

Electricity is one of humanity's most basic needs, and it is widely employed in home, industrial, and agricultural applications. The demand for electricity is really high. Even though there are several well-developed alternative energy sources, there are numerous issues with distribution and metering. Because of the mechanical nature of the components in the meter, classic electro mechanical meters, which are still extensively used today, are prone to wander over time and temperature. The problem gets worse when it comes to collecting meter readings and creating bills. This refers to a way in which telecommunication networks are used to automate data transmission in order to make bill production and payment easier at the customer's location.

5. Embedded energy meter—A novel concept for measuring and billing the consumer's energy consumption.

A novel concept of energy meter is shown, in which a consumer's maximum energy demand is stated in the meter used by the customer, and the meter, and therefore the connection, is automatically severed by an embedded system installed in the meter itself when the maximum demand is exceeded. According to the highest demand, the consumer will purchase a cash card for an amount based on the amount of energy consumed, and after that, the consumer will have to purchase another cash card or recharge the same, avoiding the hassle of having to go to the billing office, stand in a long line, and submit the bill. This system also aids in the elimination of billing management system flaws such as taking meter readings to make bills, printing bills, mailing bills to the correct address, and collecting the bill amount. As a result, this technology can significantly minimize the amount of people necessary. A new idea of distributor has also been discussed, which is utilized to disconnect a line if a consumer's daily energy use considerably exceeds the pre-demand energy consumption.

2.1 Existing System

The energy meters in use today are a modified form of the previous system; digital meter do not feature a prepaid system, in which the amount of power to be spent is anticipated and recharged before to use, similar to prepaid speak time for a mobile phone. In addition to that, there is no suitable equipment to identify illicit power usage, which is the use of power without paying for it. However, some energy meter has an LED that blinks anytime someone tries to access the meter box; however, this may be turned off using a button on the rear, which does not guarantee security.

2.2 History

In the early half of the nineteenth century, electromagnetism achieved some stunning discoveries. With the invention of the dynamo, massive amounts of electrical energy could be generated (Annoys Jedlik in 1861, Werner von Siemens in 1867). The first large-scale application of electricity was lighting. When this new product – electrical energy – first hit the market, it was obvious that a price would have to be set. Samual Gardiner of the United States was the first to copyright the meter in 1872. The length of energy given to the load was counted because all of the bulbs connected to this meter were controlled by a single switch. The introduction of Edison's light bulb made it possible to divide lighting circuits, and this meter became obsolete. The developer of the first direct current lighting distribution systems, Thomas Alva Edison (1847-1931), believed that electricity had to be sold. In 1881, he invented his 'electric meter,' which used the electrochemical effect of current (USA patent No. 251,545). These meters were in use until the end of the nineteenth century. There was, however, one major drawback: meter reading was difficult for the company but impossible for the customer. Edison eventually integrated a counting device to aid in meter reading.

Pendulum meters

Another proposal for a meter was to create motion proportional to the energy, which could then be utilized to drive a register to read. These meters were expensive since they featured two clocks, and they were gradually replaced by motor meters. Only ampere-hours or watthours could be measured using a pendulum meter, and it could only be used for direct current.

Motor meters

Another possibility was to use a motor to build a meter. The driving torque is proportionate to the load and is balanced by a braking torque when the torques are in equilibrium, resulting in rotor speed that is proportionate to the load.

Electricity meters – further improvements

Weight and dimension reductions, load range extension, compensation for changes in power factor, voltage, and temperature, elimination of friction by replacing pivot bearings with ball bearings, then doublejewel bearings, and magnetic bearings, and improving long-term stability by using better brake magnets and eliminating oil were among the many improvements made in the following years. Around the turn of the century, the three-phase induction meter was devised, with two or three measurement systems arranged on one, two, or three discs. The advancement of the power meter has been aided by new technology. Initially, a high-precision static meter was developed, based mostly on the time division multiplication theory. Hall cells were also used for business and residential meters. Hybrid meters including induction meters and electronic tariff units were developed in the 1980s. This technology was only useful for a short period of time.

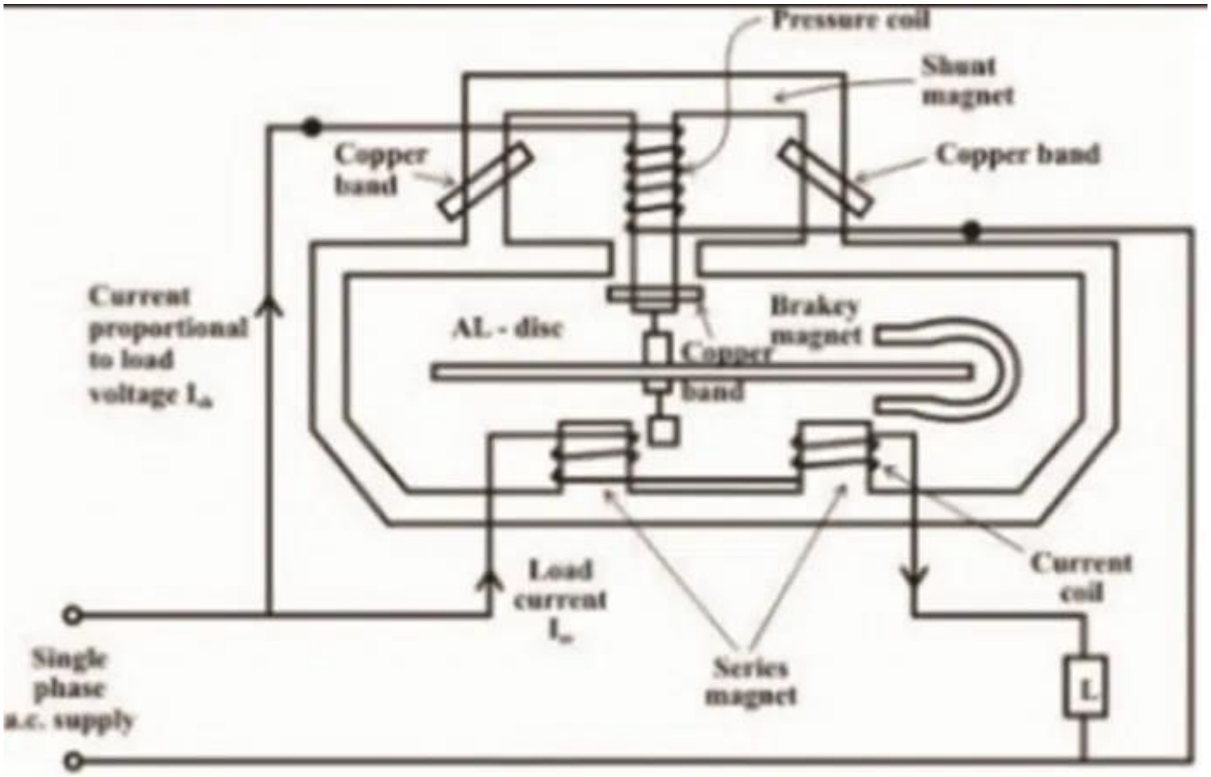
Remote metering

In the 1960s, the concept of remote metering was originally proposed. At first, remote pulse transmission was used, but it was phased out in favor of various protocols and communication mediums. In today's meters with broad functionality, which are based on the latest modern technology and use digital signal processing, the majority of functions are implemented in firmware.

2.4 Types

Electro Mechanical Induction Type Energy Meter

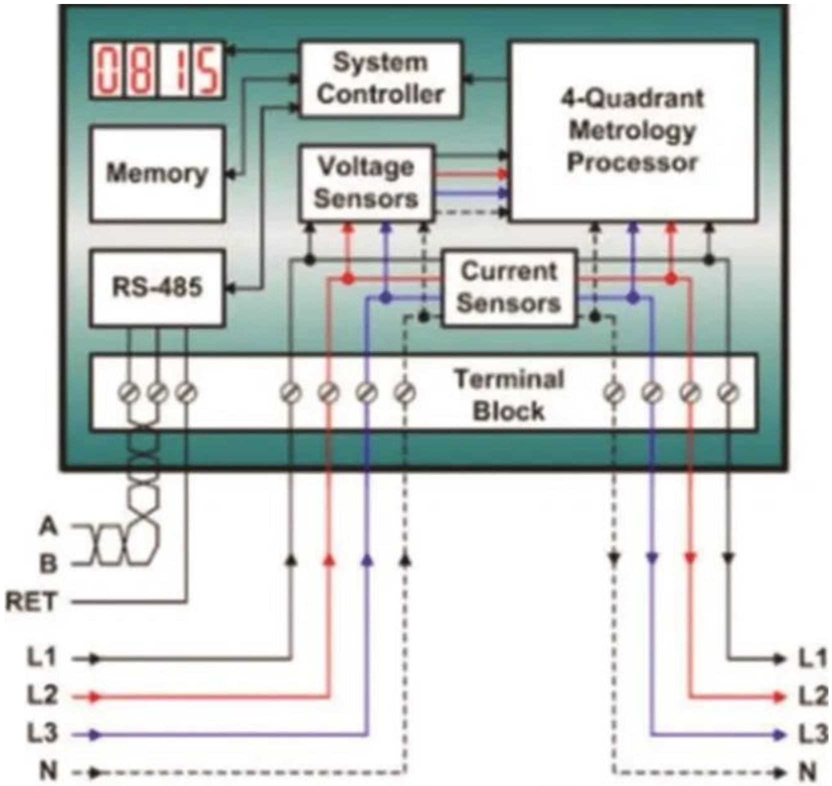
Two electro magnets and a spinning metal disc on a spindle make up the device. The power is proportional to the speed at which the disc rotates, and this power is integrated using counter mechanisms and gear trains. Induction through electromechanical means Energy metres are used for a wide range of purposes. Electromechanical induction energy metres are used to measure energy in both homes and enterprises. The government and energy companies charge customers depending on these readings. They are both cheap to make and incredibly accurate. They're utilised in factories to measure how much electricity is getting to machinery after it's been modified.



2.1 Electro Mechanical Induction Type Energy Meter

Electronic Energy Meter

No moving parts are used in the Electronic Energy Meter, which is based on Digital Micro Technology (DMT). Static Energy Meter is the name given to the electronic energy meter. A specially constructed IC called Application specified integrated circuit controls the precise operation of an electronic energy meter (ASIC). Embedded system technology is used to create ASICs for specialised purposes. Modern state electronic energy meter are electronic components that were developed recently to monitor electrical energy. The electronic meter's measurement precision is about an order of magnitude better than a mechanical meter's, and its consumption is around two orders of magnitude lower. The electronic meter is also more resistant to manipulation than its mechanical predecessor, and it is simple to add devices for prepaid operation (e.g., card readers) and for remote meter reading (e.g. telephone line, or internet).



2.2 Electronic Energy Meter

Smart Energy Meters

The installation of intelligent Meters to read, process, and send data to users is a cutting-edge metering technology. It keeps track of energy usage, switches the supply to consumers remotely, and limits the maximum amount of electricity used. Energy meters that are smart The smart energy meter has a wide range of applications and is a vital instrument for managing electricity use. It collects data from gadgets about power outages and delivers it to the utility center.

Chapter 3

Feasibility Analysis

This chapter includes an analysis of the proposed system which is necessary to determine if it is technically feasible and whether it will be a profitable approach for development.

3.1 Technical Feasibility

The current system can be put in the place of the energy meter which is actually existing at our respective buildings in the meter rooms. All the essential parameters will be monitored by the energy meter and then it will be processed in the Arduino with the protocols it has and one can get the details on their respective smartphones.

3.2 Operation Feasibility

The project's operational feasibility is an important part of the implementation process. The system's well-thought-out design assures the most efficient use of growing area and manpower. Human intervention has been reduced because the system is totally automated, requiring only human action to install, remove, or repair it. It is assumed that the majority of people who live in urban regions also hold a smartphone.

3.3 Economic Feasibility

It's fascinating to compare the system's development cost to the economic advantage received from a fully deployed system. The financial and easability benefits will outweigh the outlay. As a result, the system is economically viable.

Chapter 4

System Requirements

This chapter presents the requirements of various parts of the system.

4.1 Hardware Requirements

1. **Arduino**

   This acts as the brain of the system, processing information from the sensors and controlling the load through input commands

2. **GSM Modem**

   This is used to interface between Arduino and our phones. We can control load by sending SMS and receive energy info using GSM Modem.

3. **LCD Display**

   The LCD display is used to display various parameters such as energy consumed and the price remaining.

4. **Current sensor**

   It converts current sensed to voltage which can be relayed to Arduino

5. **Relay**

   Used to control the load. acts as a switch in the circuit

4.2 Software Requirements

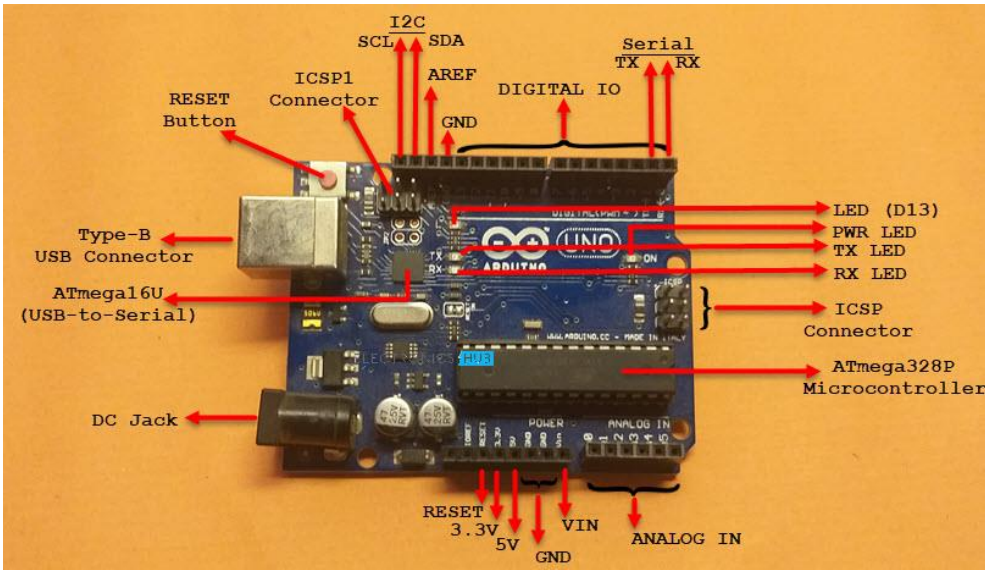
1. **Arduino ide**
   It was used to test the code and upload the code to audio module

2. **Proteus**
   It was used to test and simulate the project on software end, with the help of proteus we could do the necessary changes.

4.3 Component Selection

This is a description of various components used in the system. All the components were compared with options available and then finalized based on its merits.

1. **Arduino**



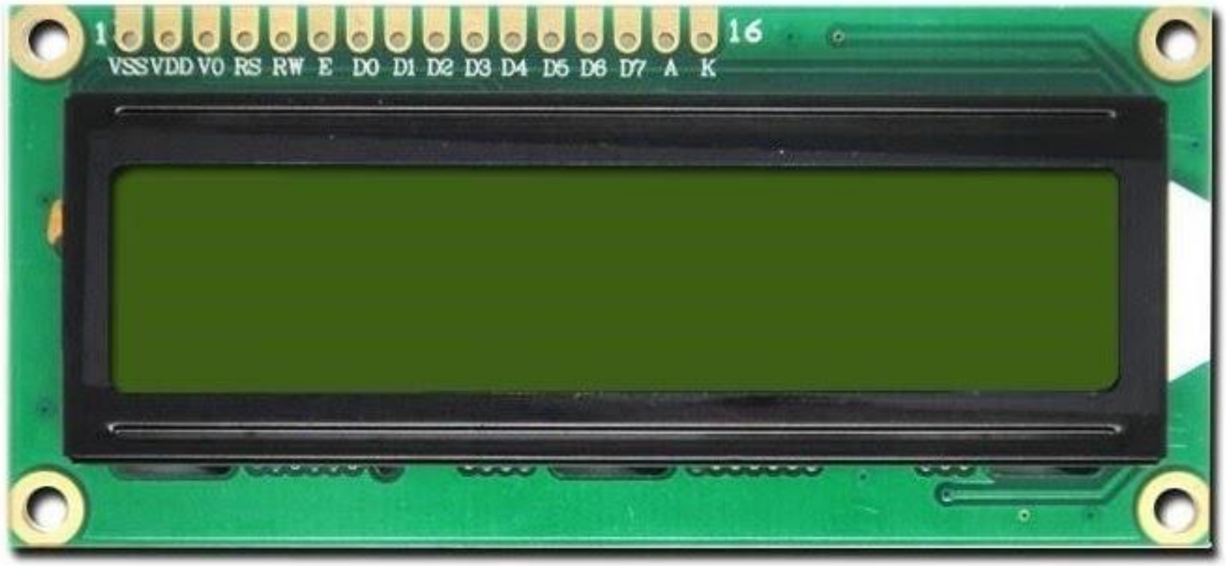
4.1 Arduino

The boards provide digital and analogue input/output (I/O) pins for connecting to expansion boards (shields) and other circuitry. Serial communications connections are available on the boards, including USB on some variants, and are used to load programmers from personal computers.

A dialect of C and C++ programming features are frequently used to programe microcontrollers. In addition to typical compiler tool chains, the Arduino project features an integrated development environment (IDE) based on the Processing language project.

MCU	ATmega328P
Architecture	AVR
Operating Voltage	5V
Input Voltage	6V – 20V (limit) 7V – 12V (recommended)
Clock Speed	16 MHz
Flash Memory	32 KB (2 KB of this used by bootloader)
SRAM	2KB
EEPROM	1KB
Digital IO Pins	24 (of which 6 can produce PWM)
Analog Input Pins	6

2. LCD Display



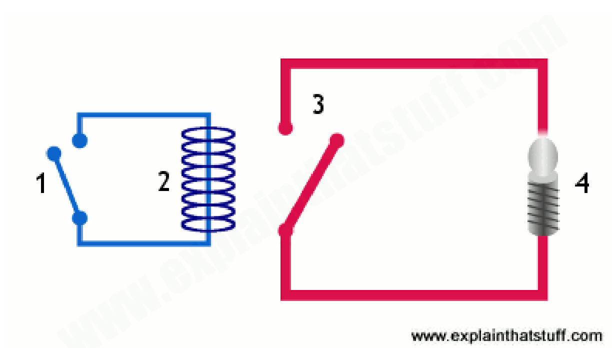
4.2 LCD

LCD (Liquid Crystal Display) screens are a form of electronic display with many applications. A 16x2 LCD display is a common module that can be found in a variety of devices and circuits. These modules are preferred over seven-segment and other multi-segment LEDs. The following are the reasons for this: LCDs are affordable, easy to programme, and have no limitations in terms of displaying unique or unique characters (unlike the seven segments), animations.

Twisted Nematic (TN) liquid crystals were utilized in the LCD, which are liquid crystals that are twisted at 90 degrees to the surface. In this state, crystals let light to pass through the polarizer, but when a voltage is applied, they become twisted and stop light from flowing through. The electric signals are sent to the electrodes sandwiched between the glasses by the LCD controller, which is in the form of a COB IC. According to the signals received from the ICs, electrodes apply voltage to the corresponding crystals. These crystals are then untwisted, obstructing the light (from the LED strip) and darkening the spots on the glass. A desired shape is produced on the LCD by applying voltage to specified crystals.

Minimum logic voltage:	4.5 V
Maximum logic voltage:	5.5 V
Typical LED backlight voltage drop:	4.2 V
Typical LED backlight current:	120 mA
Supply current:	2 mA

3. Relay



4.3 Relay

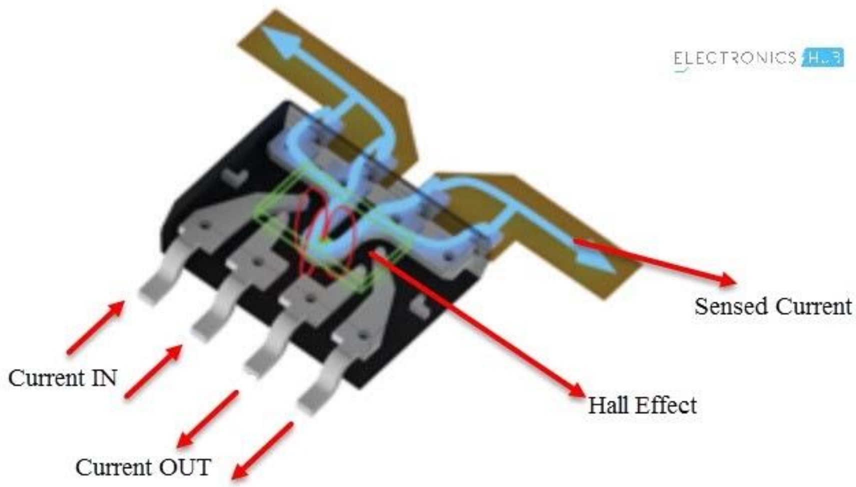
Relays are similar to transformers in that they are electromagnetic switches. We have two 'ends' that are unique from one another here as well. In our simulation, we employ a normally open (NO) relay. The input circuit, which is usually connected to the microcontroller, the output end, which is connected to the load, which is connected to the source, are the elements that we may manage. The following is how it works:

1. The input circuit (blue in this picture) is turned off, and no current flows through it until something activates it (such as a microcontroller). The output circuit has also been disabled.

2. The electromagnet, which is the metal coiled structure we saw earlier, is triggered when a small current goes through the input circuit, and a magnetic field is formed all around it.

3. The activated electromagnet attracts the metal bar in the output circuit, shutting the switch and allowing significantly more electricity to flow.

4. ACS712 Current Sensor



4.4 Current Sensor

The Hall Effect is used in the ASC712. Internally, a copper strip connects the IP+ and IP- pins. A magnetic field is formed as current travels through this copper wire, which is detected by the Hall Effect sensor.

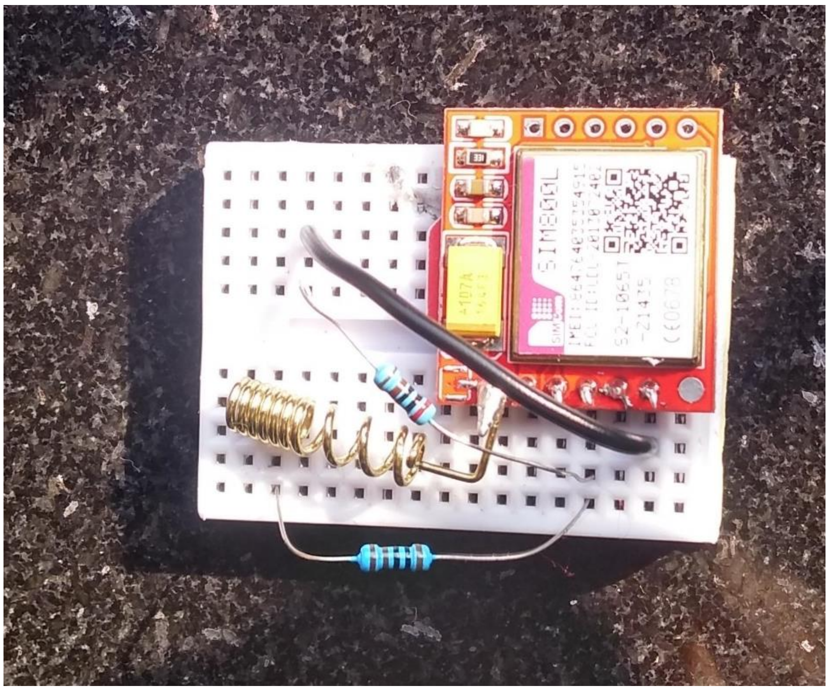
This magnetic field is subsequently converted into appropriate voltage by the Hall Effect sensor. The input and output are totally segregated in this manner.

$$I = \frac{V - 2.5}{Sensitivity}$$

Sensitivity in this case is 200 mV per A

The above equation shows the calculation for current that is being used in our code.

5. **GSM Module**



4.5 GSM Module

We have used this GSM module to interact between the user and Arduino for results. The IM800L is a tiny cellular module that can broadcast and receive GPRS data, send and receive SMS, and make and receive voice calls. This module's low cost, compact footprint, and quad band frequency capabilities make it a great solution for any design requiring long-range connectivity. After putting in the power supply, the module starts up, scans for a mobile network, and logs in automatically. The state of the connection is shown by an LED on the board (no network coverage - quick blinking, logged in - gradual blinking).

Specifications

- Supply voltage: 3.8V - 4.2V
- Recommended supply voltage: 4V
- sleep mode < 2.0mA

- idle mode < 7.0mA
- GSM transmission (avg): 350 mA
- GSM transmission (peek): 2000mA

- Module size: 25 x 23 mm
- Interface: UART (max. 2.8V) and AT commands
- SIM card socket: microSIM (bottom side)
- Supported frequencies: Quad Band (850 / 950 / 1800 /1900 MHz)
- Working temperature range: -40 do + 85 ° C

4.4 Material Requirements

There are some materials required for energy meter setup. Each is explained in detail below

1. **Load**
   For successful testing of the project we have used bulb as the load to test whether it is working or not. Here bulb is the representation of our household gadgets and appliances connected for representation purposes we have used a bulb and to gold the bulb we have used a bulb holder.

2. **Connecting Wires**
   Used to connect the different components and load to each other.

3. **Jumper Wires**
   Jumper wires are being used to connect items on your breadboard to the head pins on your Arduino. Make advantage of them to connect all of your circuits

4. **3.7V LiPo Battery**
   3.7V 1000mAH (Lithium Polymer) Lipo Rechargeable Battery also referred as Lipo or Lipoly batteries are tiny, compact and efficient. This cell has a capability of 1000mAh. These Battery is utilised to power our GSM module.

5. **Breadboard**
   We have used breadboard to connect our gsm module to Arduino. A breadboard is a solderless tool used to prototype electronics and test circuit designs on a temporary basis. Many electronic components in electronic circuits can be connected by slipping their leads or terminals into the holes and connecting them with wires where necessary. Underneath the breadboard are metal strips that connect the holes on the top of the board. The metal strips are arranged as illustrated in the diagram below. The top and bottom rows of holes are horizontally connected and divide in the middle, while the remaining holes are vertically connected.

Chapter 5

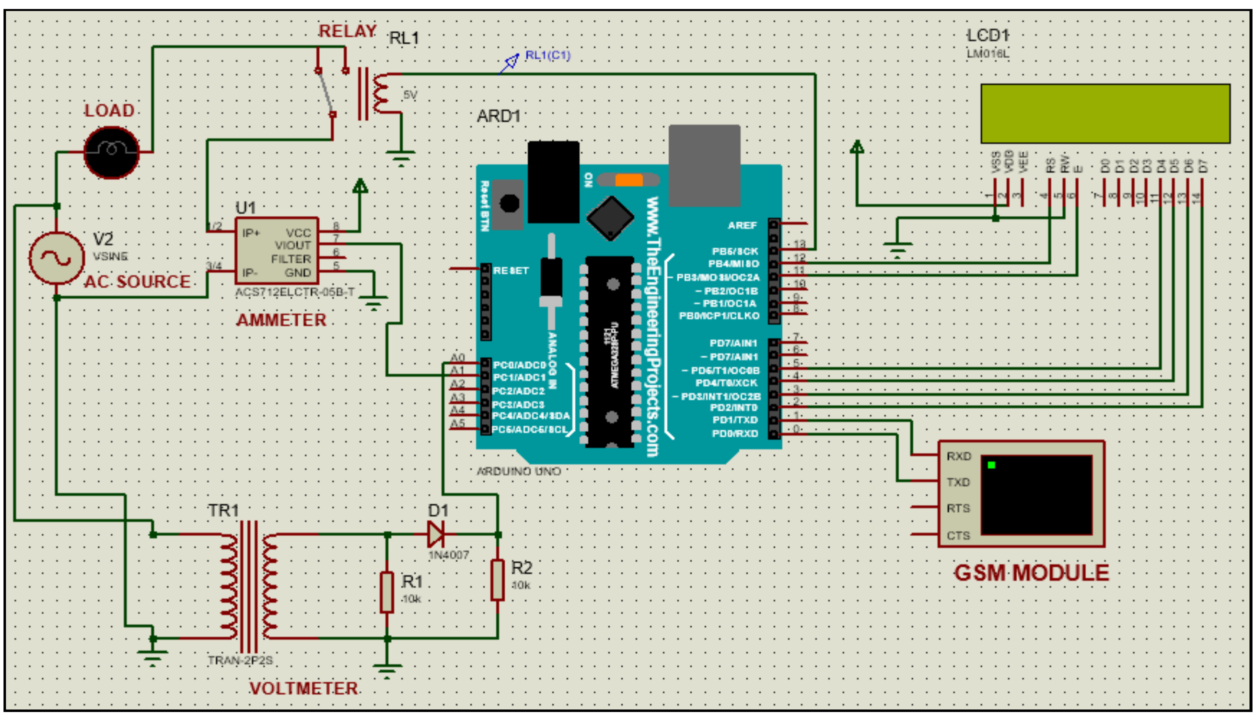
System Architecture

This chapter presents the detailed description of the system.

5.1 Software Analysis

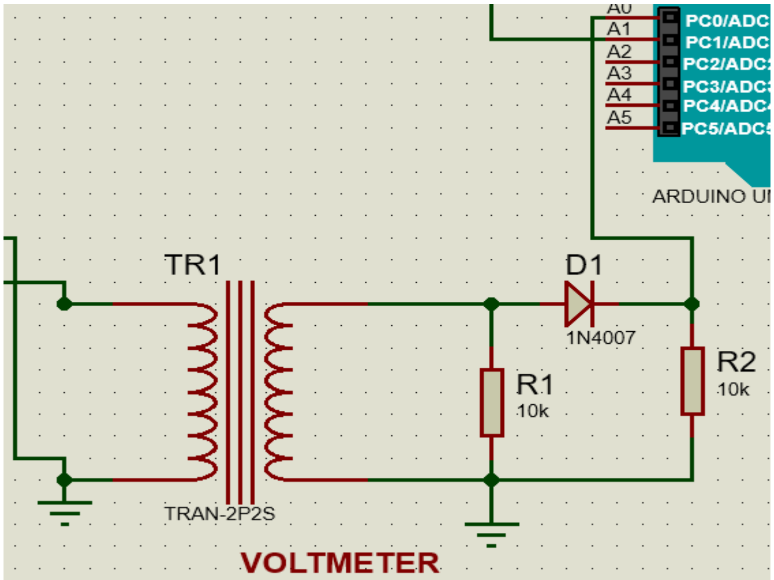
1. System Design

Shown below is the System diagram of our project. As we can see, there are many distinct components that will each be individually covered in this report. We have an AC source that seeks to mimic the power supply output that we get in our homes. It is calibrated at 230V RMS output sine wave. The power supply is connected to the load which here is a lamp and the lamp is connected to the relay which is connected in series with the ACS current sensor. The power supply is also parallel to the transformer circuit which is used to step-down the voltage and which is connected to a diode to rectify it. Its output voltage is connected to the analog pin input of the Arduino. We also have a LCD that shows the energy usage



5.1 System *Diagram*

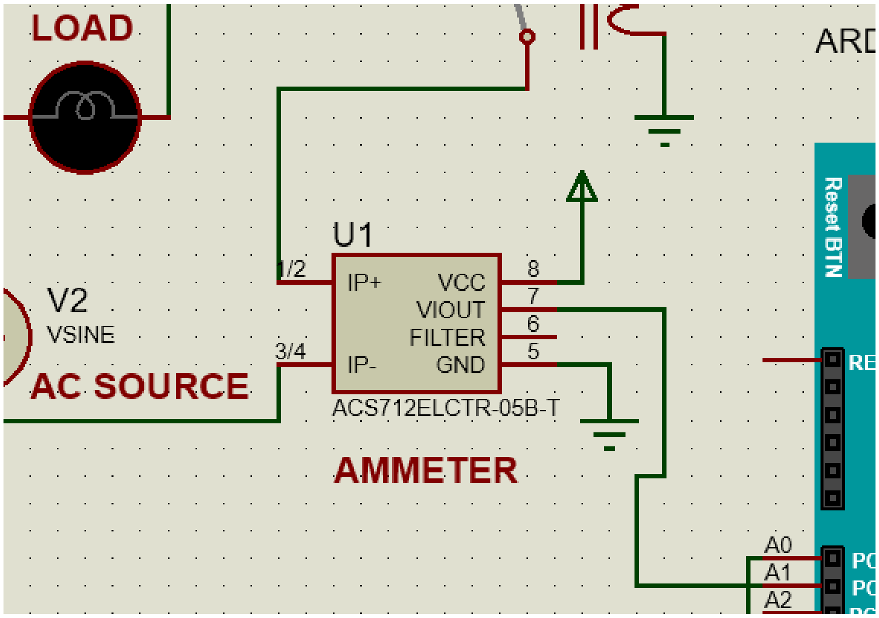
2. Voltmeter



5.2 Voltmeter

We have connected the primary side of the above transformer to the power supply. This step-down transformer converts the voltage from 325V peak to 5V peak. The diode D1, which is the 1N4007 diode, performs half wave rectification, but in the process loses out in the peak voltage as there is a 0.6V drop across the diode which leads to the peak voltage at the Arduino input to be 4.4V. Since Arduino input can range from 0 to 5V, this output voltage can be detected by it. The rectified voltage is passed on to the A0 ADC pin of the Arduino.

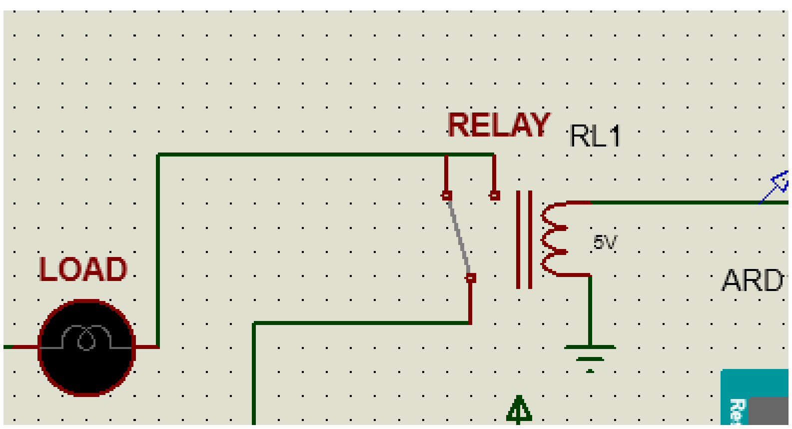
3. Ammeter



5.3 Ammeter

The ammeter is connected with the load in series. The ammeter is made up of the current sensor ACS712, which can detect currents up to 5 Ampere. The 0-amp output of the current sensor is 2.5 V and it has a sensitivity of 200 mV per ampere. So a 2A current will generate an output voltage of 2.9V. The output voltage of the ammeter is connected to the A1 ADC of the Arduino.

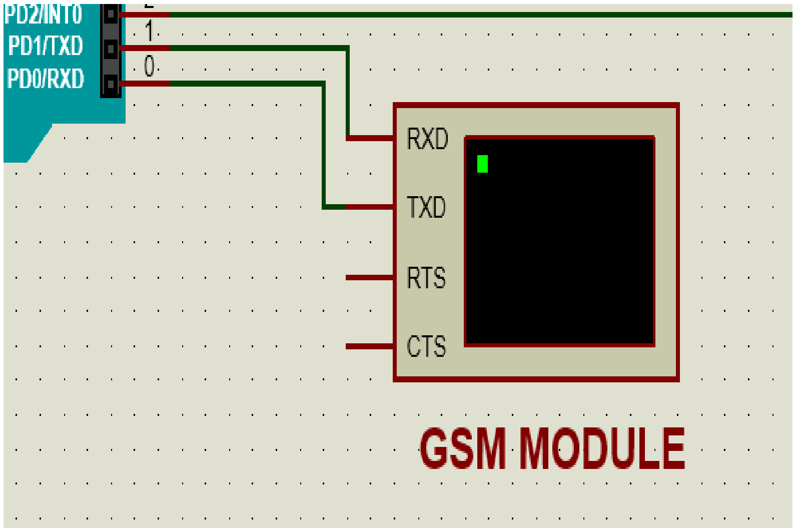
4. Relay



5.4 Relay

The relay is a switch that is used for load control. The control end of the relay is connected to the 13th digital pin of the Arduino. Whenever we give a HIGH on the corresponding pin, the relay is activated and it connects the supply to the load and allows current to flow. Correspondingly, writing a LOW on the pin causes the relay to take its original position and stop the current flowing through.

5. GSM Module



5.5 GSM Module

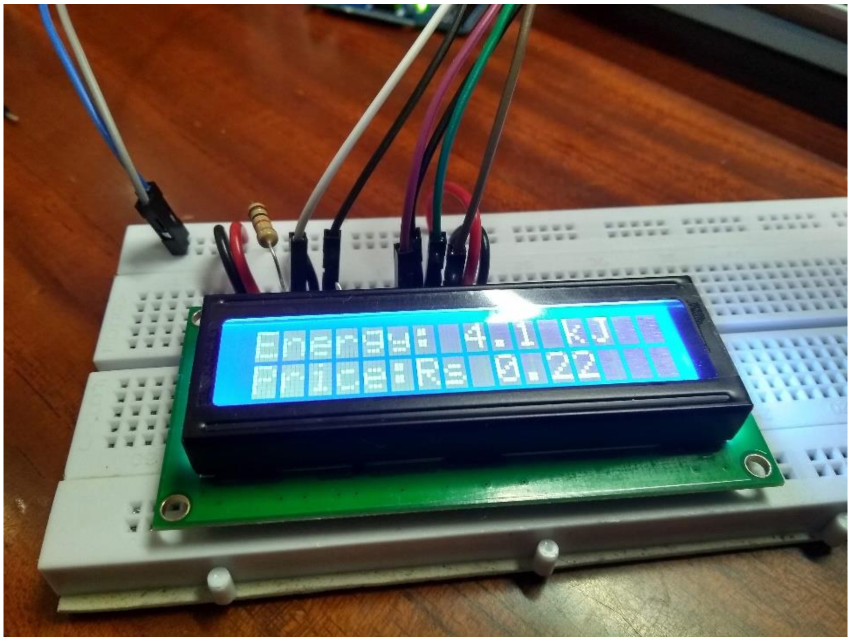
The virtual terminal of Proteus acts as a placeholder for the GSM Module. We issue commands to the Arduino using this terminal which does a range of things as detailed below.

Commands:

1. **'o' command:** Switches on the relay and allows current to flow
2. **'f' command:** Switches off the relay
3. **'e' command:** Gives amount of energy consumed by the Load and associated price, calculated at Rs 2.93 per KJ.

5.2 Hardware Analysis

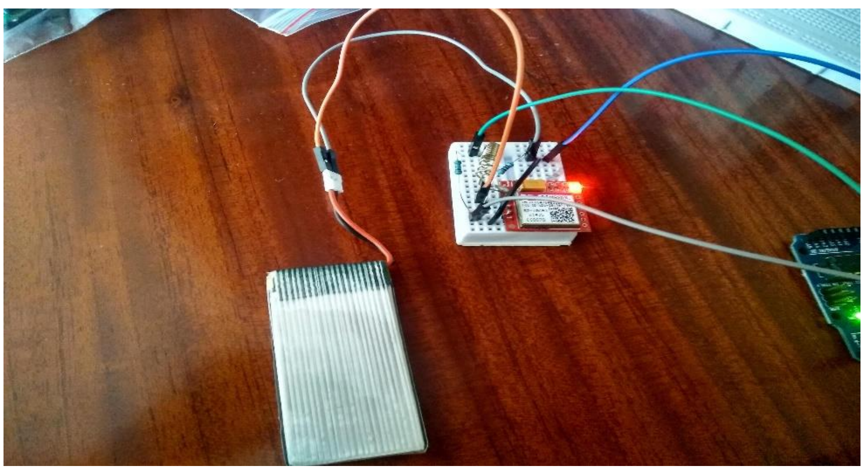
1. LCD



5.6 LCD (Hardware)

The LCD here we have used is 16*2. It is used to display the price and the energy consumed.

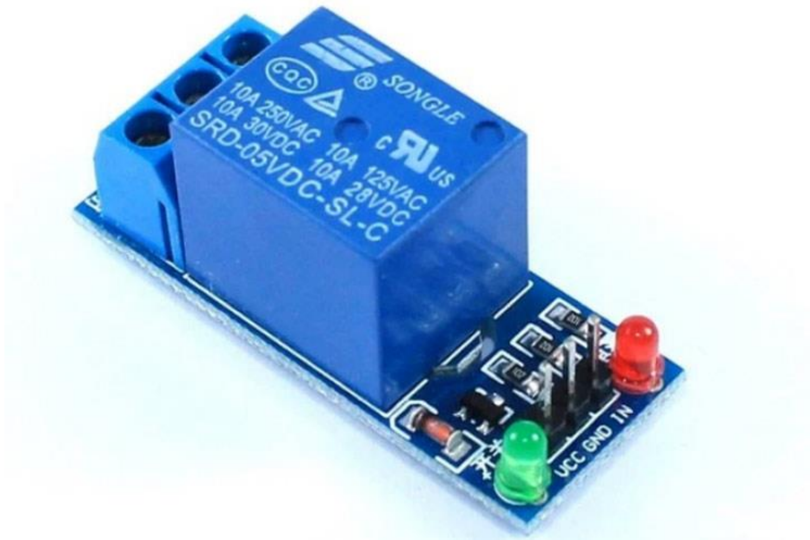
2. GSM Module



5.7 GSM Module(Hardware)

The GSM module is interfaced to send and receive the commands. It is interfaced with the Arduino and it communicates with the user using a smartphone.

3. Relay



5.8 Relay

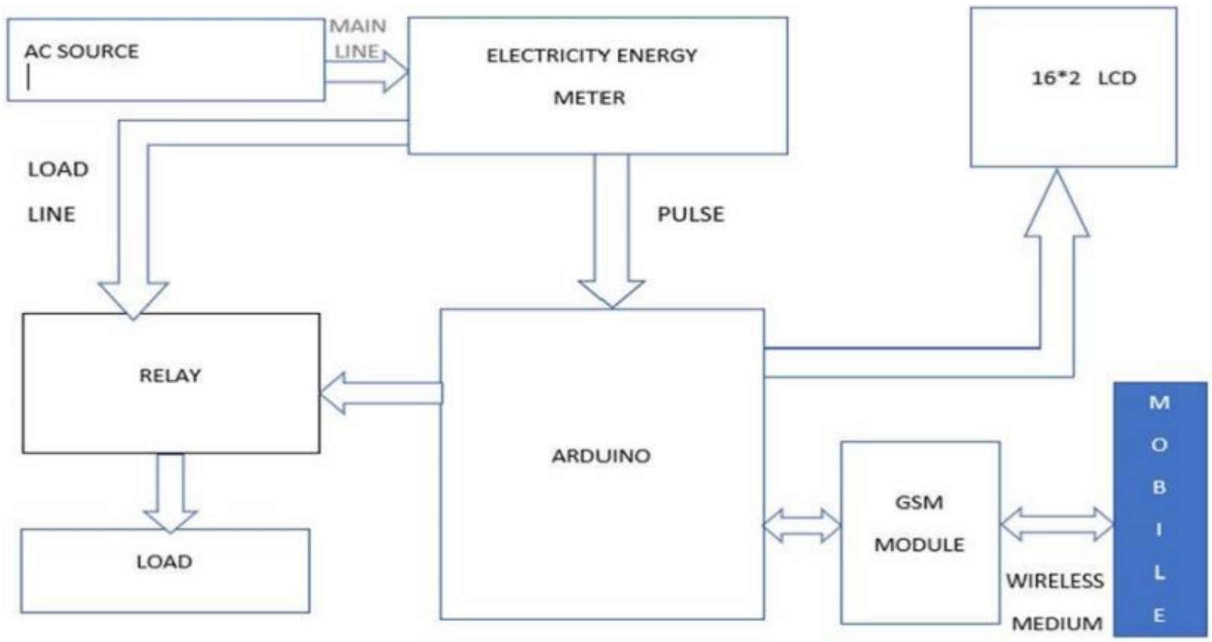
A Relay is used in our project to control the load

4. Current Sensor

5.9 Current Sensor

The current sensor's function is to sense and determine the current, which the load is consuming in our circuit.

5.3 Block Diagram and Schematic



Chapter 6

Implementation

This chapter presents in detail the work accomplished in the project. It covers all the features, technical aspects and other information about the implementation of the project.

6.1 Software Setup

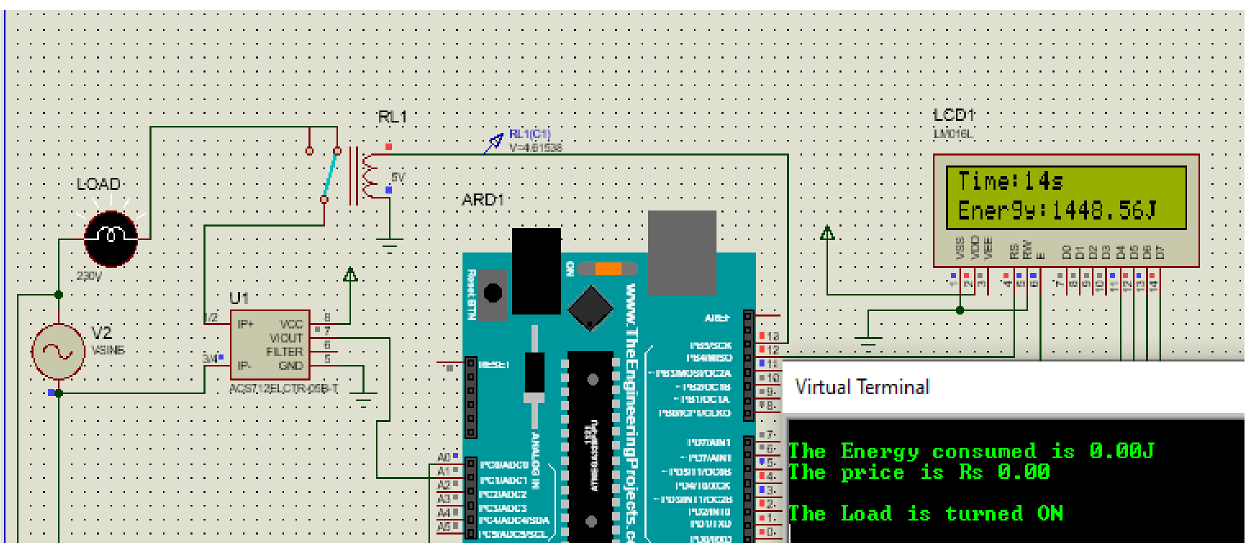
Simulation Screenshots

The simulation uses a virtual terminal with a baud rate of 9600 bps (bits per second) in place of the GSM module.

LCD

We have programmed the LCD in such a way that energy consumption is displayed every second along with the time passed since starting the energy meter

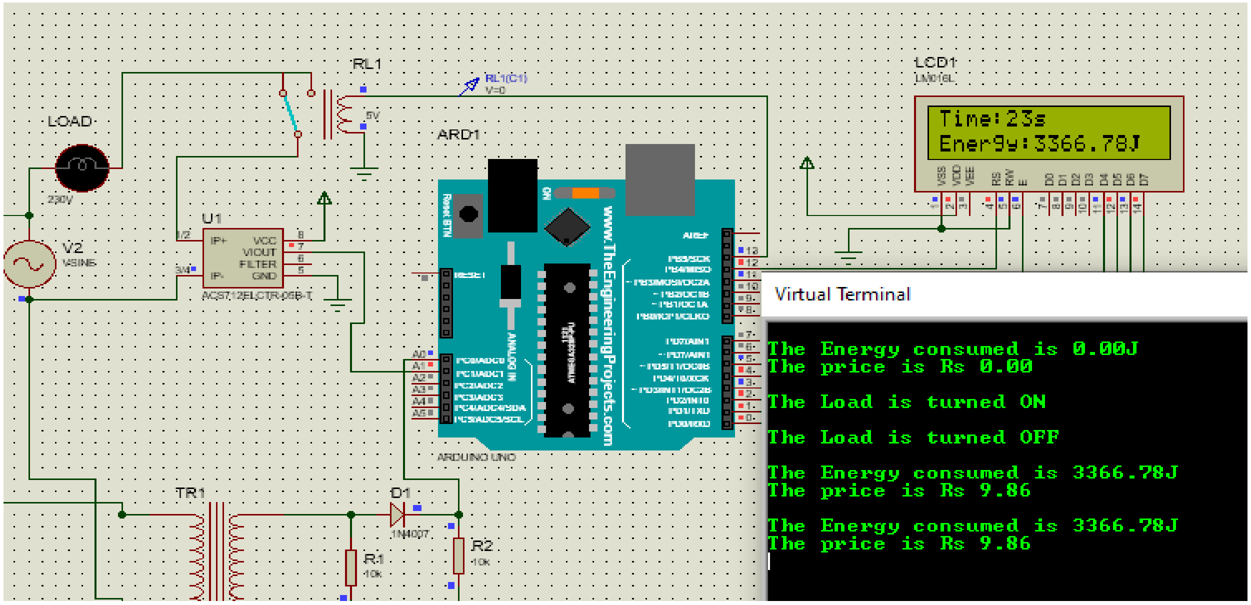
Load is turned on, using ‘o’ command



6.1 Implementation schematic 1

We can observe that the initial energy usage is zero, since the load was not connected to the supply. Consequently, the price is zero. At 13s, we turn on the load and the energy consumption starts jumping ahead.

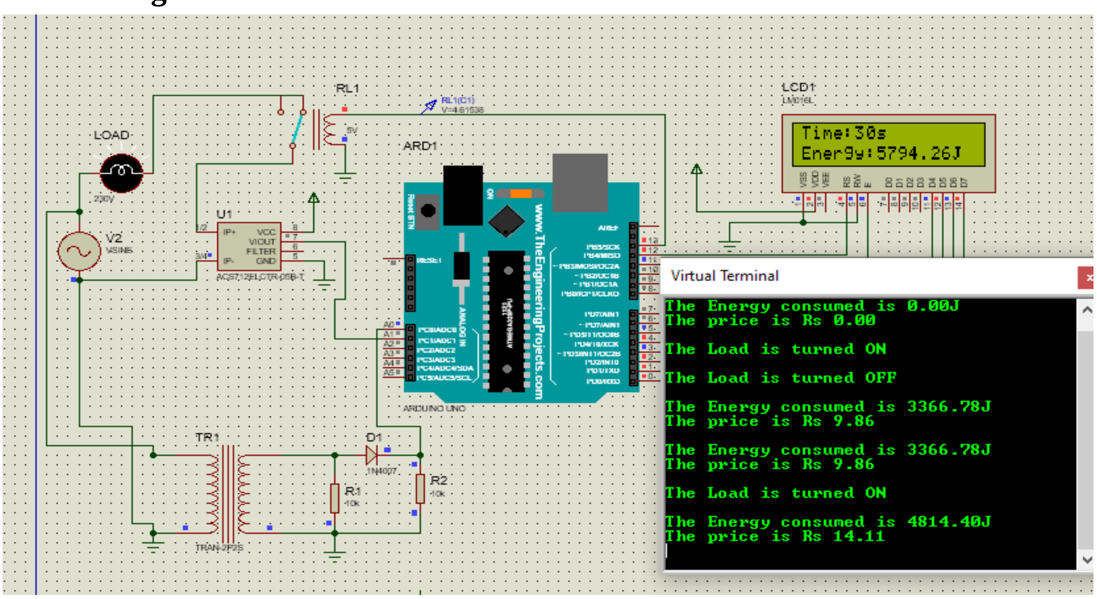
Load Turned off using ‘f’ command:



6.2 Implementation schematic 2

We use the ‘e’ command a bunch of times after using the ‘f’ command to switch off the load. We see that once the relay is off, the energy usage and the price remains constant at the level it was when it was turned off, indicating that the meter is working as expected only recording energy usage when then the load is being used.

Load turned on again:

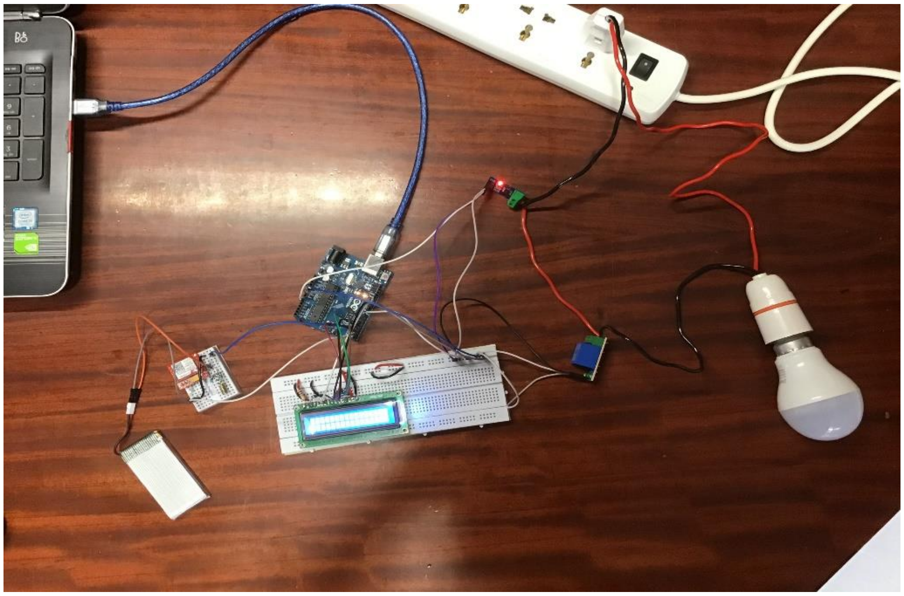


6.3 Implementation schematic 3

After a brief period of the load being off, we turned it on again and we can see that the energy consumption has picked up from where it last left off.

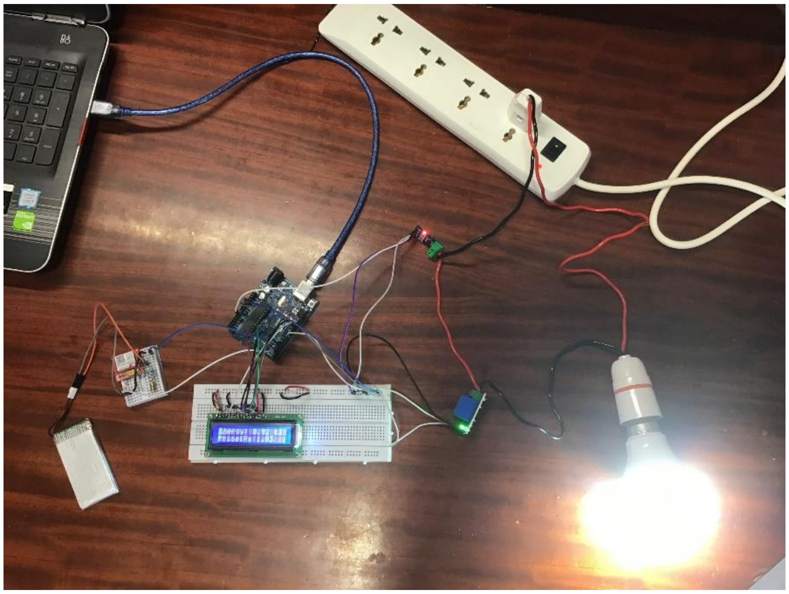
6.2 Hardware Setup

1. In this we have kept the load off



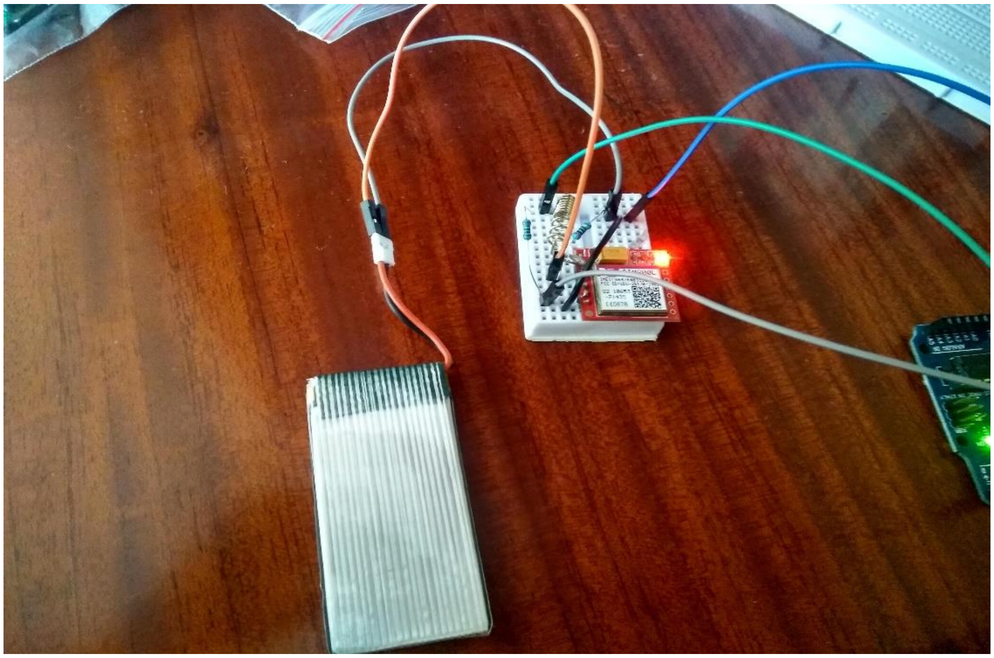
6.4 Implementation hardware fig (1)

2. In this we have turned on the load



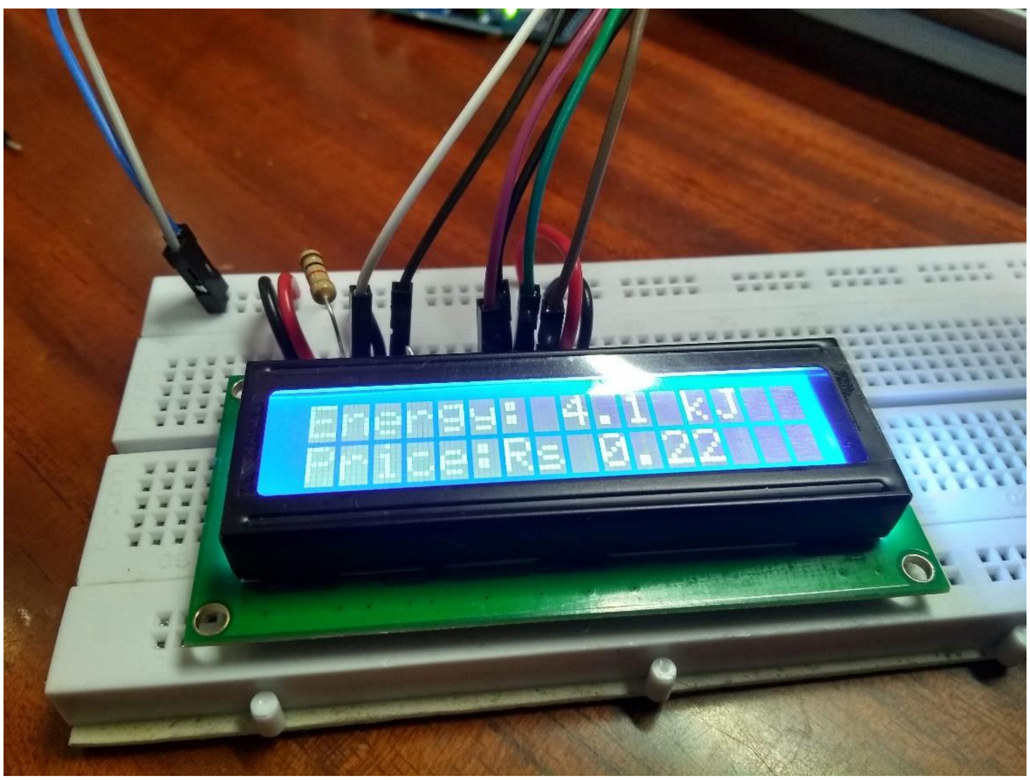
6.5 Implementation hardware fig (2)

3. GSM module working



6.6 Implementation hardware fig (3)

4. LCD showing results



6.7 Implementation hardware fig (4)

6.3 Code

```
// include the library code:

#include <LiquidCrystal.h>

// initialize the library by associating any needed LCD interface pin

// with the arduino pin number it is connected to

const int rs = 12, en = 11, d4 = 5, d5 = 4, d6 = 3, d7 = 2;

LiquidCrystal lcd(rs, en, d4, d5, d6, d7);

const long interval = 990;

unsigned long previousMillis = 0;

float power=0;

float energy=0;

char receivedChar;

boolean newData = false;

float joule_price = 2.93;

unsigned long t_start=0,on=0;

boolean is_on=false, is_off=true;

void setup() {

  // set up the LCD's number of columns and rows:
```

```
  lcd.begin(16, 2);

  pinMode(13, OUTPUT);

  pinMode(A0,INPUT); // set pin a0 as input pin

  pinMode(A1,INPUT); // set pin a1 as input pin

  Serial.begin(9600); // open the serial port at 9600 bps:

}

void loop() {

   float  sensor_voltage  = get_voltage ( 200 ) ;    // 20ms

   float sensor_current = get_currentvoltage(200);   // 20ms

   double rms_voltage= (sensor_voltage+0.6)*(325/5)*(1/sqrt(2));

   String value=String(rms_voltage);

   String main="Voltage: ";

   main.concat(value); main.concat('V');

//  Serial.print(" RMS Voltage: " );

//  Serial.println(rms_voltage);

  double rms_current=(sensor_current-2.5)/(0.200)*(1/sqrt(2));

  String current="Current: ";

  current.concat(rms_current);
```

```
//  Serial.print("RMS Current: ");
//  Serial.println(rms_current);
  recvOneChar();
  showNewData();
  unsigned long currentMillis = millis();
  // this calls get_power function evry 1 sec
  if (currentMillis - previousMillis >= interval) {
    // save the last time you blinked the LED
    previousMillis = currentMillis;
//    Serial.println(currentMillis);
    get_power(rms_voltage,rms_current);
  }


}


void recvOneChar()
{
    if (Serial.available() > 0)
    {
```

```
        receivedChar = Serial.read();
        newData = true;
    }
}
void showNewData() {

    if (newData == true && receivedChar=='e')
    {
        Serial.println();
        Serial.print("The Energy consumed is ");
        Serial.print(energy); Serial.println('J');
        float price = joule_price*(energy/1000);   //for kwHr pricing
        Serial.print("The price is Rs ");
        Serial.println(price);
        newData = false;
    }

    if (newData == true && receivedChar=='o') // turn on the load
    {
```

```
        t_start=millis();  // record start time
        is_on=true;
        is_off=false;
        Serial.println();
        Serial.println("The Load is turned ON");
        digitalWrite(13,HIGH);
        newData = false;
    }
    if (newData == true && receivedChar=='f')
    {
       Serial.println();
       Serial.println("The Load is turned OFF");
       is_on=false;
       is_off=true;
       on=on + (millis()-t_start);  //record total on time
       digitalWrite(13,LOW);
       newData = false;
    }
}
```

```
float get_power(float voltage,float current)
{
  power = voltage * current;
  if(power<3){ power=0;}
  if(is_on==true)  // means the load is turned on using 'o' command
  {
//      Serial.print("On Time is ");
//      Serial.println( on + (millis()-t_start) );
    energy = power * ( (on + (millis()-t_start) )/1000);
  }
  else{
//      Serial.print("On time is");
//      Serial.println(on);
//      Serial.println(power);
    energy += power*on;
  }
  String pr= "Energy:";
  pr.concat(energy);
```

```
    pr.concat('J');


    lcd.setCursor(0,0);
    String ti="Time:"; ti.concat(millis()/1000); ti.concat('s');
    lcd.print(ti);
    lcd.setCursor(0, 1);
    lcd.print(pr);
//    Serial.print("Power is");
//    Serial.println(power);
}
float  get_voltage ( int  n_samples )
{
  float  max_voltage = 0, voltage=0 ;


  for ( int  i = 0 ; i < n_samples ; i ++ )
  {
    voltage  = analogRead ( A0 )  *  ( 5.0  /  1023.0 ) ;
    if(voltage>max_voltage){ max_voltage=voltage;}
  }
```

```
  return ( max_voltage ) ;
}


float  get_currentvoltage ( int  n_samples )
{
  float  max_voltage = 0, voltage=0 ;
  for ( int  i = 0 ; i < n_samples ; i ++ )
  {
    voltage  = analogRead ( A1 )  *  ( 5.0  /  1023.0 ) ;


    if(voltage>max_voltage){ max_voltage=voltage;}
  }
  return ( max_voltage ) ;
}
```

6.4 Results and Analysis

The Load can be controlled by using the GSM Module which is interfaced with the Arduino. Simple commands passed to the module using SMS gives us the ability to switch on and switch off the load along with ability to know the amount of energy consumed and associated price.

This project improves upon existing infrastructure by giving us the ability to control the load anywhere with a cell network. We can also know if system is still consuming power and the bill. This remote capability gives the system owner a lot of freedom and they don't have to worry about whether they switched something off at their homes before leaving. A single SMS message is enough, as long as the microcontroller and the GSM module are powered by external batteries. The possibilities of additionalities in this project are endless and we have discussed a few of them in the Future scope section

6.5 Costing

	A	B	C	D
1	**No. of Products**	**Quantity**	**Price**	**Total**
2	25 Watt Basic Low Cost Soldering Iron - Normal Tip	1	Rs.80.00	Rs.80.00
3	Bharti Flux Cored Solder Wire - 50 gm Pack (Good Quality)	1	Rs.84.00	Rs.84.00
4	Jumper Wire - Male to Female Connector - 2 Pieces Pack	6	Rs.9.00	Rs.54.00
5	Single Strand Hookup Wire - 22AWG (Gauge) - Red - 5 metre	1	Rs.35.00	Rs.35.00
6	ACS712 - 5A Range Current Sensor Module	1	Rs.116.00	Rs.116.00
7	Single Strand Hookup Wire - 22AWG (Gauge) - Black - 5 metre	1	Rs.35.00	Rs.35.00
8	3.7V 1200mAH (Lithium Polymer) Lipo Rechargeable Battery for RC Drone	1	Rs.445.00	Rs.445.00
9	170 Points Mini Breadboard SYB-170 White	1	Rs.40.00	Rs.40.00
10	16x2 (1602) Character Blue Backlight LCD Display	1	Rs.88.00	Rs.88.00
11	1K ohm Resistor - 1/2 Watt - 5 Pieces Pack	1	Rs.6.00	Rs.6.00
12	SIM800L GPRS GSM Module Micro SIM Card Core Board Quad-band TTL Serial Port	1	Rs.245.00	Rs.245.00
13	1 Channel 5V Relay Module without Optocoupler	1	Rs.50.00	Rs.50.00
14				TOTAL=Rs.1278

6.5 Problems Faced

We faced problems interfacing the energy meter with the Arduino. There is an LED on the meter called CAL LED which blinks once every time a watt-hour is consumed by the load. Our idea was to solder a wire here and then pass it on to the analog ADC pin of the Arduino. What we found was constant variations in the ADC value even when the load was off. The blinking was completely missed and appeared as the random fluctuations of value that was already initially present. We tried various configurations, once putting a wire on the anode end only, another time, taking the voltage across the led with two wires, but none of the above approaches worked. This meant we couldn’t get a reliable value of energy consumed from it, so we had to look for an alternative. We eventually settled on ACS current sensor which can sense current in the circuit and convert it to a proportional voltage.

We faced another problem with our 16x2 LCD. We found that every time we plugged in the power pin on Arduino, it stopped. After a while we figured out that the power and ground pins of the Arduino were incorrectly soldered together and so, we used our solder iron to remove the excess solder, after which it worked as expected.

Chapter 7

Conclusion and Future scope

This chapter presents the future scope of this project. It compares our system output with some other popular systems, and also concludes by summarizing the results obtained and analyzed.

7.1 Conclusion

- In the simulation part of the project we have successfully implemented working of smart energy meters. Load in the circuit is successfully controlled with the help of commands which are given on the virtual terminal and passed to the microcontroller through the serial interface. With the help of another command, total energy consumption in Joules and the associated cost for the same, can be instantly viewed. This would benefit an individual to track and manage energy and finances efficiently.
- In the Hardware implementation we were having problems with interfacing our energy meter with the other devices because later it was discovered it was faulty but instead we used current sensor because at the end energy meter is current sensor in it. We then interfaced the current sensor and now we can see the energy consumed and the price on LCD and we can turn on and off the load using the GSM module interfaced. This would be beneficial to the user to be updated about his energy consumption in real time.

7.2 Future Scope

- We can make use of cloud computing. At present we need to send a command for checking the status but with the help of cloud computing we can directly track the consumption from anywhere on the planet and furthermore, we can control the load through the cloud, without the need of onsite presence
- We can add more features to the existing system like gas sensors and temperature sensors to make a whole smart energy system for the home
- An AI can be programmed to detect patterns in the energy usage of a particular home and suggest ways of reducing consumption.

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