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**BACHELOR OF SCIENCE IN ELECTRONIC AND
TELECOMMUNICATION ENGINEERING**

Design of an IoT Based Power Monitoring & Smart Load Balancing System

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Program: B. Sc. in ETE, IIUC^{1,2,3}

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**(THIS THESIS REPORT IS SUBMITTED FOR THE PARTIAL FULFILMENT OF THE
BACHELOR OF SCIENCE IN ELECTRONIC AND TELECOMMUNICATION
ENGINEERING)**

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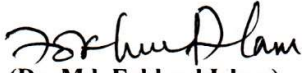
Certificate of Approval

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It is hereby declared that the work presented here in is genuine work done by us and has not concurrently submitted in candidature for any degree. The result of the thesis that we have found totally depend on our own investigation.

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ABSTRACT

Energy monitoring system has for some time been used for fundamental functionalities, for example, measure planning and charging purposes in the modern situation. Notwithstanding, the utilization of energy checking for improving energy productivity and the observing of corruption in force quality boundaries that gives significant experiences into measure debasement and deficiency finding as since quite a while ago been overlooked because of absence of capacity of the current energy checking frameworks to obtain and handle both energy and force quality information continuously. The appearance of advances, for example, the Internet of Things (IoT), Cloud figuring and Big Data has made ongoing obtaining and investigation of information conceivable. This paper examines on utilization of these advances for building up an incorporated ongoing force checking framework and its conceivable application in flaw cause-impact determination. This venture focusses on the innovations that would empower the advancement of a continuous energy checking framework and a Smart Load Balancing System.

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List of Abbreviations

IoT	Internet of Things
AMR	Automatic Meter Reading
AMI	Advanced Metering Infrastructure
RTOS	Real-Time Operating System

Chapter 1

INTRODUCTION

1.1 Introduction

The Internet of Things (IoT) is turning out to be all the more broadly utilized innovation these days. It is frequently used to allude to the developing organization for associated gadgets, or "things", that are equipped for trade information over on a low transfer speed organization. IoT is being utilized in different zones, for example, car industry, coordination's, medical care, keen matrix and savvy urban areas.

As of late, electric energy utilization development has risen fundamentally and subsequently, required significantly expanded energy supply in the coming a very long time because of expanding populace and financial turn of events. This is prompting an interest supply inadequacy [1]. In many created nations, programmed meter perusing (AMR), progressed metering foundation (AMI) or shrewd energy meter with ongoing energy data report have been executed at the family level [2-4]. Consequently, customers will actually want to see their use progressively, in the end urging them to utilize less energy to set aside cash [5]. Also, contemplates [6-8] have proposed that more energy can be saved or diminished in family unit level with constant energy utilization criticism when contrasted with regular circuitous input like month to month bills. Be that as it may, those shrewd meters are generally significant expense and require a lot of ventures on correspondence medium framework; subsequently in many non-industrial nations, these probably won't be a productive and reasonable arrangements.

Dynamic energy the board frameworks involve a sensor organization and control units gathering an enormous measure of information, which is then examined and utilized for improvement. Then again, establishment of sensors and the required cabling is costly, and in this way at times, it isn't monetarily suitable to introduce an energy the board framework. Be that as it may, new IoT based arrangements can assist with lessening the establishment exertion just as cost essentially.

Electrical energy shapes the foundation of the worldwide economy with per capita utilization expanding by 14.3 % from 2005 to 2011 [9]. The Manufacturing Industry that rules the worldwide economy represents about 42.3 % of the world power utilization [10]. This expanding pattern in the interest for electrical energy had brought about expanding costs in power. Customarily, energy cost comprised a little segment of the complete creation cost accepting generally less consideration. The increment in energy costs is driving the businesses to move towards regarding energy as an asset, which needs to be arranged and overseen for their plants as a variable information. Decrease in energy utilization for the ventures requires energy proficient activity. Energy effective assembling gives a few points of interest, for

example, cost-reserve funds, satisfaction of natural guidelines and adjusting to shopper inclination for green items. Green item is characterized by as those that are made burningthrough as little energy as could really be expected - not simply items that burn-through less energy when utilized [11]. ISO 50001 recognizes energy checking and examination as the basic exercises to be performed to improve energy productivity. Hu et al. claims that the productivity of many machine instruments are under 30 % [12].

Non-attendance of sub-metering is considered as one of the fundamental boundaries for improving energy effectiveness in both energy escalated and non-energy-concentrated ventures [13, 14]. With the presentation of sub-metering, the advantages of execution of energy proficiency practices can be evaluated as far as cost decrease which rouses interests into energy productivity programs.

As indicated by Herrmann et al. [15] comprehension and portrayal of energy utilization in machine instruments and assembling frameworks is considered as the initial move towards decrease in energy utilization. Energy saving freedoms, for example, load adjusting and proactive support relies upon the accessibility of close constant information of the energy utilization design [16].

One of the difficulties in energy the executives ascends because of the assortment of energy use across measures, every one having a novel attributes of energy utilization. The incorporation of energy the executives alongside creation the board is the key in upgrading energy productivity [17].

1.2 Motivation

Energy effective activity and proactive upkeep dependent on force investigation information requires energy utilization design in individual hardware or preparing/fabricating. This requires the assortment of adequate information for examination which requires ongoing obtaining and move of information from various sources, high preparing force and capacity of immense arrangements of information.

1.3 Objective

To design an energy monitoring system that can

- i. acquires and transfer real-time energy and power quality data to server
- ii. process and store huge sets of data in real-time
- iii. design an automatic load balancing system.

1.4 Thesis Outline

The thesis is organized as follows:

- Chapter 1 introduces the overview the topics of this research.
- Chapter 2 describes the background study of the research.
- Chapter 3 describes the methodology of the research.
- Chapter 4 represents the details of analytical analysis and result.
- Chapter 5 presents the summary of the research outcomes and shows the directions for the future research.

Chapter 2

LITERATURE REVIEW

2.1 Background Study

The 1973 Oil Crisis came about discussion on suitable utilization of the energy and prompted concentrated conversation on energy effectiveness since the time the last part of the 70s. Bunse and Vodicka [9] records three reasons improving energy proficiency in the business: energy costs, ecological guidelines and client mindfulness on naturally benevolent items.

Rodhin and Thollander [6] and Tiranni et al [5] records and talks about on different boundaries for energy productivity in non-energy concentrated and energy escalated enterprises, separately. Garetti and Taisch [3] recommends that there is a nonappearance of the necessary degree of control in energy use. This deficiency has prompted examination into strategies for assessing energy utilization designs: utilization of information on machine devices to mimic energy profiles [10], "EnergyBlocks" Methodology for anticipating energy utilization underway activities [11]. The gauging models utilized for assessing energy utilization are characterized into two classifications [8]. The first depends on driving components and the other depends on recorded information. Be that as it may, the assessed energy utilization is incorrect and accessible everywhere time stretches. Along these lines, utilization of an energy checking framework to survey energy execution with improved precision progressively is fundamental.

The idea of energy observing frameworks has for some time been utilized exclusively for distinguishing the energy devoured by the gear in an industry. The metering for an energy checking framework has been arranged into three levels [12]; and O'Driscoll and O'Donnel [13]: Facility Level, Process Chain Level and Machine Level.

The frequencies of information procurement and examination needed for the various degrees of energy checking are days for creation arranging, hours for macroplanning, and seconds for microplanning and microseconds for measure control [10].

The use of power analysis is key in perceiving measure corruption over the long haul. The utilization of energy, burden and force quality information will permit businesses to form experiences into issues that could prompt machine disappointment. The monetary results

because of the corruption in the force quality has been focused on [14]. The ongoing handling of the force quality information empowers identification of aggravations in the framework and investigation of associated occasions that might have caused the unsettling influences.

The current methodologies of energy observing frameworks come up short on the capacity for the continuous investigation of force quality information. Force quality analyzers like Fluke Power Quality Analyzers give worked in handling to ascertaining different force quality information and is intended for brief metering [15]. A legitimate execution of energy checking framework with ongoing preparing force will help in recognizing corrupting patterns in electrical frameworks permitting the attention on investigation and proactive upkeep to a particular hardware.

Shrouf and Miragliotta [8] have introduced the advantages because of appropriation of IoT and related practices. The creators considered the accompanying highlights could be empowered utilizing an IoT based Energy Monitoring System with ongoing information:

- Monitoring Power Quality

- Process design integrating energy data to reduce energy consumption
- Energy consumption adjusted based on energy price information
- Efficient use of renewable energy by adjusting production schedules
- Evaluating power generation processes

The following benefits are considered to be enhanced:

- Calculation of operational costs
- Energy efficiency of production processes increased based on real-time energy data
- Proactive maintenance based on power quality data reducing maintenance cost

2.2 Power Quality Analysis

The irregularities in the force quality can be ordered into various kinds. The fundamental peculiarities with an antagonistic impact on the gear are unequal voltage or current and sounds [18].

2.2.1 Unbalanced Voltage or Current

The size or stage deviation of the stage current and stage voltages from their appraised values is called unbalance. Voltage unbalance happens when voltages of a threephase framework are not indistinguishable or the stage distinction isn't actually 120°.

Unbalance current between the three phases can be calculated using

$$\frac{I-i}{I} \times 100\% \quad (1)$$

where, I is the rated current and i is the actual current

Similarly, unbalanced voltage can be calculated using

$$\frac{V-v}{V} \times 100\% \quad (2)$$

where, V is the rated voltage and v is the actual voltage

Usually caused by single-phase loading in a three phase system or blown-out fuse in one phase of a three-phase capacitor bank. The effects of unbalanced voltage or current are

- i. excessive drawl of reactive power,
- ii. shortening of life span of certain appliances,
- iii. degradation of FACTs controller performance,
- iv. unequal losses/heating in phases.

2.2.2 Harmonics

Caused because of charge nonlinearities of transformers, pivoting machines, arcing gadgets, semiconductor based force supplies, reactors constrained by thyristors, stage

regulators and AC controllers. Its belongings are stator and copper misfortunes in engines, stray, hysteresis misfortunes, mal-stumbling in transfers, increment in responsive influence in capacitor banks and commotion in sent signs. The other normal force quality oddities are interferences, transient under-voltage, transient over-voltage, list and swell. The oddity recognition calculations are to be actualized at various levels of the energy observing framework dependent on the time span an oddity would happen.

Chapter 3 METHODOLOGY

The Proposed model of the system is as follows. Figure 3 shows how the whole system will work. The block diagram of the system is showing that for a particular area selected how will it work. The device will collect data and based on the set values it will show the output.

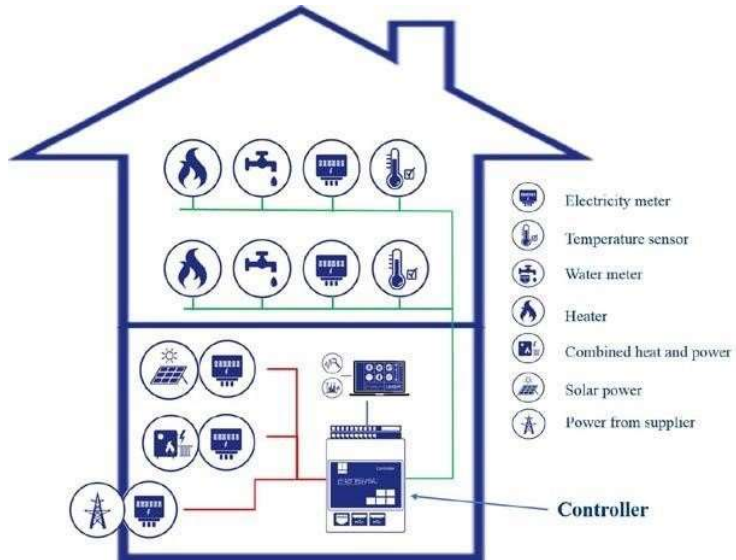


Fig. 3.1. Proposed model of the system

3.1 Proposed Model block diagram

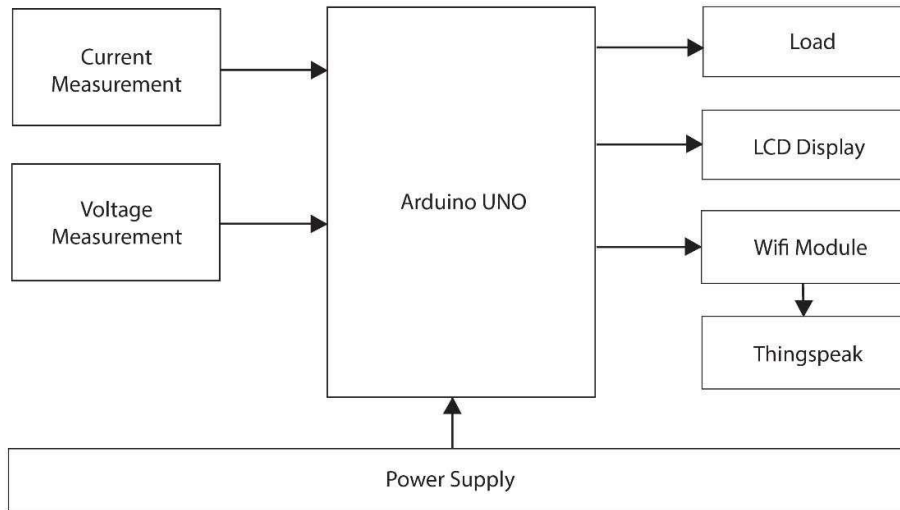


Fig. 3.2. Block diagram for proposed model of the system

3.2 Flow Chart of Proposed System

The Fig.3.3 shows the flow chart of the proposed model system.

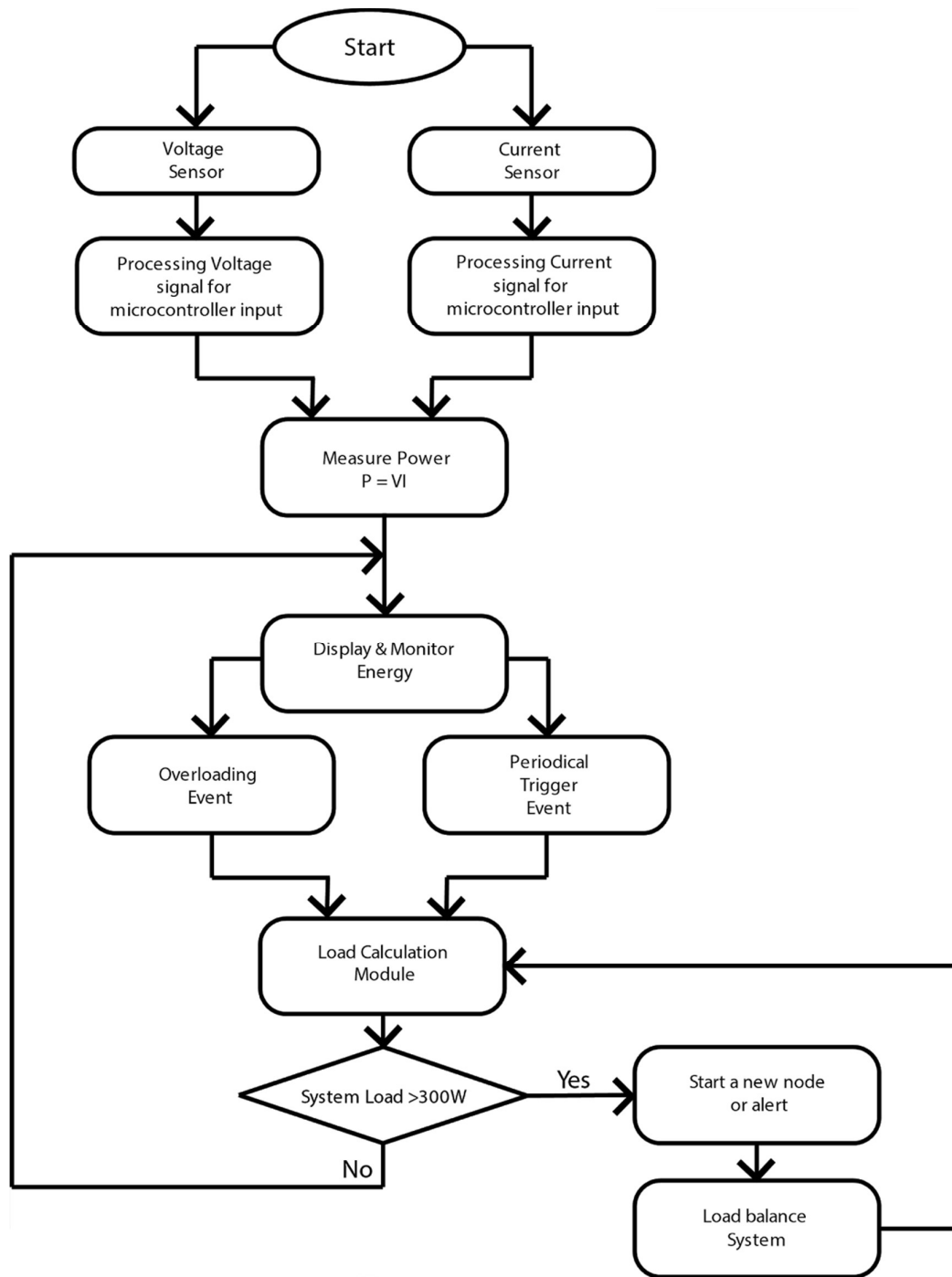


Fig. 3.3. Flow Chart for proposed model of the system

3.3 Circuit Diagram of Proposed System

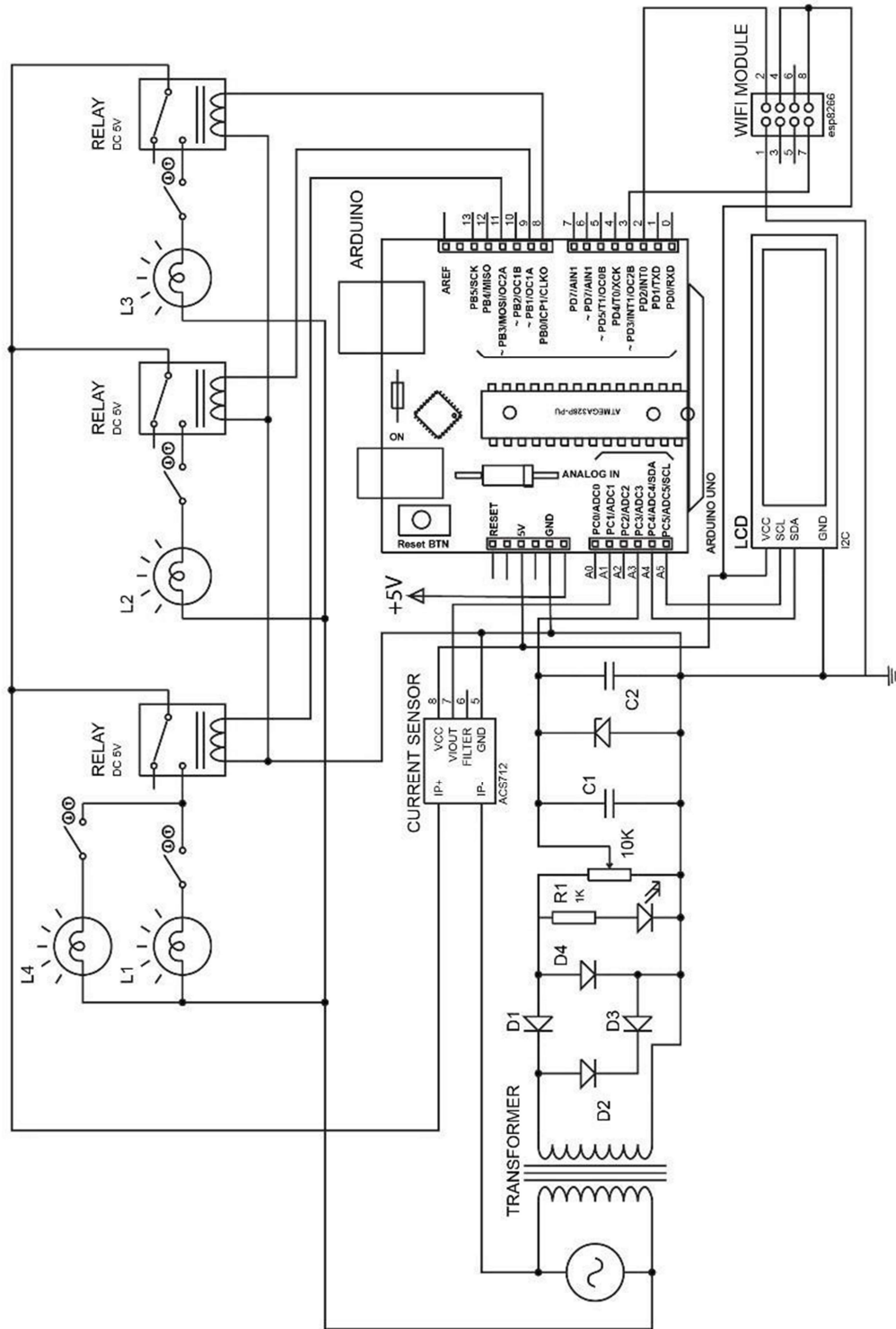


Fig. 3.4. Circuit diagram for proposed model of the system

3.4 Proposed Model in Real Life

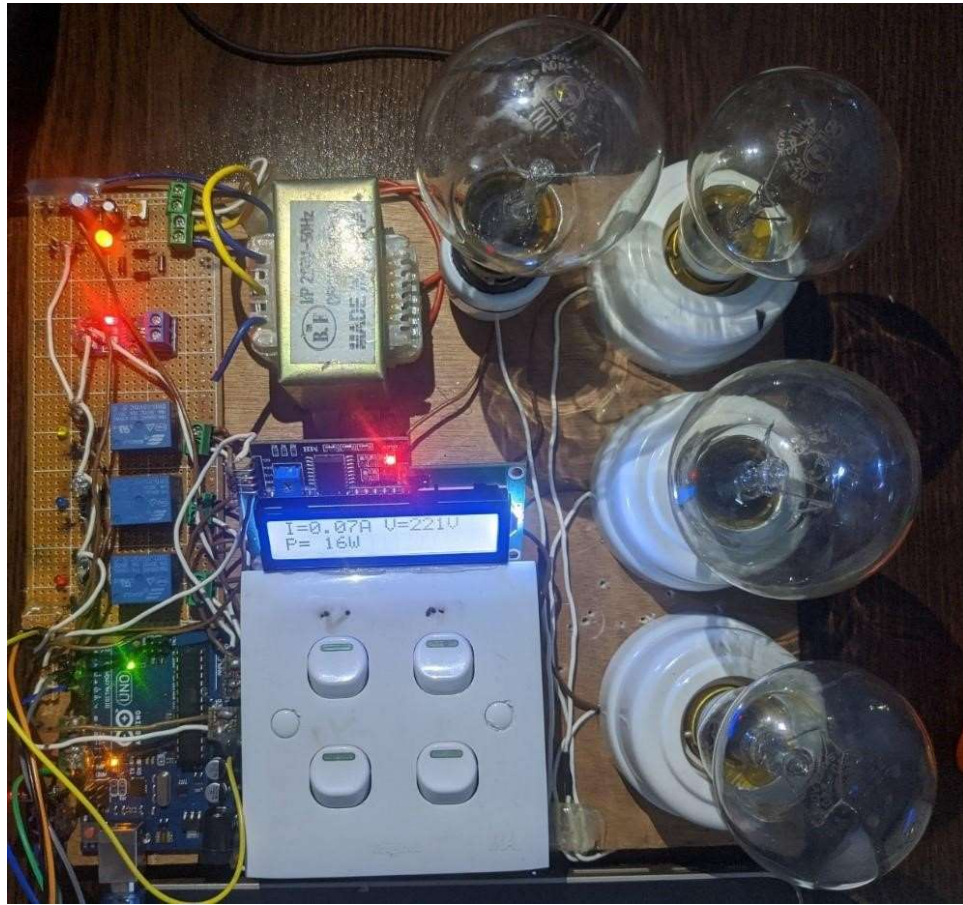


Fig. 3.5. Proposed Model in Real Life

3.5 Components of the Device

It's a device that takes data from the environment that has been selected for our research purpose. The device is built with various sensors and they take data by sensing from the environment. The sensors take analog data from the environment which later is converted into digital with the help of raspberry pi and then sent to the server where all the data are stored.

This device is consisting of the following components:

1. Arduino Uno R3
2. ESP 8266 Wi-Fi Module
3. Transformer
4. Relay
5. 5A Current Sensor

6. Diode
7. Zener Diode
8. LCD Display
9. I2c
10. Capacitor
11. Resistor
12. Variable Resistor
13. Bulb
14. Bulb Holder
15. Switch Board
16. Vero Board
17. Connectors
18. LED
- 19.

The major components are briefly discussed in the following section:

3.5.1 Arduino Uno

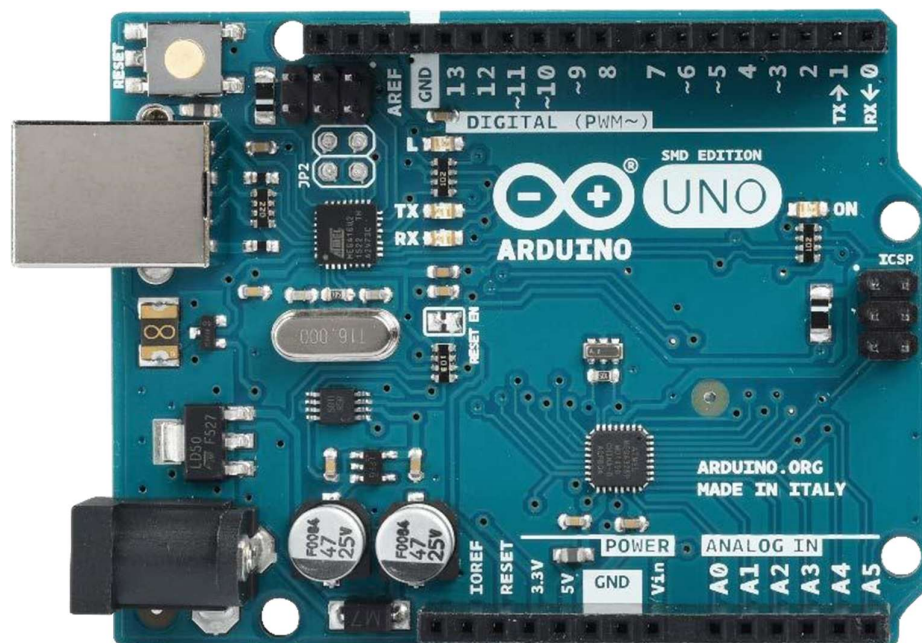


Fig. 3.6. Arduino Uno [19].

Arduino Uno is a microcontroller board dependent on the ATmega328P (datasheet). It has 14 advanced information/yield pins (of which 6 can be utilized as PWM yields), 6 simple data sources, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB association, a force jack, an ICSP header and a reset button. It contains all that expected to help the microcontroller; basically associate it to a PC with a USB link or force it with an AC-to-DC connector or battery to begin. The Pin Function of Aurdino Uno are given underneath:

Microcontroller	: ATmega328
Operating Voltage	: 5 V
Input Voltage (recommended)	: 7-12 V
Input Voltage (limit)	: 6-20 V
Digital I/O Pins	: 14 (PWM Output - 6)
Analog Input Pins	: 6
DC Current per I/O Pin	: 40 mA
DC Current for 3.3V Pin	: 50 mA
Flash Memory	: 32 KB (for Bootloader - 0.5 KB)
SRAM	: 2 KB
EEPROM	: 1 KB
Clock Speed	: 16 MHz

3.5.2 ESP 8266 Wi-Fi Module

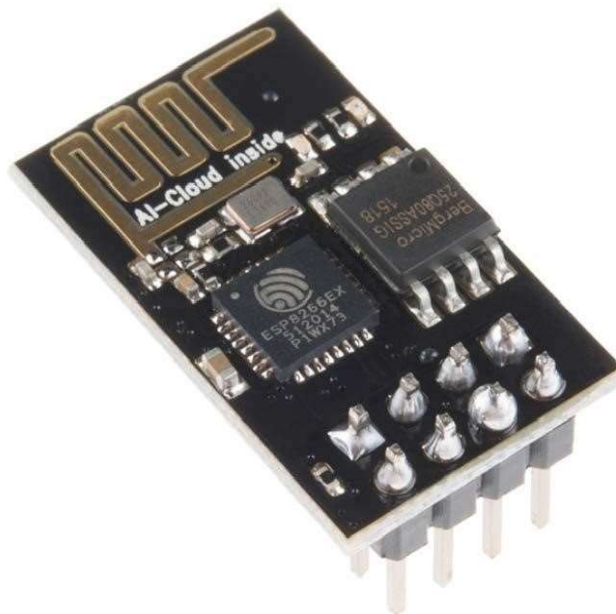


Fig. 3.7. ESP 8266 Wi-Fi Module [20].

ESP8266EX is coordinated with a 32-cycle Tensilica processor, standard advanced fringe interfaces, recieving wire switches, RF balun, power enhancer, low clamor

get speaker, channels and force the executives modules. It is equipped for working reliably in mechanical conditions, because of its wide working temperature range. With profoundly coordinated on-chip highlights and negligible outer discrete part tally, the chip offers unwavering quality, conservativeness and power. The ESP8266EX microcontroller incorporates a Tensilica L106 32-cycle RISC processor, which accomplishes extra-low force utilization and arrives at a greatest clock speed of 160 MHz. The Real-Time Operating System (RTOS) and Wi-Fi stack permit about 80% of the handling ability to be accessible for client application programming and advancement.

Table 3.1. ESP8266 Pin Configuration

Pin Number	Pin Name	Used for
1	Ground	Connected to the ground of the circuit
2	TX	Connected to Rx pin of programmer to upload program
3	GPIO-2	General purpose Input/output pin
4	CH_EN	Chip Enable – Active high
5	GPIO - 0	General purpose Input/output pin
6	Reset	Resets the module
7	RX	General purpose Input/output pin
8	Vcc	Connect to +3.3V only

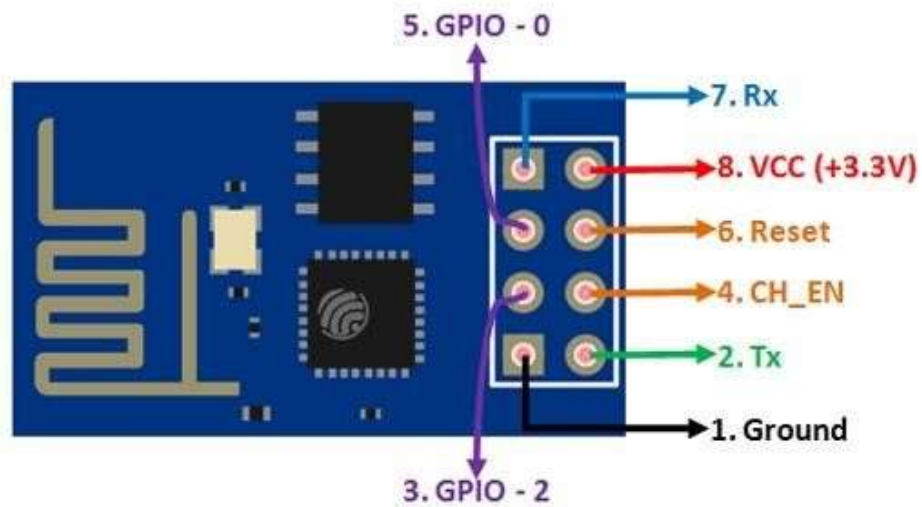


Fig. 3.8. ESP8266 Pin Configuration [20].

3.5.3 Transformer

The transformer is a static electrical gadget that moves energy by inductive coupling between its winding circuits. A differing current in the essential winding makes a shifting attractive transition in the transformer's center and accordingly a fluctuating attractive motion through the auxiliary winding.

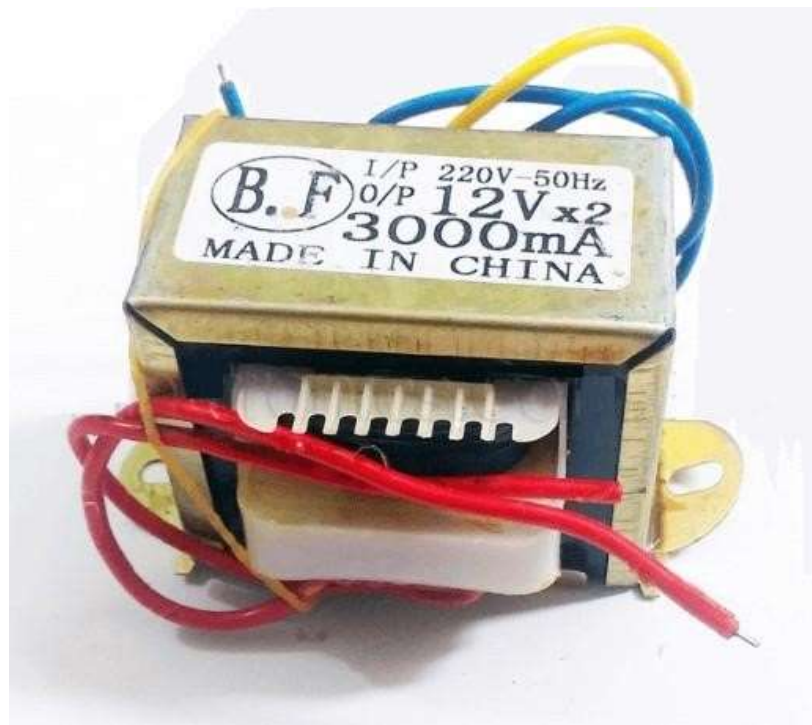


Fig. 3.9. 12V 3A Step Down Transformer [21].

12-0-12V 3Amp Center Tapped Step Down Transformer is a general purpose chassis mounting mains transformer. Transformer has 230V primary winding and center tapped secondary winding. The transformer has flying colored insulated connecting leads (Approx. 100 mm long). The Transformer act as step down transformer reducing 230V AC to 12V AC.

The specifications of 12-0-12V 3 Ampere Center Tapped Transformer are given below:

Type : Step-down Centre tapped Transformer

Input Voltage : 230V AC

Output Voltage : 12V

Output Current : 3 Amp

Mounting : Vertical mount type

Winding : Copper

3.5.4 Relay



Fig. 3.10. 5V Relay [22].

are most normally utilized exchanging gadget in hardware. There are two significant boundary of the transfer. One is the Trigger Voltage; this is the voltage needed to turn on the hand-off that is to change the contact from Common->NC to Common->NO. Our transfer here has 5V trigger voltage, yet you can likewise discover transfers of qualities 3V, 6V and even 12V so select one dependent on the accessible voltage in your task. The other boundary is your Load Voltage and Current, this is the measure of voltage or current that the NC, NO or Common terminal of the transfer could withstand, for our situation for DC it is limit of 30V and 10A. Ensure the heap you are utilizing falls into this reach.

Table 3.2. Relay Pin Configuration

Pin Number	Pin Name	Description
1	Coil End 1	Used to trigger (On/Off) the Relay, normally one end is connected to 5V and the other end to ground
2	Coil End 2	Used to trigger (On/Off) the Relay, normally one end is connected to 5V and the other end to ground
3	Common (COM)	Common is connected to one End of the Load that is to be controlled
4	Normally Close (NC)	The other end of the load is either connected to NO or NC. If connected to NC the load remains connected before trigger
5	Normally Open (NO)	The other end of the load is either connected to NO or NC. If connected to NO the load remains disconnected before trigger

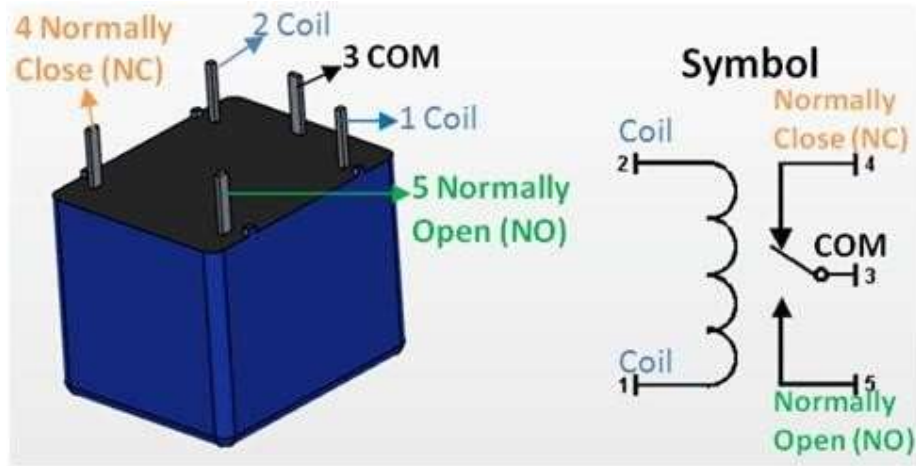


Fig. 3.11. Relay Pin Configuration [22].

3.5.5 Current Sensor ACS712-5A

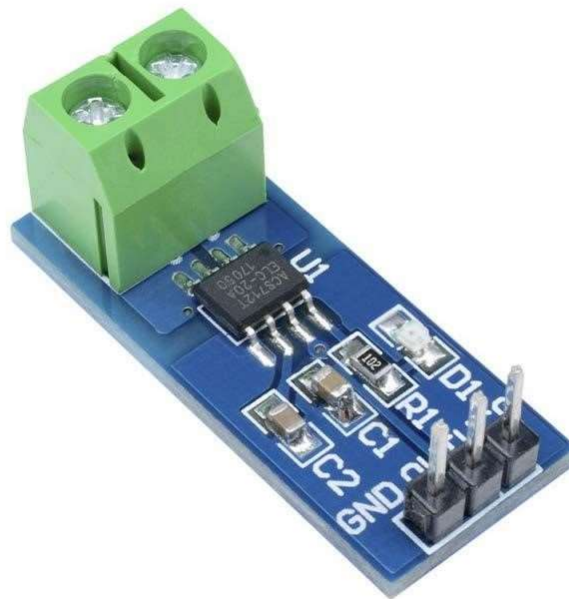


Fig. 3.12. Current Sensor ACS712-5A [23].

ACS712 is a sensor module for measuring both AC and DC current up to 5A can be measured. The output is a linear voltage between 0 to VCC, centered around $VCC/2$ at 0A. The load is connected in series to the screw terminal.

The pin description of Current Sensor ACS712-5A are given below:

Vcc (1) : Input voltage is +5V for typical applications

Output (2) : Outputs Analog voltage proportional to current

Ground (3) : Connected to ground of circuit

Wire In (T1) : The wire through current has to be measured is connected here

Wire Out (T2) : The wire through current has to be measured is connected here

3.5.6 LCD Display & I2C

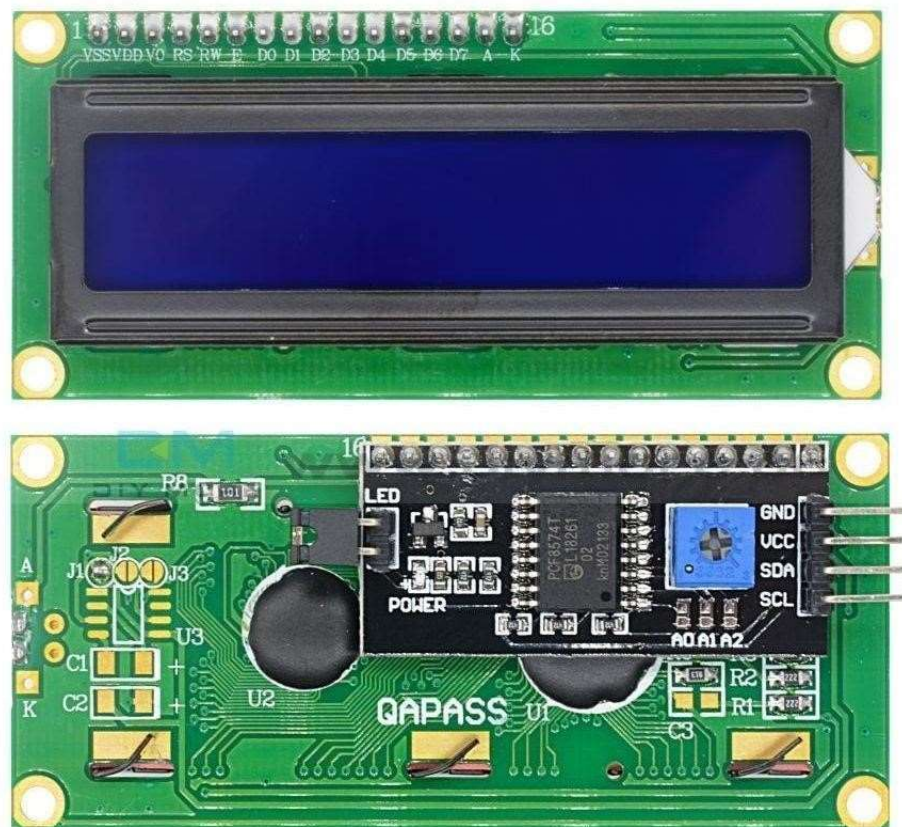


Fig. 3.13. 16×2 LCD with I2C communication interface [24].

LCD modules are generally utilized in most inserted projects, the explanation being its modest value, accessibility and developer amicable. A large portion of us would have gone over these showcases in our everyday life, either at PCO's or adding machines. The appearance and the pinouts have just been imagined above now let us get somewhat specialized. 16×2 LCD is named so on the grounds that; it has 16 Columns and 2 Rows. There are a ton of mixes accessible like, 8×1, 8×2, 10×2, 16×1, and so forth however the most utilized one is the 16×2 LCD. Typically, Arduino LCD show undertakings will run out of pin assets effectively, particularly with Arduino Uno. What's more, it is additionally extremely muddled with the wire fastening and association. This I2C 16x2 Arduino LCD Screen is utilizing an I2C correspondence interface. It implies it just necessities 4 pins for the LCD show: VCC, GND, SDA, SCL. It will save in any event 4 advanced/simple pins on Arduino. Everything connectors can be associated with the jumper wire straightforwardly.

3.5.7 Diode

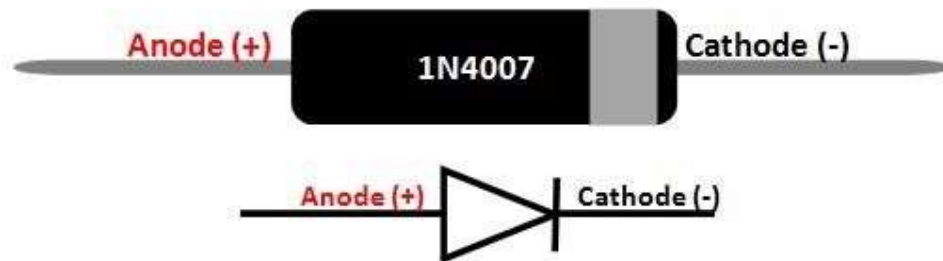


Fig. 3.14. Diode

A diode is a gadget which permits current course through just a single bearing. That is the current ought to consistently move from the Anode to cathode. The cathode terminal can be recognized by utilizing a dark bar as demonstrated in the image above.

For 1N4007 Diode, the most extreme current conveying limit is 1A it with stand tops up to 30A. Henceforth we can utilize this in circuits that are intended for under 1A. The opposite current is 5uA which is unimportant. The force dispersal of this diode is 3W. The determination of 1N4007 Diode are given beneath:

Average forward current	: 1A
Non-repetitive Peak current	: 30A
Reverse current	: 5uA

Peak repetitive Reverse voltage : 1000V

Power dissipation : 3W

3.5.8 Zener Diode

1N747A is a Zener diode from multicom that offers high unwavering quality, sharp opposite trademark, appropriate voltage adjustment over a wide application in the force gadgets field.

This Zener diode offers a 3.6V ostensible Zener voltage with $\pm 5\%$ resistance. It is a 500mW Zener diode that has a forward voltage of 1.5V. It just requires 20mA of inclination current to settle the guideline.

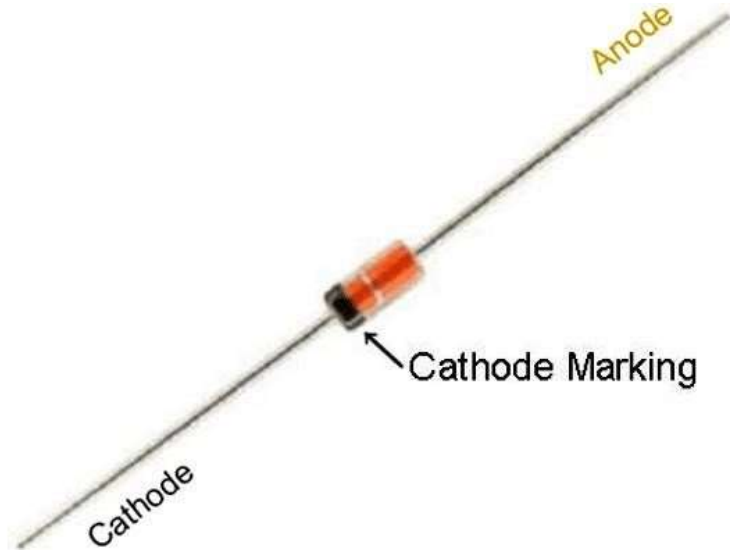


Fig. 3.15. 1N747A Zener Diode

The specification of 1N747A Zener Diode are given below:

Power rating : 500mw

Nominal Zener voltage : 3.6V

Zener voltage tolerance : $\pm 5\%$

Bias current required : 20mA

3.6 Software Requirements

1. IDE
2. THINGSPEAK website

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This chapter is all about our devices experiment and its results. We put our device in different situations to get data as much as possible.

4.2 Displaying data in LCD Display

Fig. 4.1, Fig. 4.2, Fig. 4.3 and Fig. 4.4 show the output of total voltage, current and power of active load in LCD Display respectively.

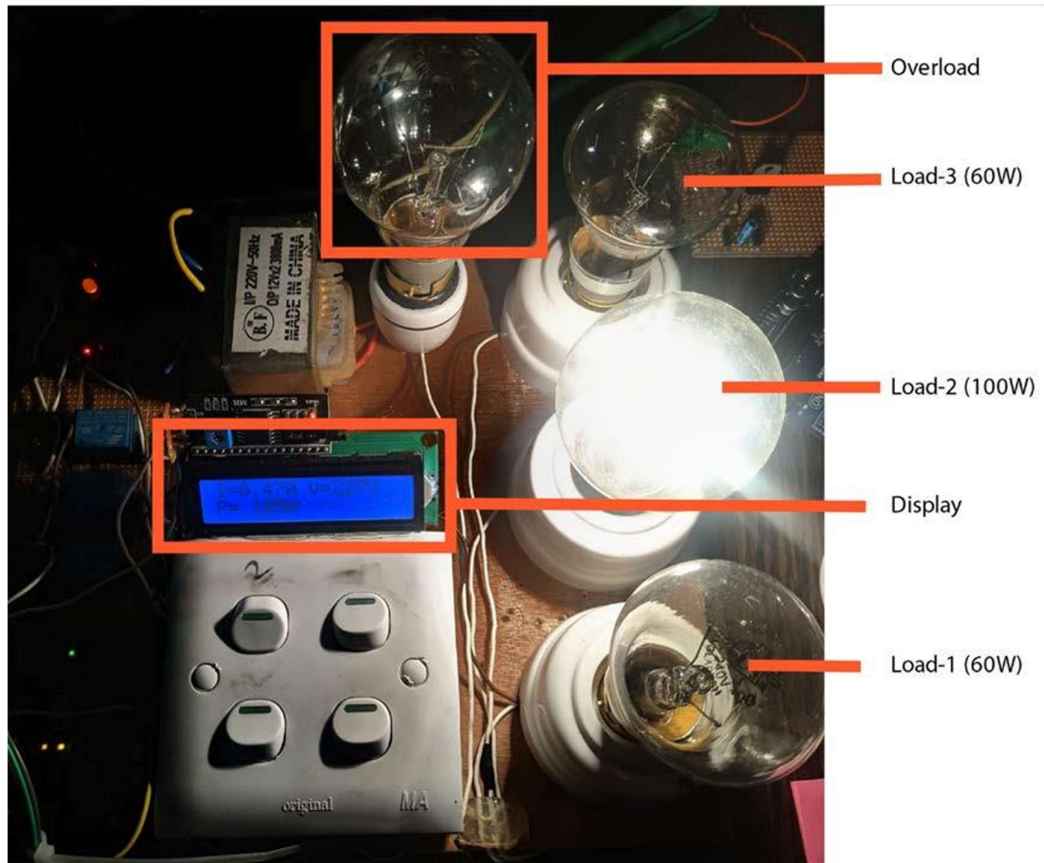


Fig. 4.1. LCD Display View (Load-2 Active)



Fig. 4.2. LCD Display View (Load-3 Active)

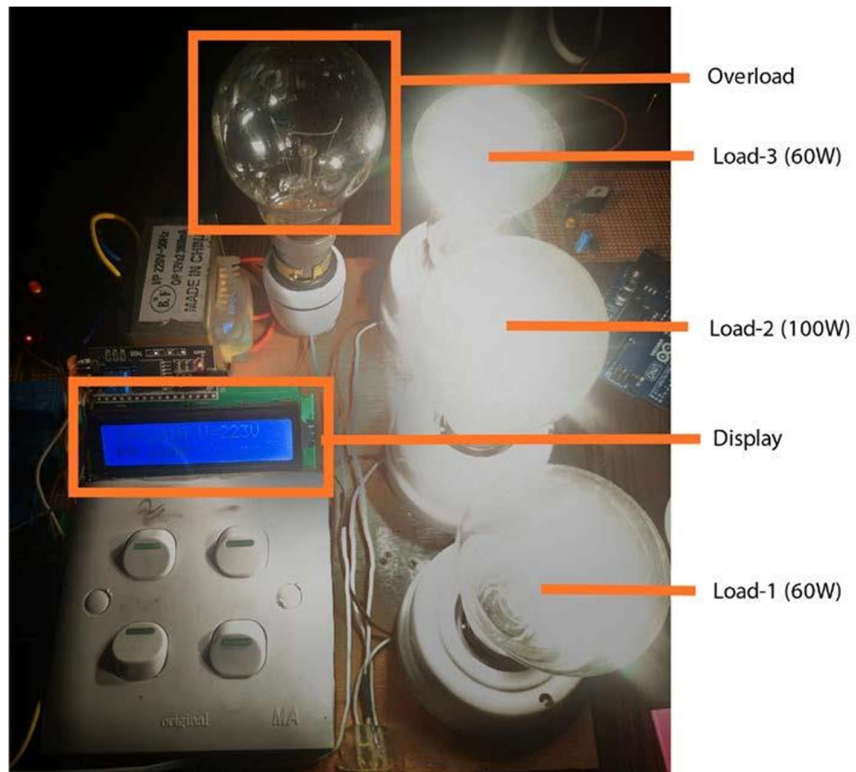


Fig. 4.3. LCD Display View (Load-1,2,3 Active)

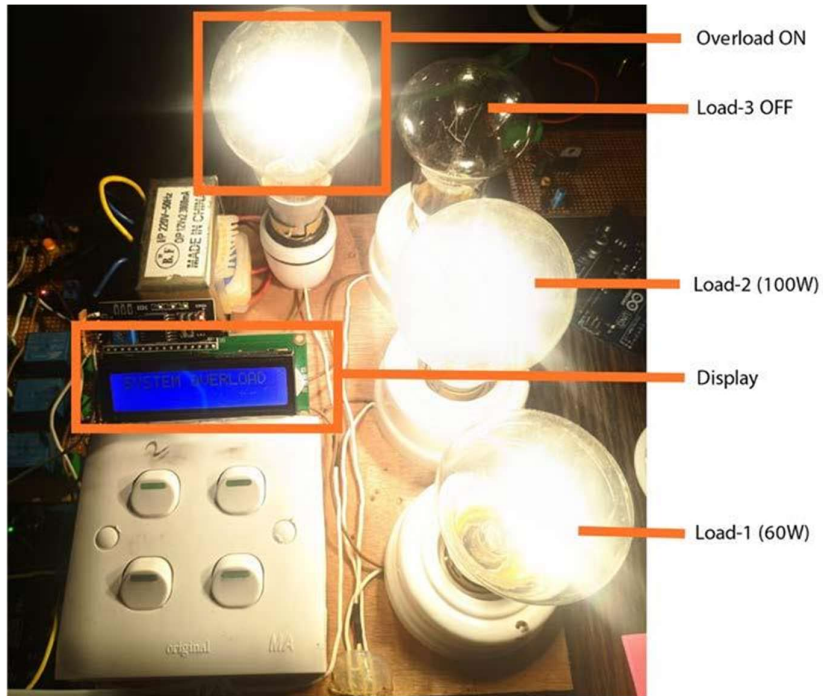


Fig. 4.4. LCD Display View (Overload active & Load-3 off)

4.3 Sending data to the cloud platform

We have selected 3 data to send over to the cloud platform. The server takes 1 input from the Arduino every 16 seconds. We took 3 variables to store the data and send it to 3 different fields of the cloud channel. Fig. 4.5, Fig. 4.6 and Fig. 4.7 show the output of current, voltage and power in the cloud platform respectively.



Fig. 4.5. Output of the device in the cloud platform (Current)



Fig. 4.6. Output of the device in the cloud platform (Voltage)

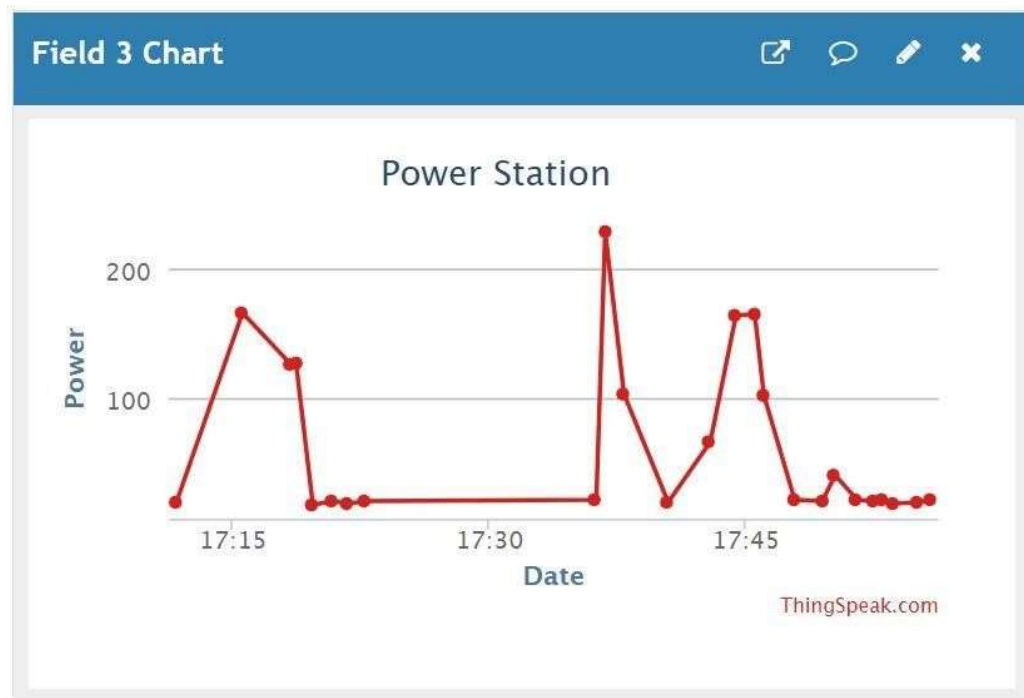


Fig. 4.7. Output of the device in the cloud platform (Power)

4.4 Result

An automatic overload balance system has been developed to monitor total energy used for a smart home application. Here, we have designed a voltage sensor and a current sensor to calculate voltage and current passing through the system. Then we have calculated total power using multiplication of voltage and current. Thus can monitor total voltage, total current and total power of the system. Here, we set the maximum threshold power is 300W. If total power in the system exceeds 300W limit, a relay has been triggered to turn off the load-3 (or we can set other load) automatically. This load balancing system can be customized for industrial and other controlling purpose. Then total active voltage, current & power have been sent to cloud platform where we can monitor total activity from anywhere in the world easily from website.

4.5 Cost Analysis

Table: 4.1: Cost Analysis of the Project

Equipment name	Quantity	Price (BDT)
Arduino UNO	1	450
Esp8266 Wi-Fi module	1	220
Transformer	1	200
Relay	3	90
5A Current Sensor	1	180
LCD Display	1	160
I2C	1	160
PCB Board	1	50
Bulb	4	200
Bulb Holder	4	160
Switch Board	4	230
	Total	2100

CHAPTER 5 CONCLUSION AND FUTURE WORKS

5.1 Conclusion

The improvement of an energy observing framework with the capacity to secure, cycle and store information progressively is needed for improving energy effectiveness tasks of the assembling enterprises and to empower proactive support. The accessibility of continuous energy and force quality information on a cloud stage alongside admittance to low inactivity recorded information and savvy load adjusting framework empowers energy saving calculations and proactive support conceivable.

5.2 Future work

The further advancement is to be done on Machine Learning calculations that will utilize the constant information to guarantee forecast of machine disappointment utilizing power quality information and approaches to improve energy productive interaction.

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APPENDIX

Source Code:

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27, 2, 1, 0, 4, 5, 6, 7, 3, POSITIVE);
#include <SoftwareSerial.h>
SoftwareSerial ser(2,3);      // RX, TX  const int sensorIn = A1; int
AcVoltOut, Power; int mVperAmp = 185; // use 100 for 20A Module
and 66 for 30A Module int LoadA = 8; int LoadB = 9; int LoadC = 11;
double Voltage = 0; double VRMS = 0.00; double AmpsRMS = 0.00;
float Volt = A3;

String apiKey = "UFJO9FK65YPWTTEQ";

void setup(){ Serial.begin(115200); lcd.begin(16,2);
pinMode(Volt, INPUT);  pinMode(8,OUTPUT);
digitalWrite(8,HIGH);  pinMode(9,OUTPUT);
digitalWrite(9,HIGH);  pinMode(11,OUTPUT);
digitalWrite(11,HIGH); ser.begin(115200);          //
reset ESP8266 ser.println("AT+RST");             //
Resetting ESP8266 char inv ="";
String cmd = "AT+CWJAP";
String Host_Name = "Emu";    // Edit Host_Name String
Password = "emu1234"; // Edit  cmd+="="; cmd+= inv;
cmd+= Host_Name; cmd+= inv; cmd+= ",";
cmd+= inv; cmd+= Password;
cmd+=
inv;
ser.println(cmd);          // Connecting ESP8266 to your WiFi Router }

void loop(){

Voltage = getVPP();
VRMS = (Voltage/2.0) *0.707; //root 2 is 0.707
```

```

AmpsRMS = (VRMS * 1000)/mVperAmp;
Serial.print(AmpsRMS);
Serial.println("Amps RMS");

int AcVolt = analogRead(Volt); //Read the division at analog pin A0 (0 to 1023)
    AcVoltOut = (AcVolt * (5.0 / 1023))*81.7; // Convert the AC division into volt
Serial.print("Volt:");
    Serial.print(AcVoltOut);

    Power=AcVoltOut*AmpsRMS;
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("I=");
lcd.print(AmpsRMS );
lcd.print("A ");
lcd.print("V=");
lcd.print(AcVoltOut );
    lcd.print("V");

    lcd.setCursor(0, 1);
lcd.print("P= " );
lcd.print(Power);
lcd.print("W ");
if(Power>300){    digitalWri
te(9,LOW);
lcd.clear();    lcd.setCursor(0, 0);
lcd.print("SYSTEM OVERLOAD");
    delay(5000);
    }

else{    digitalWrite(9,HIG
H);
    }

```

```

String state1=String(AmpsRMS);          // Converting them to string
String state2=String(AcVoltOut);
String state3=String(Power);

String cmd = "AT+CIPSTART=\"TCP\", \"";    // Establishing TCP connection
cmd += "184.106.153.149";                // api.thingspeak.com cmd += "\",80\r\n\r\n";
// port 80

ser.println(cmd); Serial.println(cmd);

if(ser.find("Error")){

    Serial.println("AT+CIPSTART      error");
return;
}

String getStr = "GET /update?api_key=";    // prepare GET string

getStr      +=      apiKey; getStr += "&field1=";
getStr += String(state1);                // Humidity Data
getStr += "&field2="; getStr += String(state2); getStr
+= "&field3="; getStr += String(state3); getStr +=
"\r\n\r\n";

cmd = "AT+CIPSEND=";
cmd += String(getStr.length());          // Total Length of data

ser.println(cmd); Serial.println(cmd);

if(ser.find(">")){

    ser.print(getStr);
Serial.print(getStr);

```

```

}

else{

    ser.println("AT+CIPCLOSE");           // closing connection

    // alert user

    Serial.println("AT+CIPCLOSE");
}
}

double getVPP() { double result; int
readValue; //value read from the sensor int
maxValue = 0; // store max value here int
minValue = 1024; // store min value here
uint32_t start_time = millis();
while((millis()-start_time) <= 50) //sample
for 3 Sec
{
readValue = analogRead(sensorIn); //
see if you have a new maxValue if
(readValue > maxValue)
{
/*record the maximum sensor value*/ maxValue
= readValue;
}    if (readValue <
minValue)
{
/*record the minimum sensor value*/ minValue
= readValue;
}
}
}

///// Subtract min from max result=((maxValue-minValue)*

```

```
5.0)/1024.0; return  
result;  
}
```