



Energy Data Logger Using Internet Of Things (IoT)

By:

Tahir Ali	1424100
Qadir Khan	152488
Abdul Haleem	152482
Iyad Alawawda	142499

THIS THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE BACHELORS OF SCIENCE (B.S.C)

SUPERVISED BY

ASSOCIATE PROF. KHONDOKAR HABIBUL KABIR

**DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT), GAZIPUR, BANGLADESH**

NOVEMBER, 2019

DECLARATION OF CANDIDATE

I hereby declare that this project report is based on our original work except for citations and Quotations, which have been duly acknowledge. We also declare that it has not been previously, concurrently submitted for any other degree or award at **IUT** or other institutions.

Signature of Supervisor:

Signature of Authors

Dr. Kandhokar Habibul Kabir

Associate. Professor

Department of Electrical & Electronics

Engineering

Islamic University of Technology (IUT)

Tahir Ali

(1424100)

Qadir Khan

(152488)

Abdul Haleem

(152482)

Iyad Alawawda

(142499)

DEDICATION

I would like to dedicate this thesis to my family who supported me through both good and tough times. They always give me the motivation to move forward in my life.

ACKNOWLEDEMENTS

All the praises are due to the merciful almighty ALLAH (SWT), the most exalted the most Beneficent, the most Merciful who blessed me to be here at Islamic University of Technology (IUT) for pursuing the Bachelor's degree.

Our Journey towards the Bachelor's degree would not have been possible without the help of many people. It is our great pleasure to take this opportunity to thank them for their support and advice that we received.

We are highly grateful to our respected supervisor, **AssociateProf. Dr. Khondokar Habibul Kabir**, for his guidance and support for this thesis. Without his bolstering influence as well as buttress to move on, we would not be intrigued, let alone to work in this area of science. He truly inspires us to be a genuine scientist and conduct research in a proper constructive way.

We would like to thank all the faculty members of EEE Dept., IUT for their continuous support and encouragement. They provided a friendly environment for us to learn and grow.

Finally, our deepest of gratitude goes to our family who always listened to our sufferings and enchanted us with their delightful words. Last but not the least we would like to thank our friends who always supported us through this journey.

ABSTRACT

IoT (Internet of things) has become an interesting topic in the field of technological research. It is basically, interconnecting of devices with each other over the internet. We typically think of the Internet of things (IoT) in terms of autonomous cars and smart homes, but some of the best applications of IoT technology are in fields that are intensely practical. One such example is Digital data logging which is a standalone device that can read electrical signals from measurement devices and store the data to server. A Voltage sensor, Current sensor and multichannel temperature logger is connected to developed Wi-Fi module Esp8266 (NodeMcu) to measure and record voltage, current, energy and the temperature of different devices, home appliances etc. capable of sensing voltage up to 440V, Current 350A and temperature with a range of 0 °C up to 50 °C, depending on the type of sensor connected. The Esp8266 Wi-Fi module receives the analogue voltage, current, temperature data from particular sensors and conversion to digital data is performed. The voltage, current and temperature reading is then uploaded to server via internet. So that it can be retrieved later on a computer. The measured data will be stored at the intervals of 1second, 5 seconds, 10 seconds, or 1 minute, at user's preference. The logger will be disconnected automatically if exceeds preset values by user and protected by single channel relay. Voltage, Current and Temperature sensors are tested to prove they have the same properties for the output voltage, current, temperature and humidity sensitivity before applied to the system.

This project is focused on the consumption of energy of a particular area and particular device. If we calculate energy consumption for one-week of any particular site or electrical equipment, then we can predict the consumption of energy for coming weeks, month and years of that site or electrical equipment. Thus, we can save energy and save money. It has potential to become a low-cost energy logger for laboratory, factory, home and offices use if the hardware is further developed.

Table of Contents

CHAPTER 01

Introduction

1.1 Introduction	14
1.2 Project Background	14
1.3 Problem Statement	14
1.4 Research Motivation	15
1.5 Project objective	15
1.6 Project Scope	15

CHAPTER02

2 Internet of Thing (IoT)

2.1 Introduction	18
2.2 Internet of Things (IoT)	19
2.3 IoT definition	20
2.4 IoT elements	22
2.5 IoT applications23
2.6 Signal sensing method	24
2.7 Summary	24

CHAPTER 03

3 Hardware and Software

3.1 Introduction	26
3.2 Data Logger Description.	26
3.3 Choice of Components.	27
3.3.1 Bread Board	28
3.3.2 Connecting wires	29
3.3.3 Esp8266	29
3.3.4 Current sensor	31
3.3.5 DHT11 Sensor.	32
3.3.6 Single Channel Relay	34
3.4 Hardware Mechanism	36
3.4.1 Site allocation	36
3.4.2 Data Logging.	36
3.5 Software	36
3.5.1 Arduino IDE.	36
3.5.2 Programming of Esp8266	37
3.5.3 Web Interfacing.	44
3.5.4 Screen-shot of Web page.	44
3.5.5 Screen-shot of Data Acquisition	46
3.6 Summary.	46

CHAPTER 04

4 Working Process

Working Process	48
4.1 Block Diagram	48
4.2 Flow Chart	49
4.3 Project View	50

CHAPTER 05

5 Experimental Studies

5.1 Hardware Implementation	53
5.2 Data analysis, Result and Decision	53

CHAPTER 06

6 Device Impact

6.1 Health and Safety	61
6.2 Lower Energy Consumption	61

CHAPTER 07

7 Conclusion and Future Work

7.1 Future Work	63
7.2 Conclusion.	64

<u>REFERNCES</u>	65
-----------------------------------	----

LIST OF FIGURES

Figure 2.1. Smart home full of smart and sensing IoT devices.

Figure 2.2. The Internet of Things emergence between 2008 and 2009

Figure 2.3. The IoT evolution

Figure 2.4. The elements of the IoT

Figure 3.1. Bread Board

Figure. 3.2. Connecting Wires

Figure 3.3. ESP8266 (Wi-Fi Module)

Figure 3.4. ACS712 Current Sensor

Figure 3.5. Voltage vs. Current graph

Figure 3.6. DHT11 (Temperature and Humidity) sensor

Figure3.7. Single channel relay

Figure 3.8. Arduino IDE

Figure 3.9. Webpage to Display Parameters

Figure 3.10.Data acquisition

Figure 5.1. Humidity Graph

Figure 4.1. Block Diagram

Figure 4.2. Flow chart

Figure 5.2. Temperature graph

Figure 5.3. Energy graph

Figure 5.4. Voltage graph

Figure 5.5. Current graph

Figure 5.6. Voltage, Temperature and humidity values

Figure. 5.7. Temperature, Humidity and Current values on mobile

Figure. 5.8. Voltage and current values on mobile

LIST OF TABLES

Table 3.1 Components of Project

LIST OF ABBREVIATIONS

IoT Internet of Things

V Voltage

C Current

OppS Opportunistic sensing

PC Personal Computers

IBSG Internet Business Solutions Group

RFID Radio-frequency identification

IERC European Research Cluster on the Internet of Things

WSNs Wireless Sensor Networks

BLE Bluetooth Low Energy

RH Relative humidity

NO Normally-open

NC Normally-closed

CHAPTER
1
INTRODUCTION

1 Introduction

This chapter introduces the main areas in this thesis, which are linked to the Internet of Things and opportunistic sensing paradigms. The chapter presents the motivation and defines the aims of this research work. Further, the thesis contributions are highlighted. Also, this chapter includes a section that introduces the sustainability aspects of this thesis.

1.1 Project Background

Energy data logger is energy monitoring devices that easy to use for analyzing the energy consumption on electrical appliance. This device records data overtime and store it in to cloud for monitoring process. Furthermore, it also displays the energy consumption in real time via ThingSpeak. It is very useful for monitoring efficiency of the electrical usage so people do not waste the energy. The element of data logging system for this project is shows in Figure 1.0. The Energy Data Logger can detect the unseen fault in appliance such overloading. It will display increasing in energy consumption directly to the cloud. A faulty appliance can cause by several effect mainly in motor powered appliance like washing machine. The communication between hardware and computer are establishing using computer Hyper-Terminal link that read the data from hardware. This energy meter can act as precaution device that tells user the state of their appliance. User can repair their appliance before it's too late because they have been warned by the spiking in energy usage by the faulty appliance.

1.2 Problem Statement

The conventional Energy Meter only displays numbers that must be calculated later to get the actual energy usage. Because of this the consumer do not aware of their energy usage and will use it unintentionally although the energy usage is exceeded their monthly expectation. As the consumers do not know their energy usage, they only know the usage at the end of the month and nothing they can do to overcome this problem. This problem can affect more to the consumer that has big family with so many appliances running at once. The energy meter also cannot record the energy usage that can be monitored by consumer in order to prevent over

consuming the energy. They also cannot analyze the energy consumption if some faulty appliance making energy usage higher than it should.

1.3 Research Motivation

Nowadays, big buildings are being equipped with an increasing number of electrical devices. Some building has bulk number of electrical and electronics devices. The monthly bill is due for let's say a whole apartment; it will not describe that which device has consumed more energy. For that reason, we are suggesting installation of energy data loggers to monitor the consumption of energy particularly. Thus, we can save energy by monitoring the consumption of electrical energy for particular device using over use and save the energy and money at a time.

1.4 Project Objective

1. The first objective of this project is to design a device and system that can display energy usage in real-time in kWh unit. The data from the energy meter can also be display in computer using serial communication.
2. Then, to record energy usages in user residence so the energy consumption in that residence can be monitored in order to use energy efficiently. The recording or logging process is controlled by the PIC and the data taken is stored in EEPROM. The data can be access using computer interface generated by Microsoft Visual Basic.
3. The appropriate graph can be also generated to give user clearer view of their energy consumption. This graph will analyze and evaluate of the total energy consumption a lot easier. The accomplishing in building this system can surely make user more aware and effective in using electrical energy.

1.5 Project Scope

The scope of this project will cover both software and hardware development. The hardware part is about designing suitable circuit, Printed Circuit Board (PCB) layout and also includes the correct component to make the hardware work as desired. After completing assembles the component, hardware test is needed to confirm it functionality. While for software development,

it will include developing the system coding using C++ for the Esp8266. The system coding must correctly integrate with the project input/output component such sensors and cloud display. Proteus 7.8 were used as simulation software for both hardware and software development. Then, the interface for the computer to displaying the data from project is created using ThingSpeak. The interface must properly in sync with the hardware so it can read the data. The software such ThingSpeak and its driver also needed in order to make the interface working.

CHAPTER

2

INTERNET OF THINGS (IoT)

2.1 Introduction

The modern world of technologies develops rapidly and brings considerable changes to human life. Gradually, everything that surrounds people in their everyday life becomes smart and makes it easier and more comfortable. Such smart things that already exist are smart devices (e.g. smart phones, tablets, watches, TV), smart transportation (e.g. cars, buses, trains), smart buildings (e.g. houses, business centers, shopping malls). They serve a human user in automatic and collaborative manner while the user does not need to make big efforts to exploit them. They communicate with each other, thereby, creating a network that can also interact with the world. This is enabled via the Internet of Things (IoT) that interconnects different objects like smart phones, watches, cars, sensors, etc. According to Gartner, by the end of this year (2019) the number of connected things which will be used all around the world will reach 8.4 billion (see Figure 1). This number has increased from 2019 to more than 21% and will grow up to 20.4 billion by 2020. This can cause to concern about the amount of energy consumed by these devices. However, the IoT can also become one of the crucial drivers of green Information and Communication Technologies (ICT), if there is an increased focus on energy efficiency. According to GeSI's report SMARTer 2030, ICT can facilitate to reduce the amount of global *CO2* emissions by 20 till 2030. Therefore, academia, industry, and government are interested in developing the IoT technologies and systems that introduce sustainable development to the world. The authors of Green internet of things for smart world highlighted green ICT principles leading to energy efficiency improvement of the IoT area. One of the principles is a length minimization of the wireless data path. It is important especially for IoT systems gathering and transferring an enormous amount of data via wireless connections. The principle can be achieved using opportunistic sensing (OppS) which utilizes the opportunity of collecting data about an environment from IoT devices (sensors) using mobile smart gadgets (e.g. smart phones, tablets, PCs etc.) carried by people, without their direct involvement. Thus, there is no need in predefined infrastructure and additional hardware. Moreover, as the devices and sensors communicate directly without mediator hops, it reduces the usage of bandwidth and, consequently, energy consumption.



Figure 2.1. Smart Home full of smart and sensing IoT devices

The world's rapid development has also brought negative consequences. One of them is over use of electrical energy. Therefore, the knowledge of over use of electrical energy becomes vital, because it affects our rural areas through load shedding. There are many people who just turn on lights, different devices and don't turn them off causing wastage of electricity and huge amount of electricity bills. Moreover, the recent search states that the demand of electricity will be 79% more in 2050 as compared to 2019.

Notably, modern people spend, on average, about 90% of their time indoors where they use different electric and electronic appliances causing the wastage of electrical energy. It is important to monitor the consumption of electricity and the wastage of electricity.

2.2 Internet of Things (IoT)

Internet of Things (IoT) plays a huge role in the modern world. It is a major enabling technology for future smart cities. In this section, we review this paradigm and its components.

2.3 IoT definition

The Internet of Things (IoT), or Internet of Objects, was proposed as a concept by Kevin Ashton in 1999. He referred it to interconnected objects with radio-frequency identification (RFID) technology. However, there is still no exact definition of the IoT paradigm today. Many visions were presented during these years, some of them are discussed further. For instance, the Cisco Internet Business Solutions Group (IBSG) in 2011 presented it as the pointing time when the number of "things or objects" connected to the Internet exceeded the world population. Moreover, IBSG assumes it happened between 2008 and 2009 (see Figure 2). European Research Cluster on the Internet of Things (IERC) generally defines the IoT as "dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual "things" have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network". The definition of "things" changes with evolution of the technology depicted on Figure 2.2.

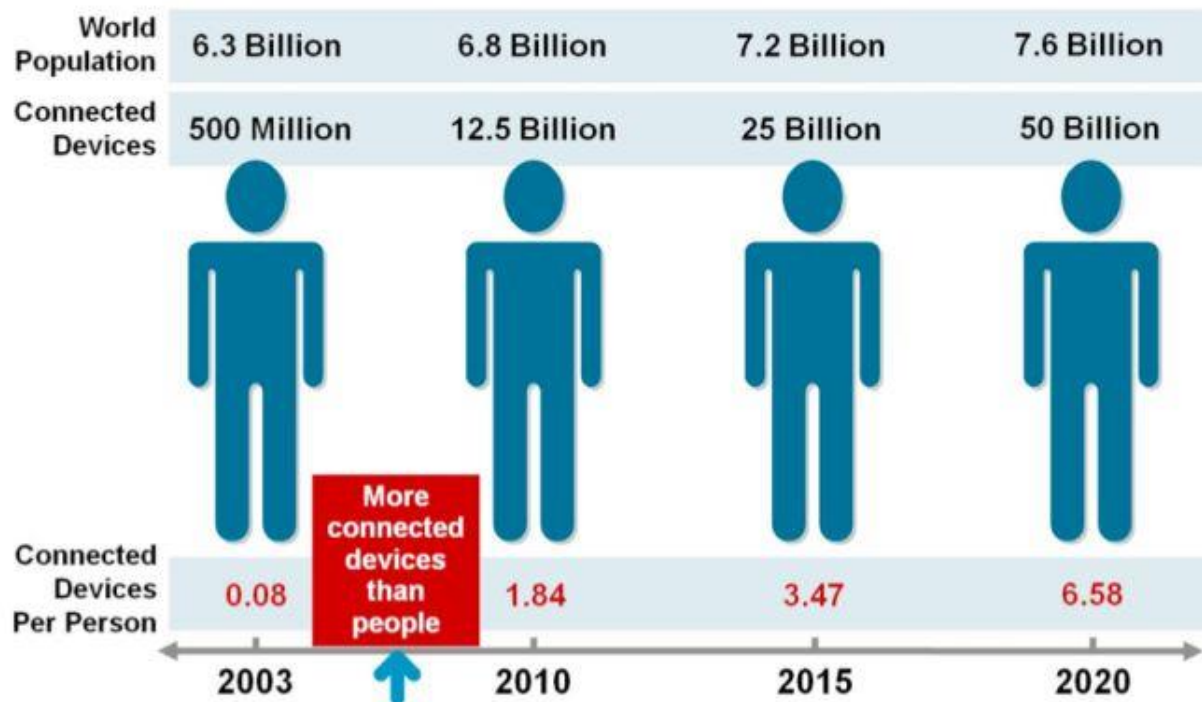


Figure 2.2 The Internet of Things emergence between 2008 and 2009

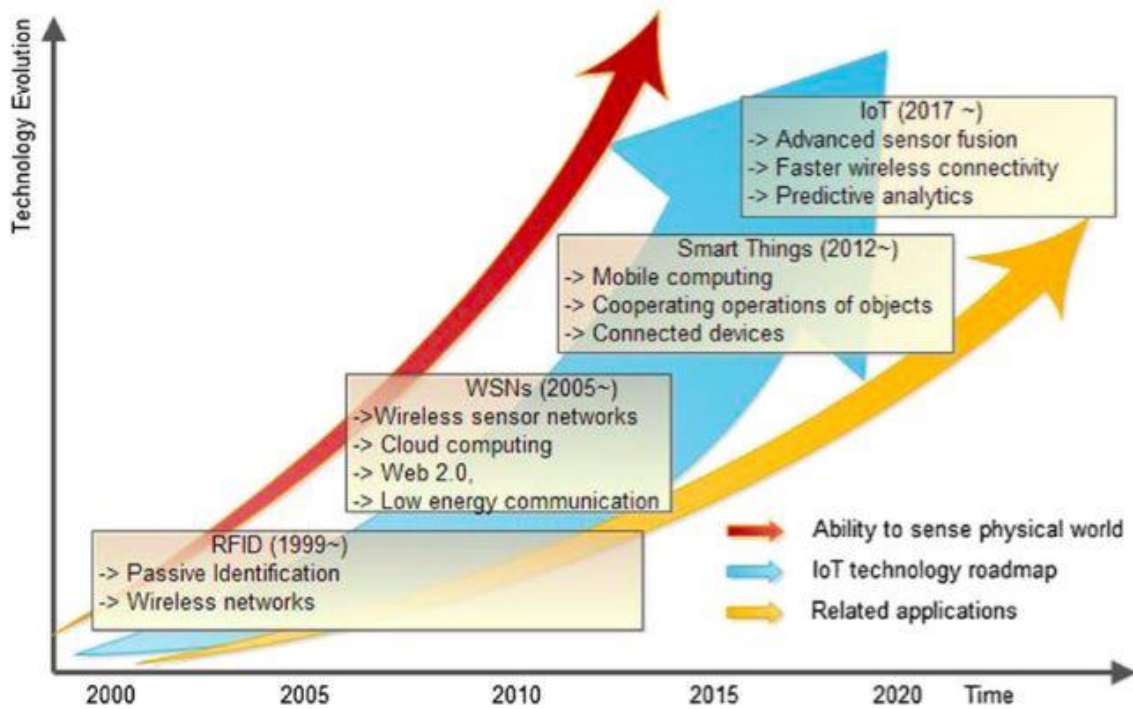


Figure 2.3. The IoT evolution

- Things-oriented - focused on the "objects" and on approaches for their identification and integration;
- Internet-oriented - adapting IP to make anything addressable and reachable from anywhere;
- Semantics-oriented - utilizing semantic technologies for data managing, storing and representing in the continuously growing network of things.
- They state that the IoT is a combination of these visions. To summarize, the IoT implies an infrastructure of smart devices (e.g. smart phones, tablets, laptops etc.) connected to the world-wide network where they communicate and exchange data with other "objects". Moreover, it allows sensing and remotely controlling such "objects" as sensors, and also processing any received information without human intervention.

2.4 IoT elements

The IoT systems do not have standardized list of the components they can contain. However, defines six elements which deliver the IoT functionality (see Figure 4):



Figure 2.4. The elements of the IoT

- Identification within the IoT paradigm implies naming (setting an ID and address) and matching services with their demand;
- Sensing means data collection from the network objects (smart sensors, actuators, wearable devices) and send it to some central sink like database or cloud;
- Communication includes technologies linking all objects together while consuming low power like Wi-Fi, Bluetooth, Z-wave, LTE-Advanced and etc.;
- Computation represents processing units (e.g. microprocessors and micro-controllers like Arduino, Esp8266, Intel, Galileo) and software applications (e.g. Blynk and ThingSpeak IoT) which execute computational ability of "things";
- Services perform some work for different applications;
- Semantics refer to the ability of knowledge extraction (recognition and analysis of data) using different machines in a smart way.

The first three elements are also highlighted in as a class of the enabling technologies. also emphasized other five IoT components from the more high-level perspective:

- Radio Frequency Identification (RFID),

- Wireless Sensor Networks (WSNs),
- addressing schemes,
- data storage and analytics,
- Visualization.

Indeed, the first four technologies perform features of the communication, sensing, identification and semantics elements described above. Noteworthy, WSNs play one of the crucial roles in the IoT paradigm as they bring a wide range of applications, through capability of sensing different environmental phenomenon. However, WSNs within the IoT paradigm differs from the conventional ones in terms of using smarter devices instead of simple sensors constrained with only sensing abilities. These devices have computational ability and consist of several different sensors. Therefore, they can make certain decisions autonomously and provide different services. Further, in this thesis, they are called sensing IoT devices. Thus, the elements defined by can be considered as basic components of the IoT systems. Further, this thesis takes into account these components during development of the proposed system.

2.5 IoT applications

The wide capabilities of the IoT bring an opportunity to apply it in all spheres of human life in order to enhance its quality. The major areas where the IoT is currently being integrated are smart homes/buildings, smart cities, environmental monitoring, healthcare, smart business/inventory and product management, security and surveillance. The general application scenario implies a system containing smart devices, sensors for different measurements communicating with each other and some central station via RF technologies like Wi-Fi, Bluetooth Low Energy (BLE), ZigBee and etc. The station collects and analyses data from them. According to the analysis, it can make some decisions and notify the system to perform some action. Thereby, the system needs a minimal human involvement to the data processing. There are still many fields where the IoT can be introduced to contribute towards their improvement and automation. We have chosen to apply our system to energy data logging.

2.6 Signal sensing method

The NodeMcu Esp8266 with the help of sensors connected to it senses the different parameters like Voltage, Current, Temperature, Humidity and energy. After sensing all parameters, it sends the data to the web server where we can see our real time data uploading and update with 10 seconds interval of time

2.7 Summary

This chapter has discussed the IoT and OppS paradigms in details. It has reviewed several works developed in this domain. Due to this, we identified a gap of these systems. They do not utilize any specific approach to collect the raw data from sensing actuators to enhance the efficiency of their system. In the implementations, they used to collect data with mobile smart devices from nearby sensors thereby applying OppS paradigm. They do not consider that these sensors might produce low accuracy data or even are not connectible because their signal strength is too low. However, the introduction of an approach that identifies efficient sensors can improve the effectiveness of this stage in the IoT systems. This idea came to us while reviewing the technique widely used in WSNs called kNN query that selects the k sensors from which the data is collected. Mostly, we have inspired by 3DkNN that uses a mobile smart device to collect the data. Moreover, we have chosen a method that helps to enable our idea of ranking the sensors that are available in radio range and then pick k top sensors to collect data from.

CHAPTER

3

HARDWARE AND SOFTWARE

3.1 Introduction:

Monitoring and data logging are an essential part for the proper and efficient operation of any electrical energy system. The monitoring system is used to protect the overall system especially over use of energy. Usually, almost all monitoring system for electrical system displays voltage, current, energy, temperature and humidity on the system cloud. Recently wireless connection of Bluetooth and Wi-Fi is used for both local or remote control and monitoring system design. Data logging of an energy system can be done by storing all monitoring parameters using different type of analog or digital sensors. Data is stored in the data logger device or on the cloud. This memory can be increased or update depending on the user requirement. The complexity of the data logger depends on the required numbers of the sensor, data collecting device and the technology or method using for the acquisition of data.

Energy monitoring and data logging systems require a huge number of input parameters and these types of system is very expensive [32]. There are some commercial monitoring systems for electrical energy system with the option of on-grid or off the grid. However, this complex and expensive monitoring and data logging system is not suitable for small energy system. To overcome the technological and cost limitation, a NodeMcu, ESP8266, and Wi-Fi based data logger have been designed to provide a low cost, reliable and user-friendly monitoring system for energy data logging system, mainly for the rural electrification programs in developing countries in Asia and Africa.

3.2 Data logger Description:

To provide a low-cost low power energy data logger for a small monitoring for the rural electrification in the developing countries like Bangladesh, India, Nepal etc. an ESP8266 microcontroller-based system is designed using Arduino IDE software. It has a simple local web server which is configured using C language, and the monitored parameters are stored on the cloud. All the monitoring parameters are shown in a real time data and can be download from the web page through an internet browser like Firefox Mozilla, Google Chrome or even Microsoft Edge by the end user. To measure the current, IC aACS712 Current Sensor issued. Which can

measure up to 250A? Voltage sensor is built in proteus to measure the voltage. Temperature and Humidity sensor is used to measure the temperature up to 50C and humidity up to 80. The detailed hardware is design discussed throughout this chapter. A web page for displaying those monitoring parameters is also developed which is discussed in the next chapter. It is the heart of our model. We have used several components to fulfill the prototype model. In this section we are going to discuss about all those components as well as software we used to build the system.

3.3 Choice of component

The main portion of a prototype model is its components which are going to be used to operate the whole system. In this case it is very necessary to choose those components very carefully. In addition, if we do not choose components carefully, there might be some problems. For instance, when we will integrate the whole circuit together, some of the components might not perform well, there can have certain voltage drop or elements might not get proper power supply. In this case the whole system can be failed whereas the whole circuit integration is correct. So, perfect choice of components is really a big issue while making prototype models. Besides, costing is a big issue here as in the market, everyone generally prefers a good output with a very less budget. That is why for making a good product we all should bear in mind the cost minimization. We have selected different components to make the device physically. We tried to use cheap and effective as well as market available components. To build this project we have used different components. Table-4.1 shows the component list of our prototype model. We have tried to show almost all the characteristics and behavior of different component that are used as a hardware part in our model.

TABLE 3.1 Components of Project

Serial	Components	Quantity
1	Vero board	1
2	breadboard	1
3	NodeMcu Esp8266	1
4	DTH11 Temperature and Humidity Sensor	1
5	Single Channel Relay	1
6	Resistors	8
7	ACS712-5A Current sensor	1
8	Voltage Sensor	1
9	IC 4051	1
10	Connecting Wires	25
11	Male connector	1
12	Female Header	4
13	+3v supply Charger	1

3.3.1 Breadboard

A breadboard is a solder less device for temporary prototype with electronics and test circuit designs. Most electronic components in electronic circuits can be interconnected by inserting their leads or terminals into the holes and then making connections through wires where appropriate. The breadboard has strips of metal underneath the board and connects the holes on the top of the board. The metal strips are laid out as shown below. The top and bottom rows of holes are connected horizontally and split in the middle while the remaining holes are connected vertically.



Figure3.1.Bread Board

3.3.2 Connecting Wires

Connecting wires allows an electrical current to travel from one point on a circuit to another because electricity needs a medium through which it can move. Most of the connecting wires are made up of copper or aluminum. Copper is cheap and good conductivity. Instead of the copper, silver can also be used which has high conductivity but it is too costly to use.



Fig. 3.2Connecting Wires

3.3.3 Esp8266

The ESP8266 Wi-Fi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, meaning, you can simply hook this up to your Arduino device and get about as much Wi-Fi-ability as a Wi-Fi Shield offers (and that's just out of the box)! The ESP8266 module is an extremely cost-effective board with a huge, and ever growing, community. Figure 6 depicts esp8266

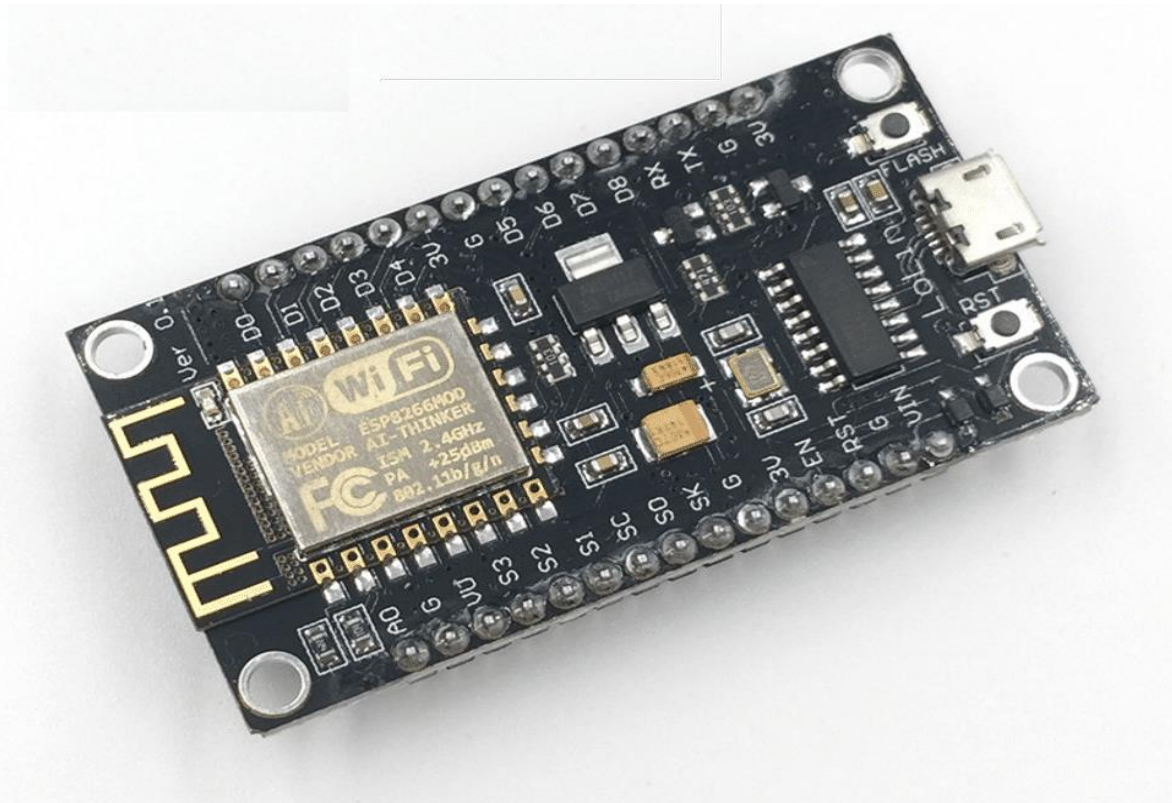


Figure 3.3ESP8266 (Wi-Fi Module)

This module has a powerful enough on-board processing and storage capability that allows it to be integrated with the sensors and other application specific devices through its GPIOs with minimal development up-front and minimal loading during runtime. Its high degree of on-chip integration allows for minimal external circuitry, including the front-end module, is designed to occupy minimal PCB area. The ESP8266 supports APSD for VoIP applications and Bluetooth co-existence interfaces; it contains a self-calibrated RF allowing it to work under all operating conditions, and requires no external RF parts.

Specification:

- Open-source
- Interactive
- Programmable

- Low cost
- Simple
- Smart
- WI-FI enabled
- USB-TTL included
- Plug and Play

3.3.4 Current Sensor

ACS712 Current Sensor IC is used to measure the current of different electrical devices. The cool thing about an ACS712 is that current is measured in two directions. What that means is that if we sample fast enough and long enough, we are sure to find the peak in one direction and the peak in another direction as the ACS712 has a 5 μ s output rise time in response to step input current. We are measuring AC current of 50Hz i.e. 20mSec per cycle and we get around 4000 Samples in one cycle.



Figure 3.4.ACS712 Current Sensor

With both peaks known, it is a matter of knowing the shape of the waveform to calculate the current. In the case of line or mains power, we know that waveform to be a SINE wave. Knowing that allows us to apply a basic electronic formula to yield a decent result. ACS712 provides economical and precise solutions for AC or DC current sensing in the industrial, commercial, and communications systems. The device consists of a precise, low-offset, linear Hall sensor circuit with a copper conduction path located near the surface of the die. The operating voltage is 5 V single supply and the output voltage is proportional to AC or DC currents. The ACS712 sensor has low- noise analog signal path and a sensitivity of 66 to 185 mV/A. It can measure up to 20 A of the input current of a load.

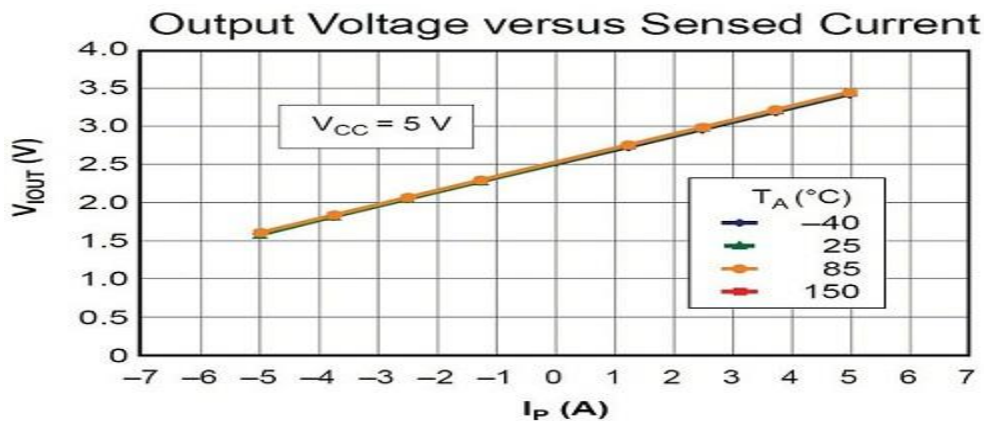


Figure 3.5. voltage Vs current graph

ACS712 Current Sensor Module – 5A Specification:

- Supply Voltage: 4.5V ~ 5.5V DC
- Measure Current Range: -5A ~ 5A
- Sensitivity: 180mV/A ~190mV/A, Typical: 185mV/A
-

3.3.5 DHT11 (Temperature and Humidity) sensor:

The DHT11 humidity and temperature sensor measures relative humidity (RH) and temperature. This sensor includes a resistive element and a sense of wet NTC temperature measuring devices.

It has excellent quality, fast response, anti-interference ability and high cost performance advantages. Relative humidity is the ratio of water vapor in air vs. the saturation point of water vapor in air. $\text{Relative Humidity} = (\text{density of water vapor} / \text{density of water vapor at saturation}) \times 100\%$ The DHT11 calculates relative humidity by measuring the electrical resistance between two electrodes. The humidity sensing component of the DHT11 is a moisture holding substrate (usually a salt or conductive plastic polymer) with the electrodes applied to the surface. When water vapor is absorbed by the substrate, ions are released by the substrate which increases the conductivity between the electrodes. The change in resistance between the two electrodes is proportional to the relative humidity. Higher relative humidity decreases the resistance between the electrodes while lower relative humidity increases the resistance between the electrodes. Inside the DHT11 you can see electrodes applied to a substrate on the front of the chip: The temperature readings from the DHT11 come from a surface mounted **NTC temperature sensor** (thermistor) built into the unit.

Specification:

- Operating Voltage: 3.5V to 5.5V
- Operating current: 0.3mA (measuring) 60uA (standby)



Figure 3.6DHT11 (Temperature and Humidity) sensor

- Output: Serial data
- Temperature Range: 0°C to 50°C
- Humidity Range: 20
- Resolution: Temperature and Humidity both are 16-bit
- Accuracy: $\pm 1^\circ\text{C}$ and ± 1

3.3.6 Single Channel 5v Relay

A relay is an electrically operated device. It has a control system and (also called input circuit or input contactor) and controlled system (also called output circuit or output contactor). It is frequently used in automatic control circuit. To put it simply, it is an automatic switch to controlling a high-current circuit with a low-current signal.

The advantages of a relay lie in its lower inertia of the moving, stability, long-term reliability and small volume. It is widely adopted in devices of power protection, automation technology, sport, remote control, reconnaissance and communication, as well as in devices of electro mechanics and power electronics. Generally speaking, a relay contains an induction part which can reflect input variable like current, voltage, power, resistance, frequency, temperature, pressure, speed and light etc. It also contains an actuator module (output) which can energize or de-energize the connection of controlled circuit. There is an intermediary part between input part and output part that is used to coupling and isolate input current, as well as actuate the output. When the rated value of input (voltage, current and temperature etc.) is above the critical value, the controlled output circuit of relay will be energized or de energized.

NB: input into a relay can be divided into two categories: electrical quantities (including current, voltage, frequency, power etc.) and non- electrical quantities (including temperature, pressure, speed, etc.)

Features

The features of 1-Channel Relay module are as follow:

- 1) Good in safety. In power system and high voltage system, the lower current can control the higher one.
- 2) 1-channel high voltage system output, meeting the needs of single channel control.
- 3) Wide range of controllable voltage.
- 4) Being able to control high load current, which can reach 240V, 10A.
- 5) With a normally-open (NO) contact and a normally-closed (NC) contacts.

Interface Connecting and Setting

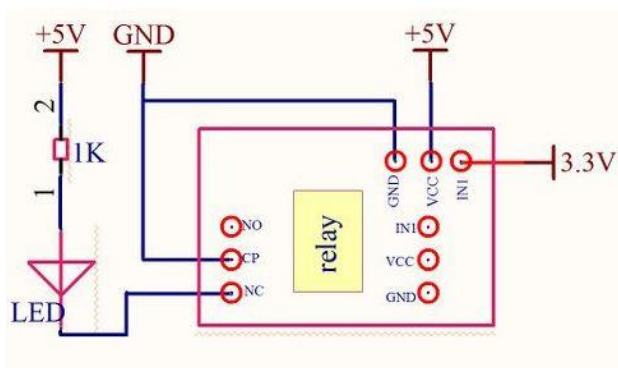
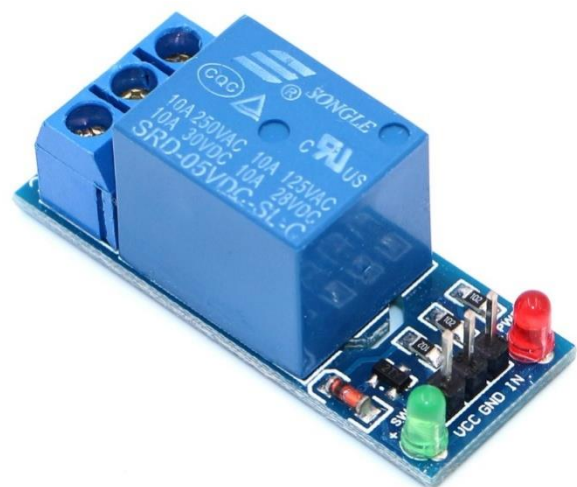


Fig3.7single channel relay & interface



3.4 Hardware Mechanism

Hardware mechanism is the most important part of this project. In this section we have discussed how hardware part will work.

3.4.1 Site allocation

We have to select the site for collect the data logging.

3.4.2 Data logging:

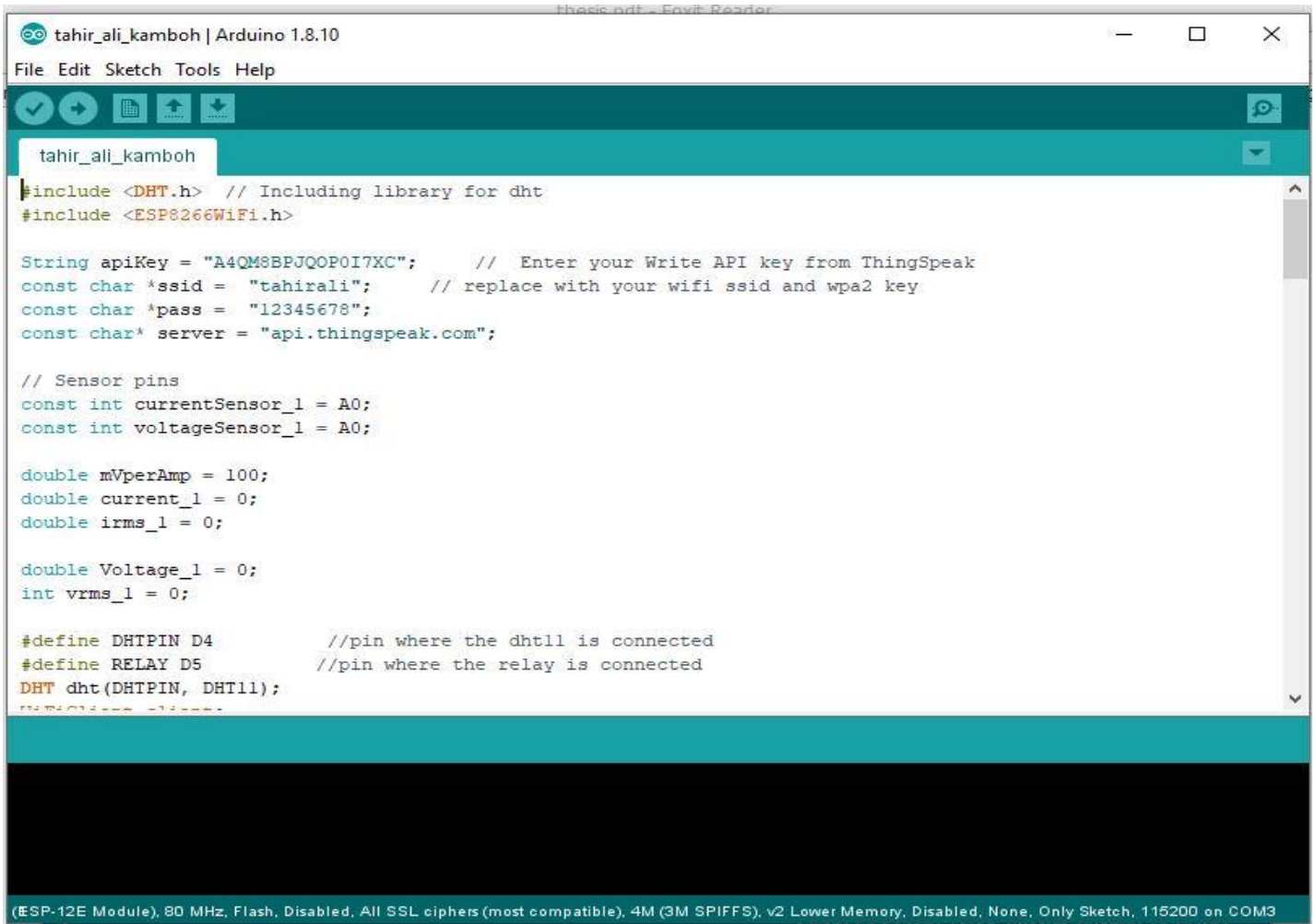
We will connect the energy data logger to our desired site to collect the data of energy consumption. The data logger after connecting to load collects the data and transfers the real time data to the Server. We can access our data easily on server.

3.5 Software

In our prototype model we are using the Arduino IDE software to program the NodeMCU ESP8266 micro controllers and ThingSpeak app to configure the android control system.

3.5.1 Arduino IDE:

Arduino integrated development environment (IDE) is a cross-platform application which is written for both Windows and Linux operating systems using Java programming language. Arduino IDE is developed by Arduino and it originated from the IDE for the languages Processing and Wiring. The IDE consists of a text editor for writing code, a compiler, and debugger to compile the code and checking errors in the code. It supports the languages C and C++ using special rules of code structuring. **Figure 3.8** shows an Arduino IDE sketch.



```
Arduino IDE - tahir_ali_kamboh | Arduino 1.8.10
File Edit Sketch Tools Help

tahir_ali_kamboh

#include <DHT.h> // Including library for dht
#include <ESP8266WiFi.h>

String apiKey = "A4QM8BPJQOP0I7XC"; // Enter your Write API key from ThingSpeak
const char *ssid = "tahirali"; // replace with your wifi ssid and wpa2 key
const char *pass = "12345678";
const char* server = "api.thingspeak.com";

// Sensor pins
const int currentSensor_1 = A0;
const int voltageSensor_1 = A0;

double mVperAmp = 100;
double current_1 = 0;
double irms_1 = 0;

double Voltage_1 = 0;
int vrms_1 = 0;

#define DHTPIN D4 //pin where the dht11 is connected
#define RELAY D5 //pin where the relay is connected
DHT dht(DHTPIN, DHT11);
//DHT11 sensor class

(ESP-12E Module), 80 MHz, Flash, Disabled, All SSL ciphers (most compatible), 4M (3M SPIFFS), v2 Lower Memory, Disabled, None, Only Sketch, 115200 on COM3
```

Figure 3.8. Arduino IDE

A software library from the Wiring project is supplied by Arduino IDE, which offers many common input and output procedures. In this IDE a code only requires two basic functions, one is set up which initializes all modes and setup of different pins. The other function is a loop which executes in the cyclic order of its commands. The Arduino IDE uses the *avrdude* program to convert the executable code into a text file in a hexadecimal encoding which is loaded into the Esp8266 board by a loader program in the board's firmware.

3.5.2 Programming of ESP8266:

```
#include <DHT.h> // Including library for dht
```

```
#include <ESP8266WiFi.h>
```

```

String apiKey = "A4QM8BPJQOP0I7XC"; // Enter your Write API key from ThingSpeak

const char *ssid= "tahirali"; // replace with your wifissid and wpa2 key

const char *pass = "12345678";

const char* server = "api.thingspeak.com";

// Sensor pins

const int currentSensor_1 = A0;

const int voltageSensor_1 = A0;

double mVperAmp = 100;

double current_1 = 0;

double irms_1 = 0;

double Voltage_1 = 0;

int vrms_1 = 0;

#define DHTPIN D4 //pin where the dht11 is connected

#define RELAY D5 //pin where the relay is connected

DHT dht(DHTPIN, DHT11);

WiFiClient client;

void setup()

```

```
{  
Serial.begin(115200);  
  
pinMode(RELAY, OUTPUT);  
  
digitalWrite(RELAY, HIGH);  
  
delay(10);  
  
dht.begin();  
  
Serial.println("Connecting to ");  
  
Serial.println(ssid);  
  
WiFi.begin(ssid, pass);  
  
while (WiFi.status() != WL_CONNECTED)  
{  
delay(500);  
Serial.print(".");  
}  
  
Serial.println("");  
  
Serial.println("WiFi connected");  
}  
  
void loop()  
{  
  
float H = dht.readHumidity();  
  
float T = dht.readTemperature();
```

```

Voltage_1 = getVPP(0, voltageSensor_1);
vrms_1 = (Voltage_1 / 2.0) * 0.707 * 575;
vrms_1 = vrms_1;

if (H > 80 || T > 50) {
digitalWrite(RELAY, LOW);
}
else {
digitalWrite(RELAY, HIGH);
}

float V = vrms_1 / 2.83;
float I = 0;
float E = V * I * 0.8;

if (isnan(H) || isnan(T))
{
Serial.println("Failed to read from DHT sensor!");
return;
}

if (client.connect(server, 80) // "184.106.153.149" or api.thingspeak.com

```



```
{
    String postStr = apiKey;
postStr += "&field1=";
postStr += String(V);
postStr += "&field2=";
postStr += String(I);
postStr += "&field3=";
postStr += String(T);
postStr += "&field4=";
postStr += String(H);
postStr += "&field5=";
postStr += String(E);
postStr += "\r\n\r\n";
client.print("POST /update HTTP/1.1\n");
client.print("Host: api.thingspeak.com\n");
client.print("Connection: close\n");
client.print("X-THINGSPEAKAPIKEY: " + apiKey + "\n");
client.print("Content-Type: application/x-www-form-urlencoded\n");
client.print("Content-Length: ");
client.print(postStr.length());
client.print("\n\n");
client.print(postStr);
```

```

Serial.print("Temperature: ");

Serial.print(T);

Serial.print(" degrees Celcius, Humidity: ");

Serial.print(H);

Serial.print(" %, Voltage: ");

Serial.print(V);

Serial.println("V. Send to Thingspeak.");

}

client.stop();

Serial.println("Waiting...");

// thingspeak needs minimum 15 sec delay between updates

delay(1000);

}

float getVPP(int pinValue, char property)
{
float result;

int readValue;

int maxValue = 0;

int minValue = 1024;

uint32_t start_time = millis();

while ((millis() - start_time) < 1000)

```

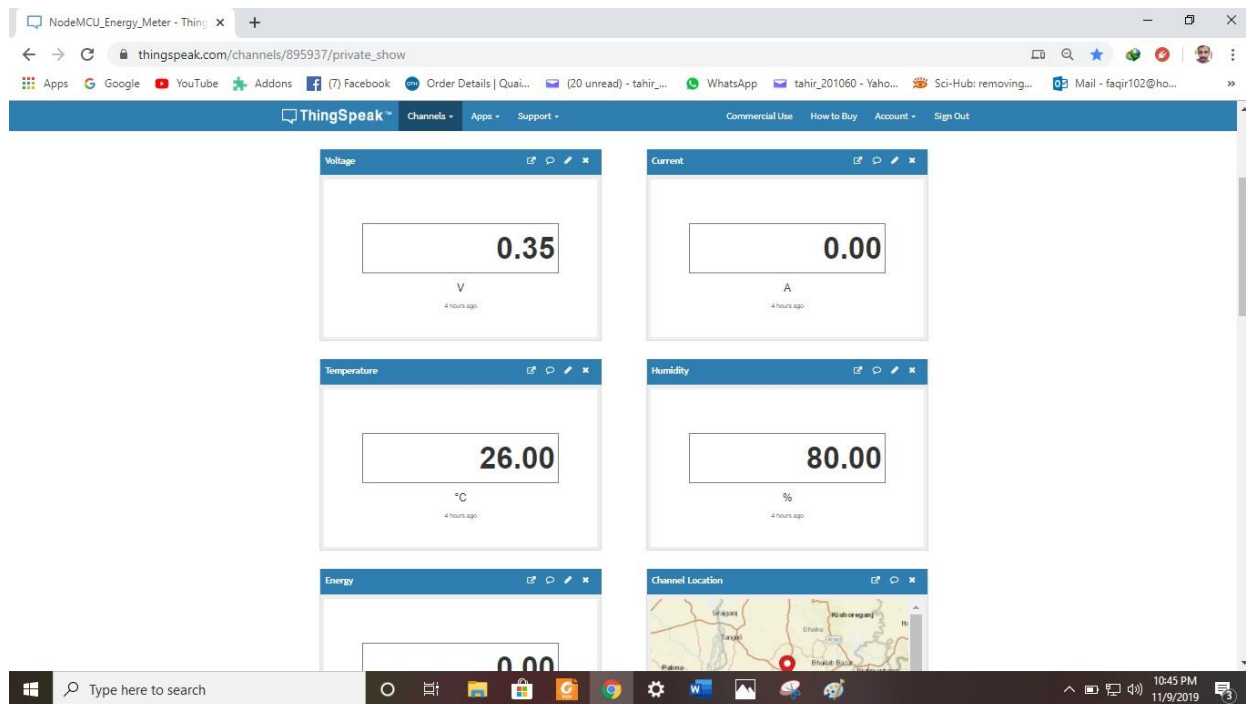
```
{
  if (pinValue == 0)
  {
readValue = analogRead(property);
  }
  else if (pinValue == 1)
  {
readValue = analogRead(property);
  }
  if (readValue>maxValue)
  {
maxValue = readValue;
  }
  if (readValue<minValue)
  {
minValue = readValue;
  }
  }
  result = ((maxValue - minValue) * 5.0) / 1024.0;
  return result;
}
```

3.5.3 Web Interfacing:

A local free web server is signed up to display all monitoring parameters of the electrical equipment system. This server is built within the ESP8266 microcontroller. The Esp8266 development board is a Wi-Fi compatible system which can act as an Access Point (AP) and a client, for example, a personal computer (PC), laptop or cell phone, can be connected to its Wi-Fi. Whenever a client gets connected to its AP, then it can browse that local server data through a webpage.

3.5.4 Screen-shot of the Web page:

The Local Web server page https://thingspeak.com/channels/895937/private_show is shown in the figure.



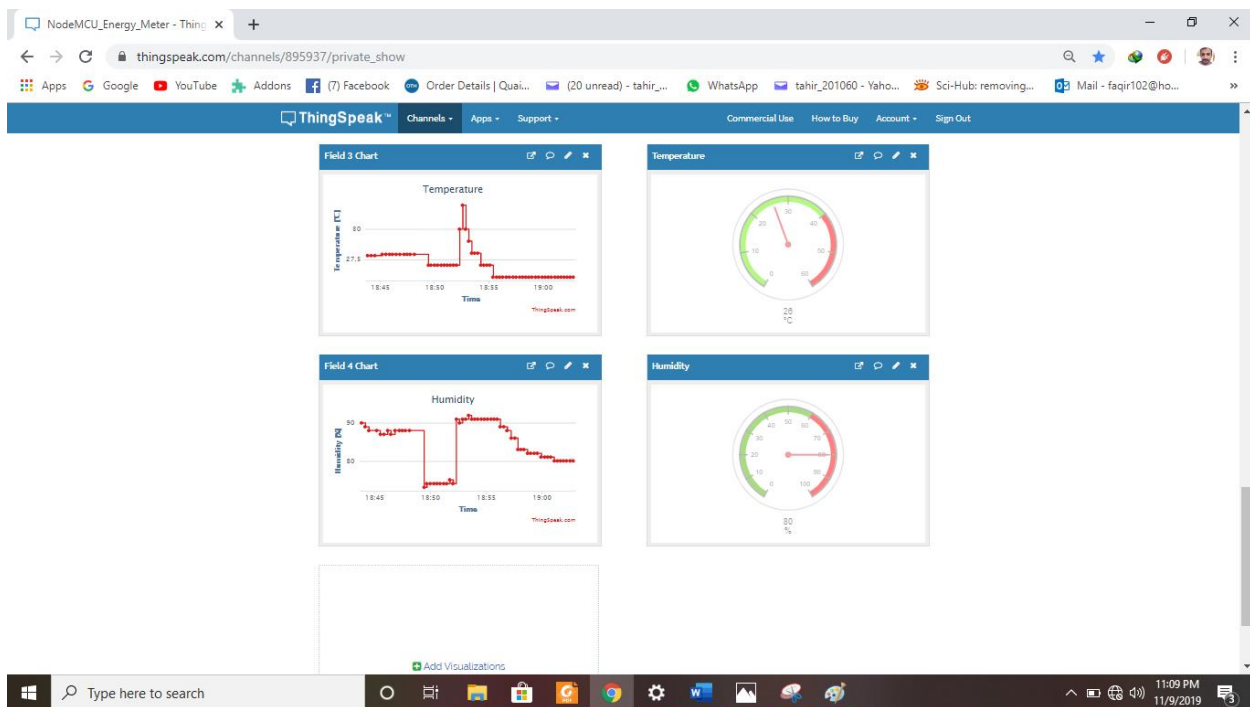
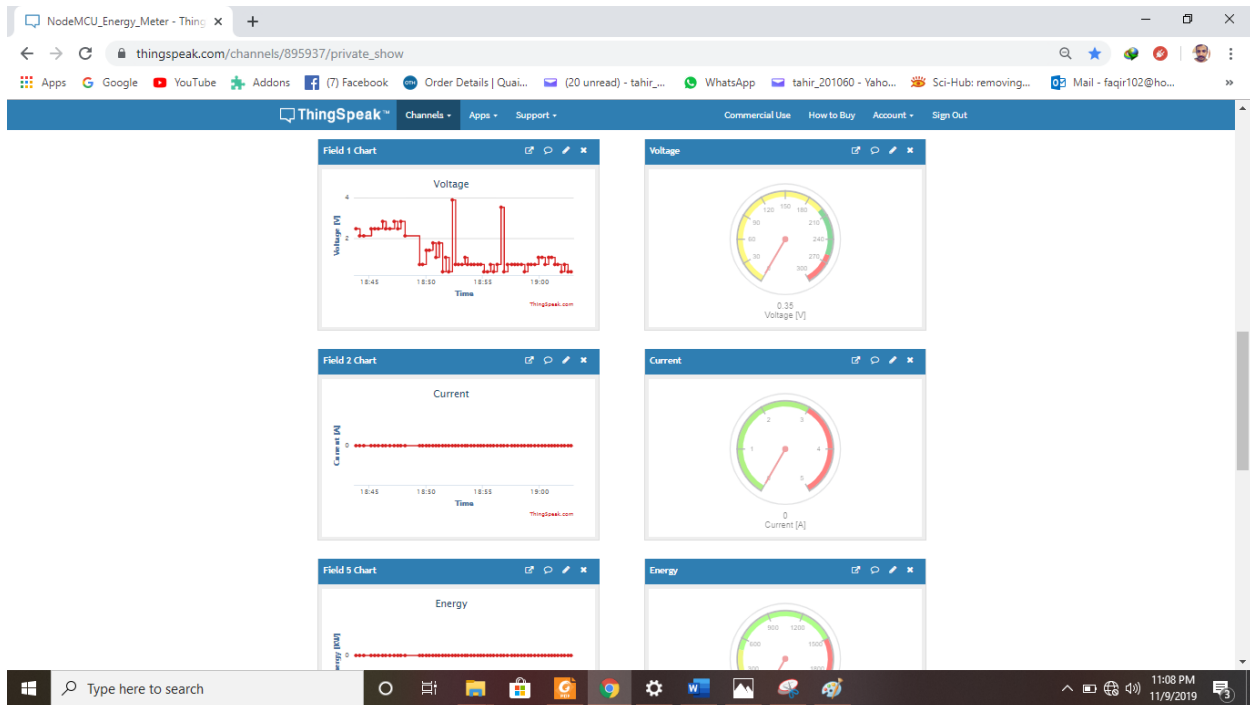


Figure 3.9 Webpage to Display Parameters

3.5.5 Screen-Shot of Data Acquisition:

The serial monitor of Arduino IDE is used to display the data logging values for cloud; figure 3-15 shows the data logging process.

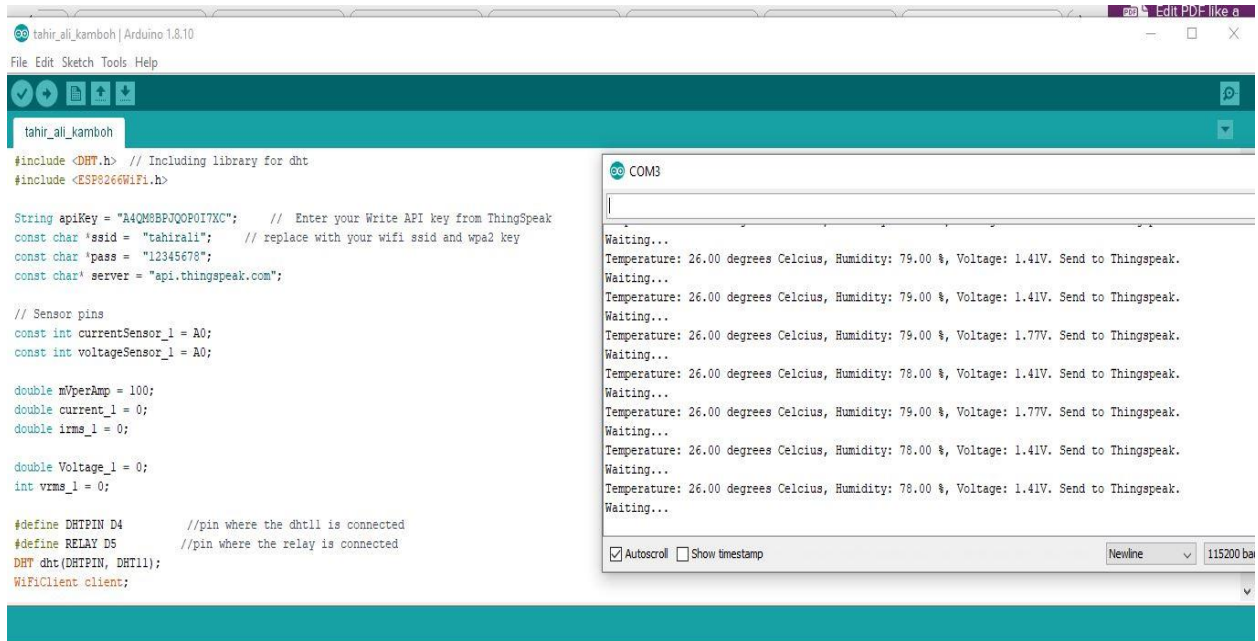


Figure 3.10 Data acquisition

The stored data can be read from the cloud webpage by clicking on the private view button link provided on the webpage. This webpage contains all monitoring values which can be used for troubleshooting and monitoring of energy consumption.

3.6 Summary:

There are many complex commercial monitoring systems available in the market for large and medium energy data logging. However, it is hard to find any cost-effective data logger for a small energy data logging. A simple low-cost user-friendly energy monitoring and data logging system design have been discussed for a small Energy System in this chapter. All the monitoring parameters are displayed on a webpage through a local web server which also provides remote data download from the webpage. This data logger can be accessed by a cell phone commonly used by people in developing countries like Bangladesh.

CHAPTER
4
WORKING PROCESS

Working Process

In this chapter we have discussed the whole working process of our device. Here we have not only showed the project's physical view but also, we have discussed all the working principles, a block diagram of the system and two flowcharts of the whole process. The working principles of the total system are shown on the flow chart and overview of the system is shown on the block diagram below.

4.1 Block Diagram

Block Diagram is a visual portrayal of a framework that utilizes straight forward, marked hinders that speak to single or different things, substances or ideas, associated by lines to demonstrate connections between them. A substance relationship chart (ERD), one case of a square outline, speaks to a data framework by demonstrating the connections between individuals, objects, spots, ideas or occasions inside that frame work. Block Diagrams are a summed-up portrayal of an idea and are not proposed to show finish data concerning plan or produce. In contrast to schematics, outlines and design charts, square graphs don't depict the essential detail for physical development. In this section we draw a diagram of our whole system using blocks. Where NodeMcu Esp8266 is connected with 3 sensors, a Single Channel Relay is connected for the protection of Circuit from any type of fault. On the other hand, micro controller NodeMcu is also connected with ThingSpeak website Server where we can see desired sensing results.

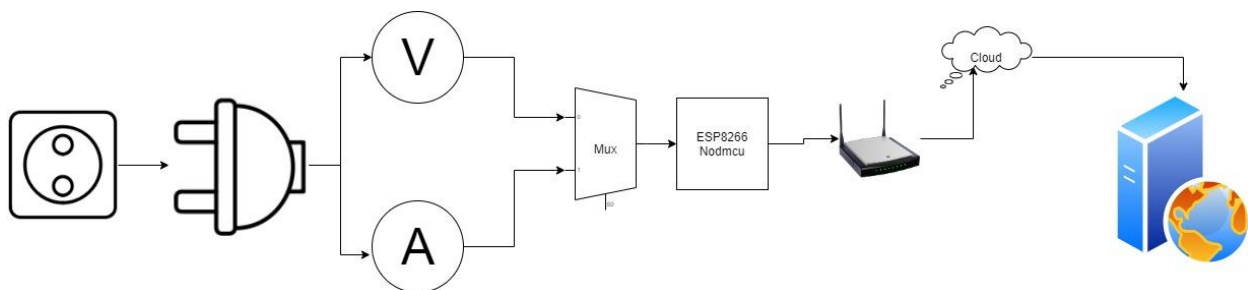


Figure 4.1. Block diagram

4.2 Flow Chart

A flowchart is a formalized realistic portrayal of a rationale succession, work or assembling process, association outline, or comparable formalized structure. The motivation behind a stream outline is to furnish individuals with a typical dialect or reference moment that managing a venture or process. Flowcharts utilize straightforward geometric images and bolts to characterize connections. In programming, for example, the start or end of a program is spoken to by an oval. A procedure is spoken to by a square shape, a choice is spoken to by a precious stone and an I/O process is spoken to by a parallelogram. The Internet is spoken to by a cloud. Flowcharts are utilized in planning and archiving straightforward procedures or projects. Like different sorts of graphs, they help picture what is happening and, in this way, help comprehend a procedure, and maybe likewise find more subtle highlights inside the procedure, similar to defects and bottlenecks. There are diverse kinds of flowcharts: each sort has Working Process very own arrangement of boxes and documentations. The Flow Charts of our system is given below.

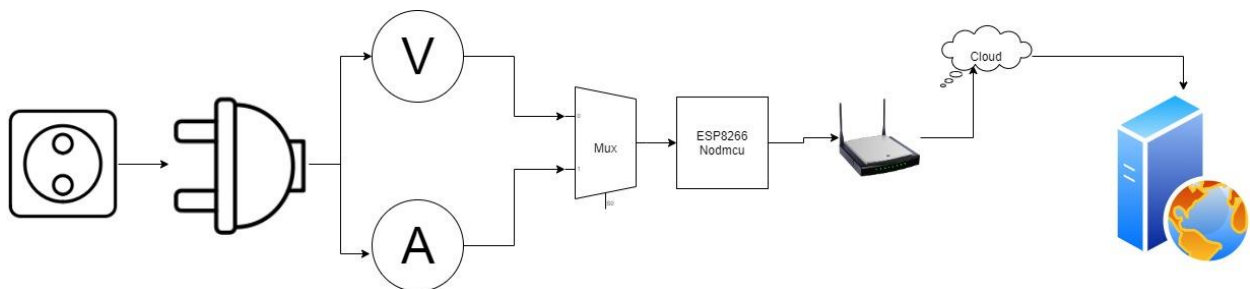


Figure 4.2. flow diagram

4.3 Project View

Here, we can see the physical view of our prototype model in Fig. 4.3.

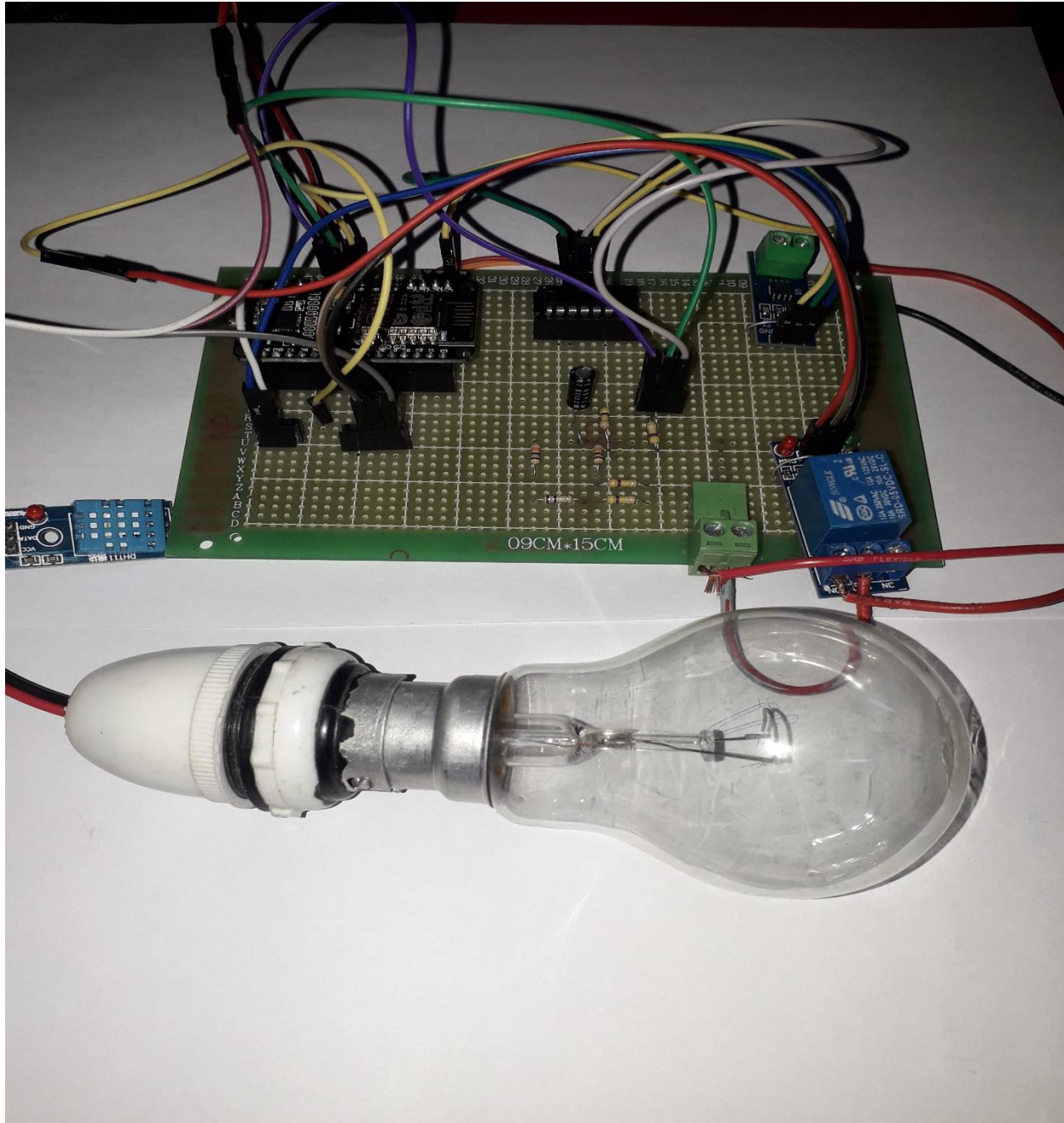


Figure 4.3 Project View

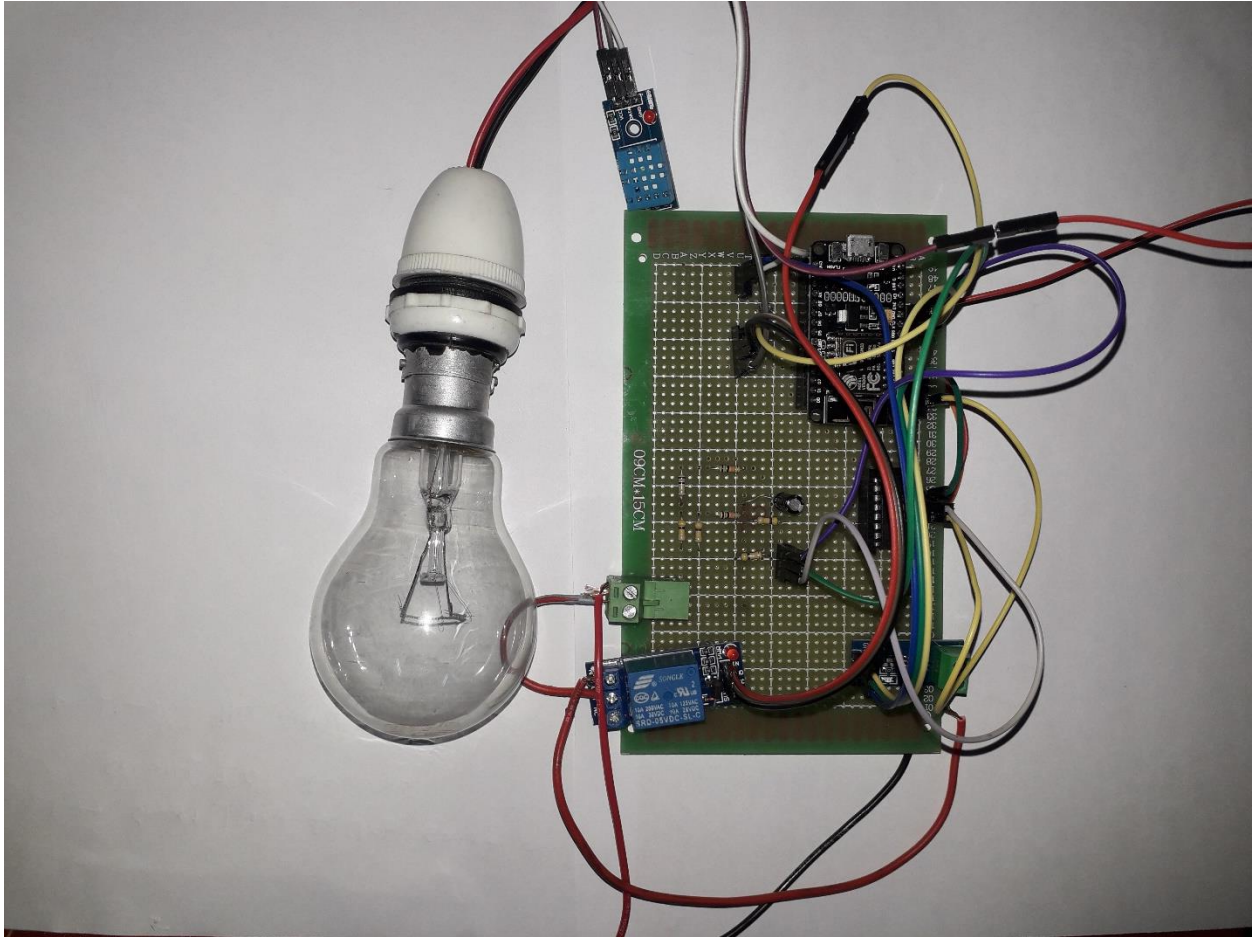


Figure 4.4. Project View with load

CHAPTER
5
EXPERIMENTAL STUDIES

Experimental Studies

We have done some measurements and analysis with the components of the device. These topics are mentioned below

5.1 Hardware Implementation

First of all our three sensors are connected with the Esp8266. Here NodeMcu provides the power supply to the sensors to start sensing their particular parameters from the environment and hardware. Here Current sensor, voltage sensor, Relay and DHT11 3V pins and ground pins are connected to NodeMcu.

Based on the results of current, voltage and DHT11 sensors; they will start transferring data to the website automatically. The VCC pin of Current sensor is connected with the digital pin 3v3 and Out pin with digital pin of IC 4051 accordingly. The VCC pin of Relay is connected with the digital pin 3v3 and the IN pin with D5 of ESP8266. DHT11 temperature and humidity sensor is connected with NodeMCU ESP8266. GND and VCC pin of DHT11 is connected with GND pin and 3v3 of NodeMCU. Remaining digital pin OUT of DHT11 is connected with the digital pin D4 of NodeMCU. DHT11 is sending sensor data to NodeMCU through this digital pin. The100Wbulb is connected as load with the circuit.

5.2 Data analysis, Result and Decision

Three sensors are connected with the circuit start sensing the data and with the help of NodeMCU transfers the data to the website. We can monitor these sensor values in real time on the website.

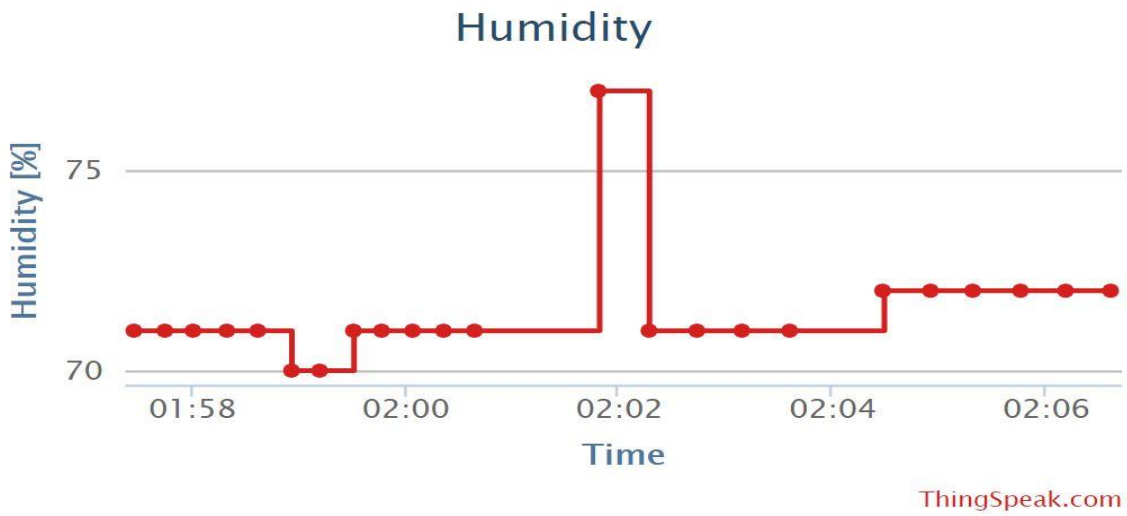


Figure 5.1 Humidity Graph

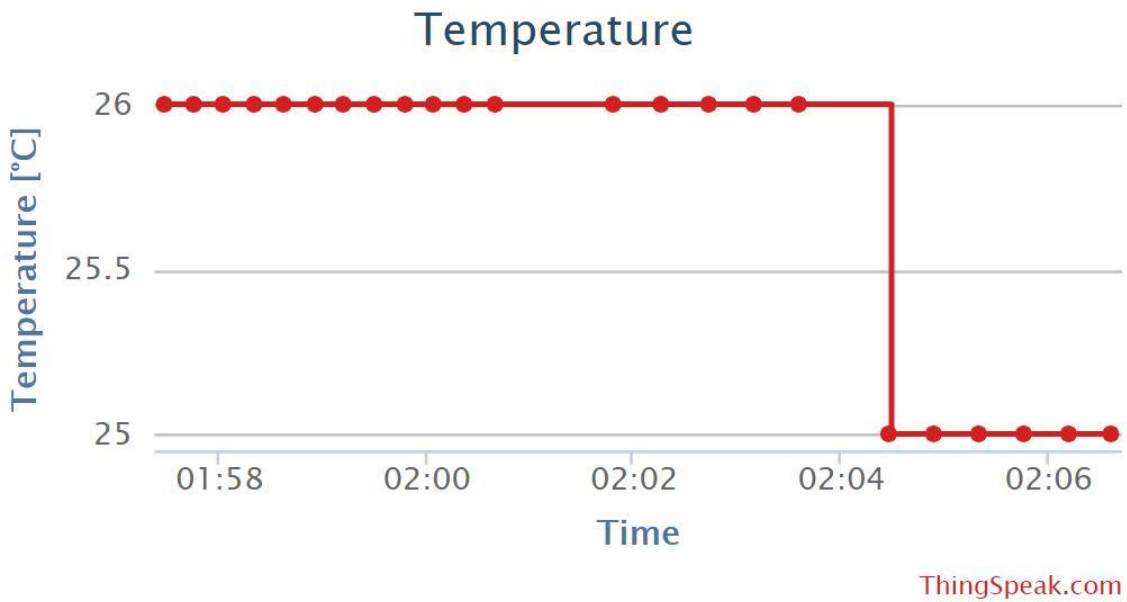


Figure 5.2 Temperature graph

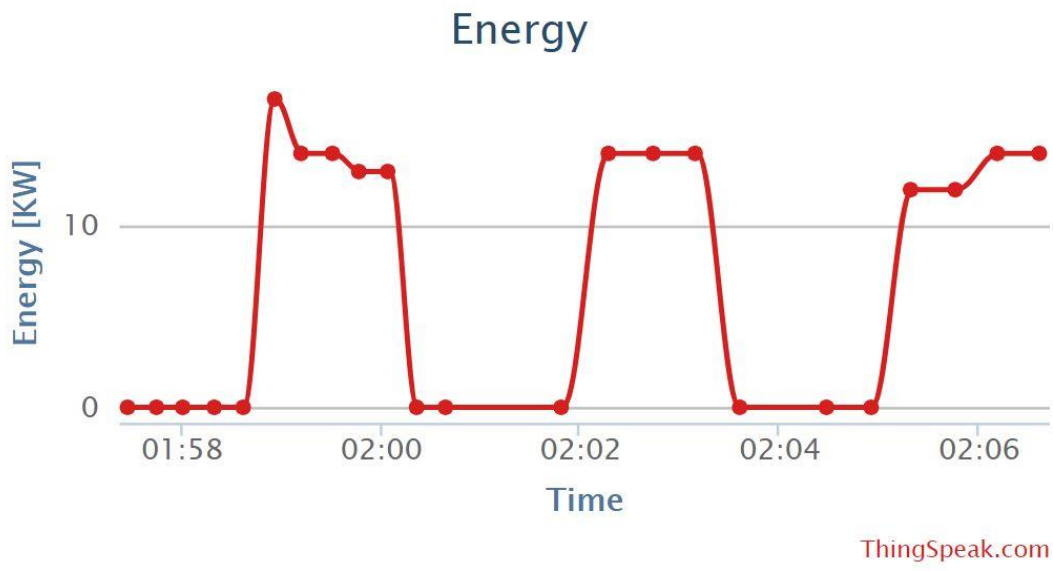


Figure 5.3. Energy graph

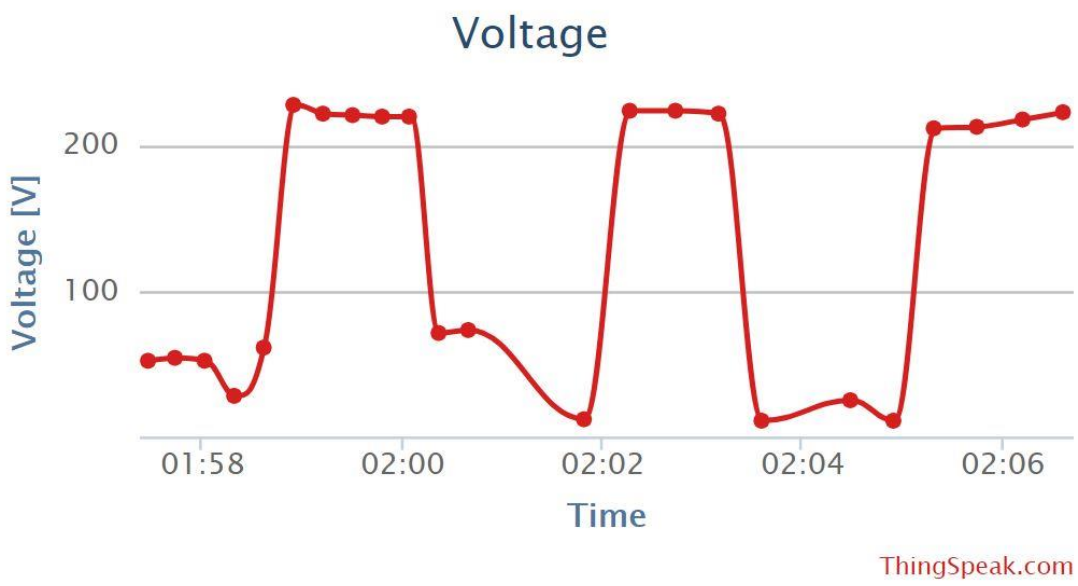


Figure 5.4. Voltage graph

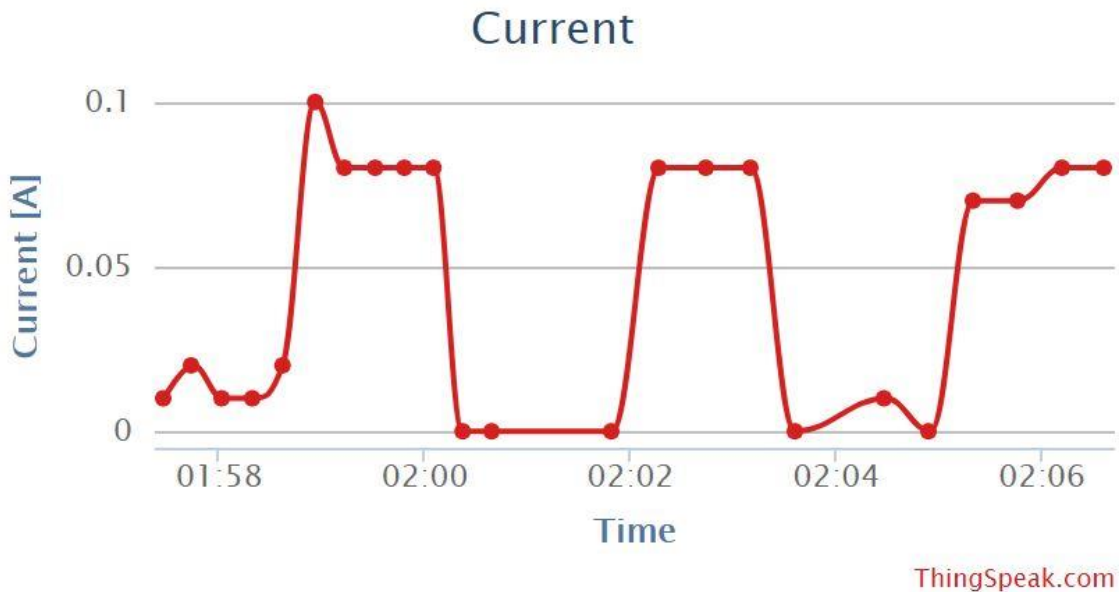


Figure 5.5. Current graph

Our target is not only to measure the sensor values but also to use those sensor values for taking the decision. In a simple way we can say that, our system will show us that how much energy the system has consumed in particular time frame.

Temperature sensors are designed to use in almost any application as well as the prototype models and industry. The temperature is estimated with the assistance of an NTC thermistor or negative temperature coefficient thermistor. This sensor features a calibrated digital signal output with the temperature and humidity sensor capability. It is integrated with a high-performance 8-bit micro controller. This DHT11 temperature and humidity sensor is connected with the NodeMCU ESP8266. When our system is on, the temperature and humidity sensor (DHT11) will start measuring the temperature and humidity values automatically from the surrounding

environment. Serial port of load sensors shows the sensor value. Here in the **Fig.5.6** shows the outputs of sensor data in serial monitor.

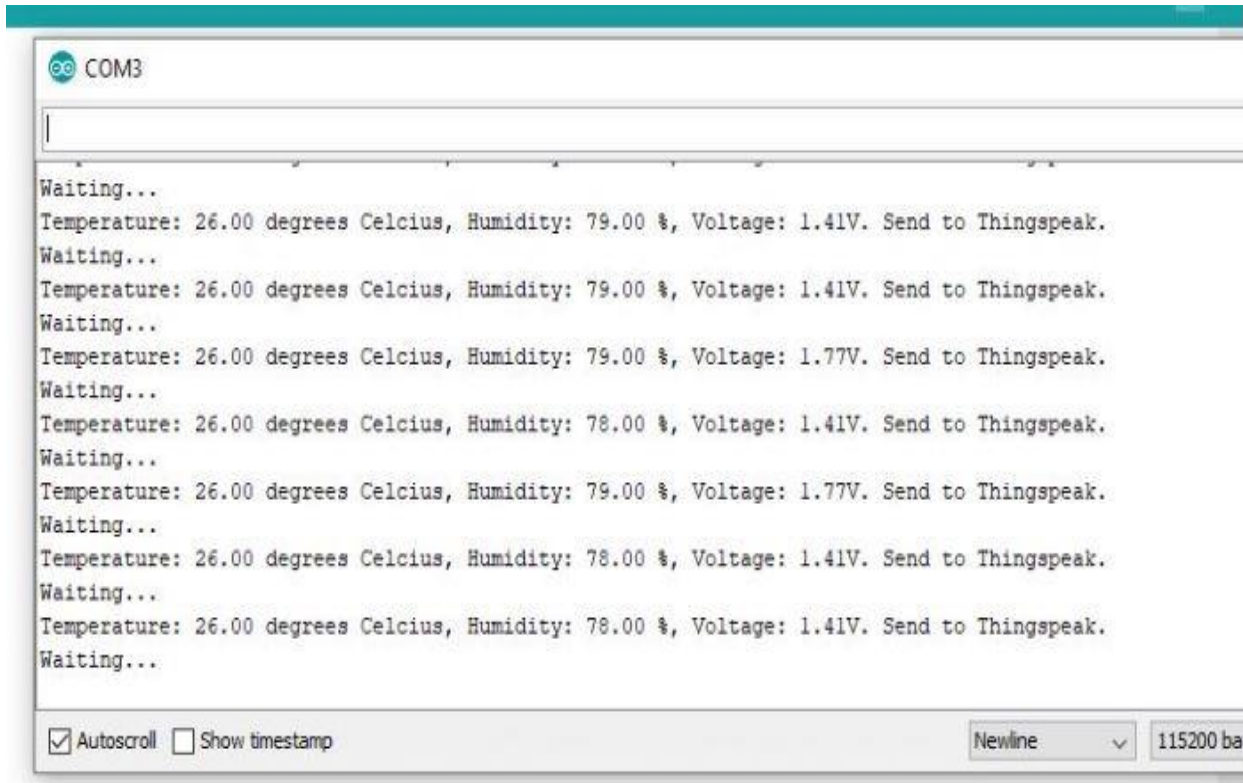
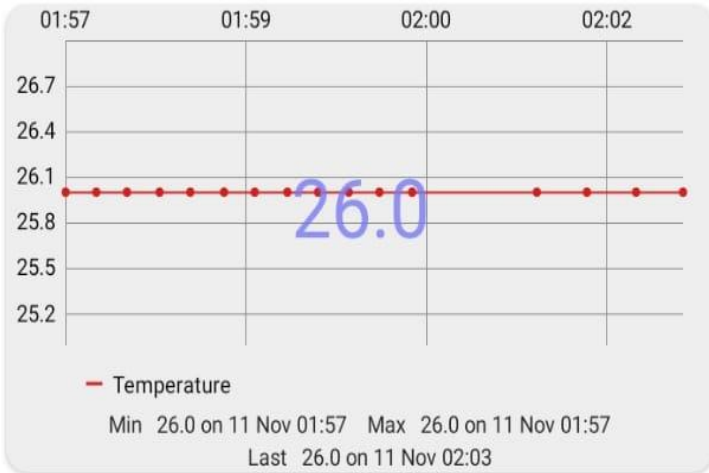


Figure 5.6. Voltage, Temperature and humidity values

In Fig. 5.6 we can see that the values of temperature and humidity sensor (DHT11). Here the temperature is fluctuating between 26 degree Celsius and 28 degree Celsius then stabilizes at 27 degree Celsius. With the help of voltage sensor, we also measure the voltage and with the help of current we also measure current as shown in Fig. 5.6. we can see our data logging on mobile also. As shown in Fig. 5.7.& 5.8.



NodeMCU_Energy_Meter



NodeMCU_Energy_Meter



DA DOCTOR ASSISTANT Book Home-Based GME Screening For Your Helper | \$40

DA DOCTOR ASSISTANT Book Home-Based GME Screening For Your Helper | \$40



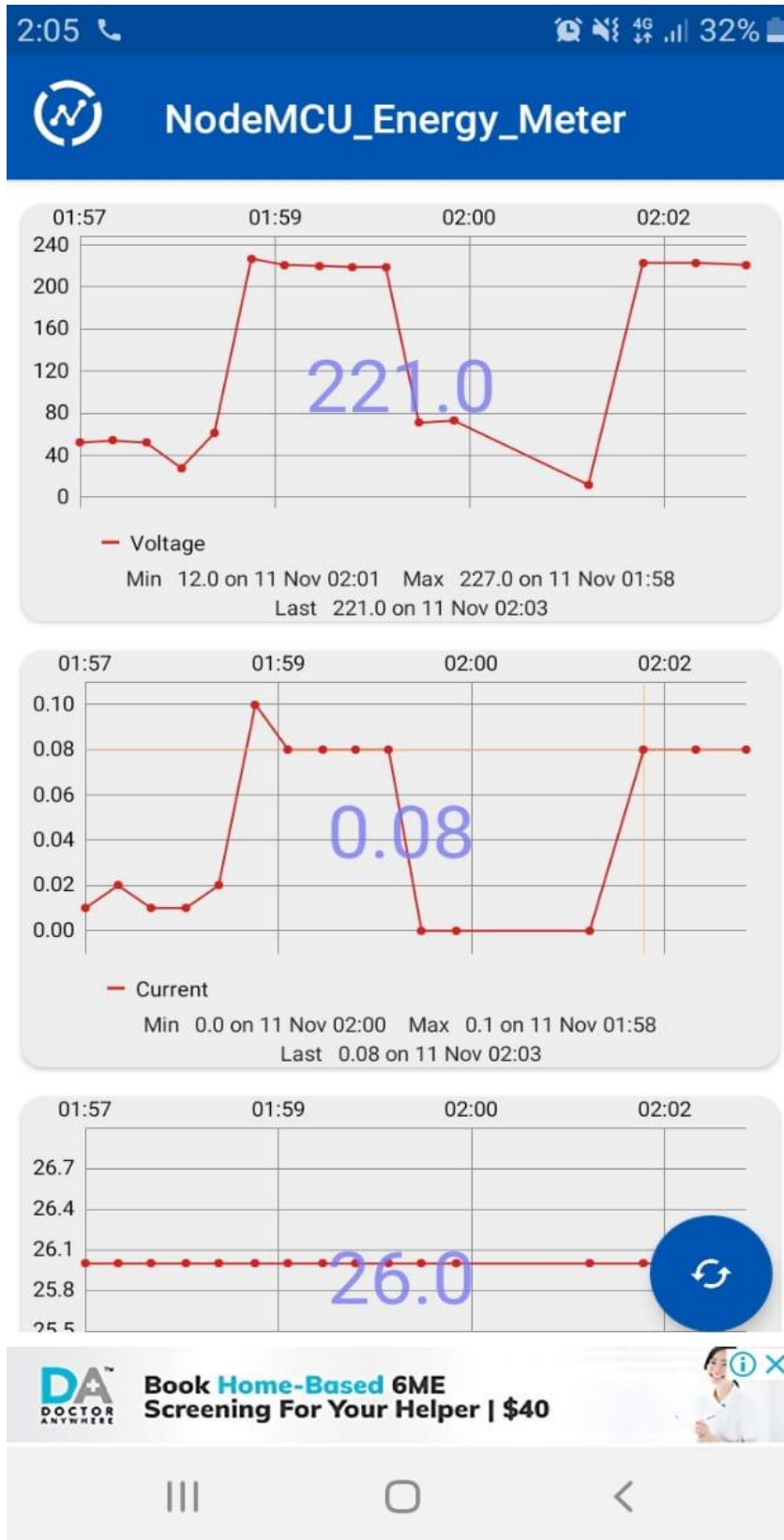


Fig. 5.8. Voltage and current values on mobile

CHAPTER
6
DEVICE IMPACT

Device Impact

In this chapter we have discussed different impact of the device in different aspect like. Besides this we have also discussed cost analysis and economic impact of this device.

6.1 Health and Safety Impact

Our prototype model is designed in a way, so that it can be helpful to people in safety issues. In recent days, in our society over use of electrical energy is common now days. Many people leave their electric appliances ON. For this reason, we have designed a prototype model of energy data logger where our system will automatically detect over use of energy in our homes. After detecting, our system will share this energy consumption from the Home with the help of an Esp8266 to the website. Where we can monitor our daily energy consumption So, we can see our over usage of energy and keep us safe from big amount bills.

6.2 Lower energy consumption

Another major problem of our society is wastage of energy and in recent days this problem is becoming more acute. As a fastest developing country many factories and mega malls are being established, in a result we are facing the energy problem. To reduce this kind of problem, many agendas and project works are developing but still this problem has not been solved properly. So, we all should come forward in order to solve excess energy consumption, otherwise in near future we will face more energy issues. Here, in our prototype model we are proposing temperature-controlled energy data logger using (IoT) which is able to collect data and send it to the web server. As it is designed for rooms, so it can be installed in home, office, schools, colleges and many more places easily. As a result, huge amount of energy and electricity can be saved.

CHAPTER

7

CONCLUSION AND FUTURE WORK

7.1 Future work

We live during a time where inventive innovation could easily compare to ever previously. Numerous individuals feel like they can't work except if they have a type of innovative contraption set up, and this stretches out to the home, which is the reason we are contemplating here what's on the horizon for home robotization. In any case, you need to trust that the savvy innovation utilized inside home computerization programming will keep on expanding its pervasiveness among individuals around the nation. Ten years prior, the idea of a cell phone with a touch-screen, a music player, a completely working web program and more alternatives appeared as though a curiosity held just for the most favored individuals. Five years prior, the possibility of such items as Amazon's Alexa menial helper appeared to be really unusual. However, in 2018, these are only a portion of the numerous innovative instruments that a substantial level of the populace depends upon every day. As innovation keeps on being created and new strategies for administration preparing are trialed, this will undoubtedly proceed such a movement.

With respect to energy data logging specifically, energy consumption data logging will turn into a significantly bigger need than it as of now is. As we hear increasingly about any semblance of digital assaults and over usage of energy, this will have individual's data logging consistently, and it reaches out to the home, where a house that brags all these magnificently valuable things will turn into a more prominent focus for energy data logging, particularly amid occasion times. Right now, old-school mortgage holders are adhering to the more customary, less propelled methods for protecting their homes from over usage of electrical energy. Finally, home mechanization Future Work & Conclusions as of now to a great degree progressed, with the capacity to control temperature, power consumption and the sky is the limit from there, alongside littler yet similarly significant procedures, for example, exchanging over TV stations and noting your telephone. That is the condition of play in 2019, and we have just overcome much, however would you be able to envision the advancements that could be made in the years to come? We at times joke about the assignments that youngsters decline to do physically on the grounds that they have shrewd innovation to do it for them, yet this is just going to increment. Anyway, we have a few gets ready for our exploration too. So, after a period we can investigate that information to improve our framework. We previously thought of utilizing that

information to anticipate the most agreeable temperature, voltage, current and energy. So that in the wake of running for a couple of days our framework can consequently log the energy data. To do this work we require internet 24/7 as the data can be sent to the website.

7.2 Conclusion:

For a smooth, efficient and robust operation of any electrical energy system, a data logger, and monitoring system is very foremost. Data logger and monitoring system enables the proper operation and contributes to identifying system malfunctioning before any major failure. By having a data logger, it becomes very easy to trace any particular data on a specific time period which leads to an easily traceable scenario to find any anomalies in operation. Moreover, deploying the monitoring system in the electrical energy system increases system reliability and ensure smooth operation. An efficient monitoring system can assist the user of this energy system to run the system trouble-free for many years.

To design a Smart Home System (SHS) using energy data logger, a load is connected to the data logger and real-life data has been collected. After designing the overall system, it has been clouded to ThingSpeak website for an energy analysis.

In this thesis, a low-cost, user-friendly, reliable data logger and monitoring system has been developed for Smart Home energy system, mainly for the small home system in a rural area or remote area of a developing country. This data logger stores all monitoring parameter on a cloud and displays that on a ThingSpeak website. Data can be seen directly from the webpage to analyze and verify the system operation. For an efficient monitoring, an Android App is also available for a cell phone to display all parameters in real time basis. Cell phones are commonly used in developing countries and people are familiar with their use and application. This data logger is developed using ESP8266 microcontroller with the help of open sourced software called Arduino. The developed data logger hardware prototype is very simple and uses only three sensors for temperature, voltage, and current sensing. Moreover, the easily accessible android app is also available for monitoring energy parameters with open source software to make it cost effective.

References

- [1] Cui, Y., Kim, M., Gu, Y., jin Jung, J., and Lee, H. (2014). Home appliance management system for monitoring digitized devices using cloud computing technology in ubiquitous sensor network environment. *International Journal of Distributed Sensor Networks*, 10(2):174097.
- [2] Fernandes, R., Matos, J. N., Varum, T., and Pinho, P. (2014). Wi-fi intruder detection. In *2014 IEEE Conference on Wireless Sensors (ICWiSE)*, pages 96–99.
- [3] Gu, H., Diao, Y., Liu, W., and Zhang, X. (2011). The design of smart home platform based on cloud computing. In *Proceedings of 2011 International Conference on Electronic Mechanical Engineering and Information Technology*, volume 8, pages 3919–3922
- [4] Huaiyu, X., Ruidan, S., Xiaoyu, H., and Qing, N. (2009). Remote control system design based on web server for digital home. In *2009 Ninth International Conference on Hybrid Intelligent Systems*, volume 2, pages 457–461.
- [5] Huang, L.-C., Chang, H.-C., Chen, C.-C., and Kuo, C.-C. (2011). A zigbee-based monitoring and protection system for building electrical safety. *Energy and Buildings*, 43(6):1418 – 1426.
- [6] Longe, O. M., Ouahada, K., Rimer, S., Zhu, H., and Ferreira, H. C. (2015). Effective energy consumption scheduling in smart homes. In *AFRICON 2015*, pages 1–5.
- Mao, X., Li, K., Zhang, Z., and Liang, J. (2017). Design and implementation of a new smart home control system based on internet of things. In *2017 International Smart Cities Conference (ISC2)*, pages 1–5.
- [7] Nag, D., Majumder, D., Raquib, C. M., Pramanik, S., Basu, A., Rana, T. K., and Rana, B. (2017). Green energy powered smart healthy home. In *2017 8th Annual Industrial Automation and Electromechanical Engineering Conference (IEMECON)*, pages 47–51.
- [8] Nguyen, T. V., Lee, D. G., Seol, Y. H., Yu, M. H., and Choi, D. (2007). Ubiquitous

access to home appliance control system using infrared ray and power line communication. In *2007 3rd IEEE/IFIP International Conference in Central Asia on Internet*, pages 1–4.

[9] Panwar, A., Singh, A., Kumawat, R., Jaidka, S., and Garg, K. (2017). Eyrre smart home automation using internet of things. In *2017 Computing Conference*, pages 1368–1370.

[10] Quwaider, M. (2017). Real-time intruder surveillance using low-cost remote wireless sensors. In *2017 8th International Conference on Information and Communication Systems (ICICS)*, pages 194–199.

[11] Sowmiya, M. and Sabeenian, R. S. (2017). Security and monitoring system by using rfid tags and multiple sensors. In *2017 IEEE International Conference on Electrical, Instrumentation and Communication Engineering (ICEICE)*, pages 1–5.

[12] Tejani, D., Al-Kuwari, A. M. A. H., and Potdar, V. (2011). Energy conservation in a smart home. In *5th IEEE International Conference on Digital Ecosystems and Technologies (IEEE DEST 2011)*, pages 241–246

[13] Wang, P., Jiang, H., Shi, W., and Cheng, M. (2009). Design and realization of remote control in smart home system. In *2009 International Conference on Communication Software and Networks*, pages 13–15.

[14] Wang, P., Yan, L., Wang, J., and Zhu, Y. (2010). The remote intelligent controlling and monitoring system of home appliances based on gprs/gsm. In *2010 IEEE International Conference on Information Theory and Information Security*, pages 958–961.

[15] Wang, X., Liu, S., and Li, Q. (2017). Research on control strategy of pwm rectifier technology based on dsp. In *2017 IEEE International Conference on Information and Automation (ICIA)*, pages 1050–1053.

[16] Zhang, Y., Xu, D., Yan, C., and Zou, S. (2015). Hybrid pwm scheme for the grid inverter. *IEEE Journal of Emerging and Selected Topics in Power Electronics*, 3(4):1151–1159.

[17] International Energy Outlook 2017, Energy Information Administration (EIA), available: [https://www.eia.gov/outlooks/ieo/pdf/0484\(2017\).pdf](https://www.eia.gov/outlooks/ieo/pdf/0484(2017).pdf).

[18] "Electrification: So how many people are we actually talking about?" Energy Access - Africa. July 19, 2017. Accessed November 25, 2017. <https://energyaccessafrica.com/2016/07/05/so-how-many-people-are-we-actually-talking-about/>.

[19] B. Shrihariprasath and V. Rathinasabapathy, "A smart IoT system for monitoring solar PV power conditioning unit," *2016 World Conference on Futuristic Trends in Research and Innovation for Social Welfare (Startup Conclave)*, 2016.

[20]. V. Maulik, K. Chudasama, M., Bhatt and B., Gohil. "Real Time Data Monitoring of PV Solar cell using LabVIEW", 2016.

[21] S. AG, "DATA MANAGER M", *Sma.de*, 2017. [Online]. Available: <https://www.sma.de/en/products/monitoring-control/data-manager-m.html>. [Accessed: 26- Nov- 2017].

[22]. A. J. Swart, H. C. Pienaar, and R. M. Schoeman. "Cost-effective energy monitoring of domestic off-grid PV systems." *JEPE, Journal of Energy and Power Engineering*, vol. 5, pp.182-188, 2013.

[23]Nashwa El-Bendary, Mohamed Mostafa M. Fouad, Rabie A. Ramadan, Soumya Banerjee and Aboul Ella Hassanien, "Smart Environmental Monitoring Using Wireless Sensor Networks",K15146_C025.indd, 2013

[24] Grzegorz Lehmann, Andreas Rieger, Marco Blumendorf, SahinAlbayrakDAI, "A 3-Layer Architecture for Smart Environment Models"/A model-based approach/Labor Technische University Berlin, Germany 978-1-4244-5328-3/10 © IEEE,2010.

[25] Moghavvemi M. and Tan. S. “A reliable and economically feasible remote sensing system for temperature and relative humidity measurement”. Sensors and Actuators. 2005. 181-185.

[26] DESCO Official Website: <https://www.desco.org.bd/?page=pre-paid-meter>

[27] Khan, A.H. (2015). A Nobel Design of DC Micro Grid For Rural Area In Bangladesh. INTERNATIONAL JOURNAL OF TECHNOLOGY ENHANCEMENT AND EMERGING ENGINEERING RESEARCH, 3(01), 19-56

[28] Endesa S.A. 2017. <https://www.endesaclientes.com/smart-meter.html>

[29] Datasheet. Arduino MEGA2560. <http://www.mantech.co.za/datasheets/products/A000047.pdf>

[30] Datasheet. Arduino UNO. <http://digital.csic.es/bitstream/10261/127788/7/D-c-%20Arduino%20uno.pdf>

[31] Shanghai SIM Com Wireless Solutions Ltd. (2009). Hardware Design SIM 900A_HD_V1.01. http://www.image.micros.com.pl/dane_techiczne_auto/sim900a.pdf

[32] Wikipedia. Wikimedia Foundation. Web. 31 October, 2014. <https://www.itead.cc/wiki/Stackable_SD_Card_shield_V3.0

