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ABSTRACT

Nowadays it can be seen that most of the garbage across the roadside are overloaded because the wastes are not collected periodically.It creates unhygienic condition for the people and creates bad odor around the surroundings. This leads in spreading some deadly diseases & human illness.To overcome this problem,a project called IOT Based Solid Waste Management System is designed. In this system raspberry pi,ultrasonic sensor, weight sensor and proximity sensor along with Global Positioning System (GPS) module is employed to track the level, weight of trash and location of garbage bin while transporting to dumping site such that these details can be accessed by the concern authorities from their place with the help of internet and an immediate action can be made to clean the containers.In this system, there are multiple containers located throughout the city or the campus,these containers are provided with embedded device which helps in tracking the level of the garbage bins and unique ID is provided for every container in the city so that it is easy to identify which garbage bin is full. When the sensors reach the threshold limit set (20 cm for ultrasonic sensor, 5kg for weight sensor), alert is provided via tweet. The vision of our project is to manage solid wastes insmart and systematic way.

Keywords: -

GPS, IOT, Proximity sensor, Raspberry pi, Ultrasonic sensor

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ABBREVIATIONS

ARM	: Advanced RISC Machine
IDE	: Integrated Development Environment
IOT	: Internet of Things
GPIO	: General Purpose Input Output
GPS	: Global Positioning System
GSM	: Global System for Mobile Communication
GUI	: Graphical User Interface
LED	: Light Emitting Diode
OS	: Operating System
PCB	: Printed Circuit Board
RAM	: Random Access Memory

1. Introduction

Things (Embedded devices) that are connected to Internet and these devices can be controlled remotely is commonly called as Internet of Things.The future Nepal will be digitalized. Everything will be based on internet. The usage of internet will become a part of our life. Evolution of cloud computing and IOT is increasing rapidly. In our system, the waste containers are connected to the internet to get the real-time information about it. In the recent years, there has been a rapid growth in population which leads to more waste disposal. So, a proper waste management system is necessary to avoid spreading some deadly diseases, managing the waste containers by monitoring the status of it and accordingly taking the decision. There are multiple containers located throughout the city or the Campus (Educational Institutions, Companies, Hospitals etc). The data is received, analyzed and processed in the cloud, and hence displays the status of the garbage in the container on the GUI based web browser. Also, on reaching threshold values alert is provided via twitter.

1.1. Background

In present there is a rapid growth in the population which leads to large quantity of waste disposal in the cities. The overflow of container will create an unpleasant environment and it affects many people by spreading the deadly disease. The implementation of proposed waste management system will avoid the spreading of such disease. The containers are properly managed and information is seen regularly and the municipality officer makes immediate response by intimating to truck driver. The truck driver will go immediately and collect the waste form the container. Multiple containers are connected through the cities. The containers are integrated with ultrasonic sensor, GPS module. The ultrasonic sensor is used to detect the level of dust in the container. After detecting the level of waste in the container, information and location traced by GPS is send via internet to the server and hence displayed in webpage. This information is sent to the web browser.Pictures of container being overflown and the waste from the container are spilled out from all around is common. This will lead to the cause of many disease as many numbers of insect and mosquito breed on it. The managing of solid waste is the major problem in the city. This solid waste management system will eradicate such a problem or reduce the problem.

1.2. Problem Statements

As we have seen number of times the containers are getting overflown and concern person don't get the information within time and due to which unsanitary condition formed in the surroundings, at the same time bad smell spread out due to waste, bad look of the city which paves the way for air pollution and to some harmful diseases around the locality which is easily spreadable.

i. Disadvantages of the existing system
   - Time consuming and less effective: trucks go whether containers are full or not
   - High costs
   - Unhygienic environment and look of the city
   - Bad smell spreads and may cause illness to human beings

ii. Advantages of designed system
   - Real time information on the fill level of the container via IOT.
   - Deployment of container based on the actual needs.
   - Cost reduction and resource optimization.
   - Improves environment quality i.e. cleaner cities.

1.3. Objectives

The objectives of the projects are divided into the main and specific objective and shown below as:

1.3.1. Main Objective

The main objective of this is to design and implement IOT based solid waste management system.

1.3.2. Specific Objectives

The specific objectives of this project are:

i. To detect the level of waste inside the container using ultrasonic sensor.
ii. To implement GPS module to find location of the container.
iii. To transmit measured parameters wirelessly using Wi-Fi.
iv. To designa webpage that displays relevant information about container.

1.4. Scope and Application

These are the fields where this project can be used as listed below:

- This project can be extensively used in different cities, hospitals, organizations and localities.
- It can play a significant role for making smart city.
- It can be used by waste management office, municipality office for making environment clean in a smart way.

2. Literature Review

2.1. Historical Background

Conventional approach to Municipal Solid Waste Management (MSWM) suffers from lack of sustainable collection throughput [1], lack of data on collection time and location, lack of efficient monitoring systems of waste bin status, lack of efficient systems for waste collection and transportation, and delays in collection. Creativity of having reliable approach on solid waste management is needed, starting from the existing strengths of the city and build up on them with good involvement of all stakeholders in designing their own local models [2]. The use of technology can be adopted to improve the quality of waste data collection, the service availability and reliability in a city thus, building smart cities' world in the aspects of waste management.According to [3]"A Smart City is a city well performing in a forward-looking way in the following fundamental components (i.e., Smart Economy, Smart Mobility, Smart Environment, Smart People, Smart Living, and Smart Governance), built on the 'smart' combination of endowments and activities of self-decisive, independent and aware citizens". Therefore, smart city process for waste collection is a fundamental point in achieving green city environment and well-being of the citizen and its quality should be considered seriously.

2.2. Review of Related Literatures

In [4], the ZigBee, GSM and ARM7 is used to form the integrated system to monitor the waste bins remotely. The sensors are placed in the common garbage bins placed at the public places. When the garbage reaches the level of the sensor, then that indication will be given to ARM 7 Controller. The controller will give indication to the driver of garbage collection truck as to which garbage bin is completely filled and needs urgent attention. ARM 7 will give indication by sending SMS using GSM technology. In [5], they came to a point It is important to understand the societal concerns over the increased rate of resource consumption and waste production and therefore the policy makers have encouraged recycling and reuse strategies to reduce the demand for raw materials and to decrease the quantity of waste going to landfill. In [6],it is being proposed in this paper that introduction of an integrated system combined with an integrated system of Radio Frequency Identification, Global

Position System, General Packet Radio Service, Geographic Information System and web camera will solve the problem of solid waste They also analyzed the actual performance of the system. In [7], this paper objective of the study was to determine the characterization of the waste and the current system of management activities. The paper highlights an overview of the current municipal solid waste management (MSWM) system of Thoubal Municipality and it concludes with a few suggestions, which may be beneficial to the authorities to work towards further improvement of the current management systems.In [8], the designed system describes that the level of garbage in the dustbins is detected with the help of sensor systems, and communicated to the authorized control room through GSM system. Microcontroller is used to interface the sensor system with GSM system. A GUI is also developed to monitor the desired information related to the garbage for different selected locations. This will help to manage the garbage collection efficiently in [9], it describes the application of our model of "Smart Bin" in managing the waste collection system of an entire city. The network of sensors enabled smart bins connected through the cellular network generates a large amount of data, which is further analyzed and visualized at real time to gain insights about the status of waste around the city. This paper also aims at encouraging further research in the topic of waste management.

2.3. Review of Existing Systems

Many journals, research papers, projects, book related to waste management system [10]has been reviewed, analyzed to draw some new prospective and concept for development of the project. There is a need to design a user-friendly system which will be utilizing the latest technologies for waste management. Moreover, Waste. Management office of Lilliput district was visited for the purpose of data collection regarding the techniques practiced for waste management. During analysis it was found that manually each garbage routes are checked daily rendering mini trucks. Though for the purpose of tracking vehicles GPS system was implemented there. With a population of over 466,784 the total quantum of municipal solid waste generated in Lalitpur is approx. 70 tons per day. Waste Management office employs 12 trucks (capacity of 2.8 metric cube), 3tractors (capacity of 1.5 metric cube) along with some 3 wheelers.

3. Methodology

3.1. Flow diagram of Methodology Adopted

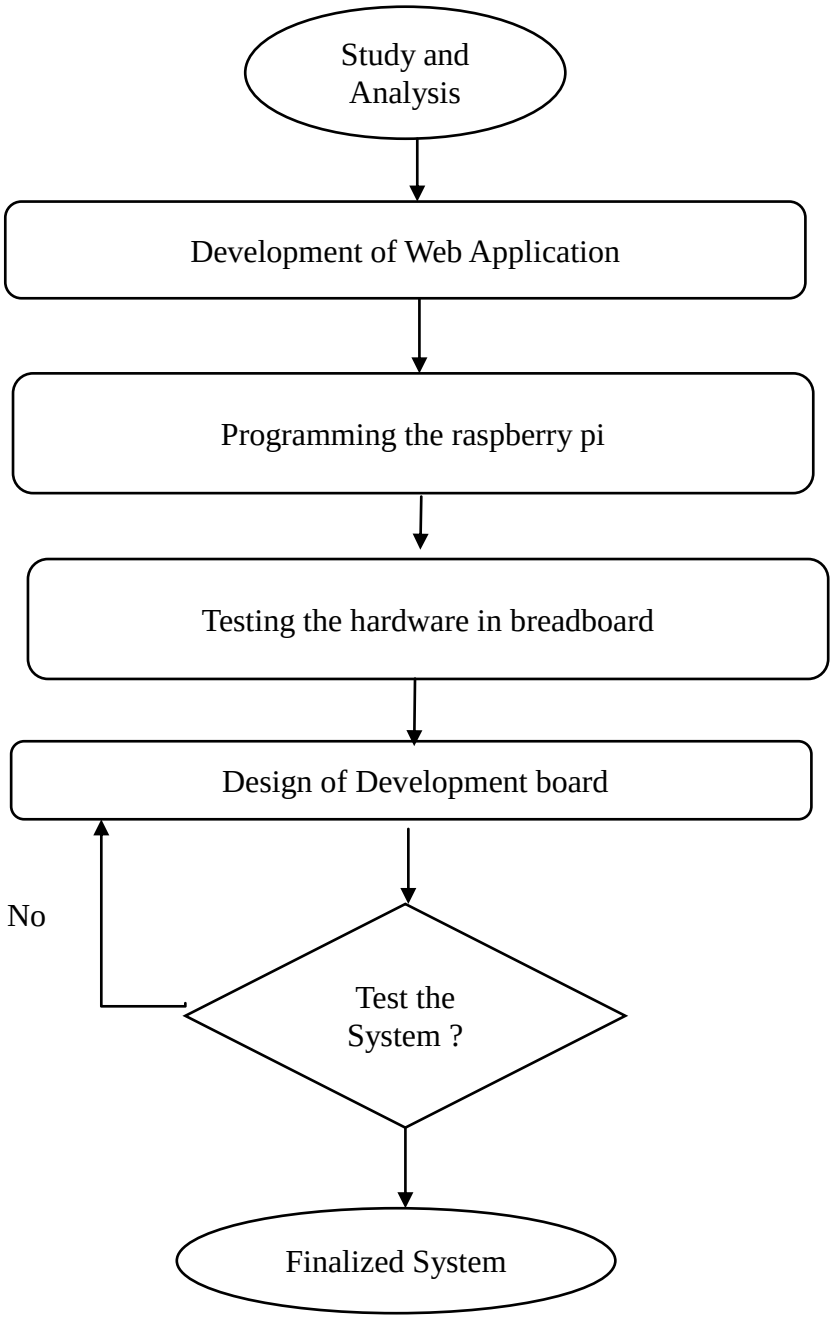

Fig 3.1: Flow diagram of methodology adopted

At first, analyzing of the project in detail and then taking factors such as economical, technical feasibility, finalization of the project is done. And the requirement for the project is analyzed properly, moving further to the design portion. For this, proteus is used for simulation. Simulation will lead in the development of the project. Pi should

be programmed accordingly to visualize sensor data in webpage. If the simulation goes correct, breadboard will be accordingly used for interfacing of sensor network with raspberry pi. After the completion of development in the breadboard, testing and verification are the next steps.

3.2. Block Diagram of the System

Transmitter Side

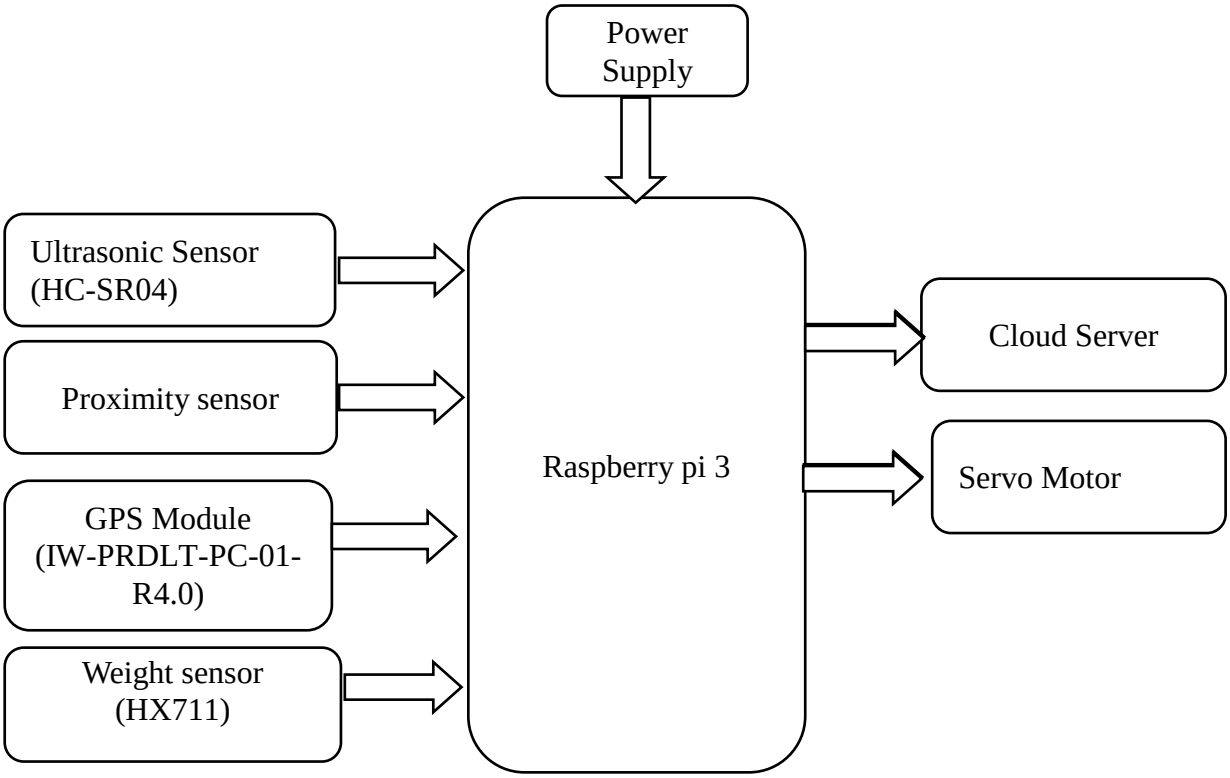

Fig 3.2.1: Block diagram of the system (Transmitter Side)

The approach for designing this system is to implement a Raspberry Pi-based control module that detects particular threshold value of garbage level in a container along with its location using GPS module. Moreover, ultrasonic sensor is used for sensing the garbage level of the container. Proximity sensor is used for the purpose of opening and closing the lid of container. Thus, all these data are saved in cloud server which can be fetched from any place having internet access.

Reciever Side

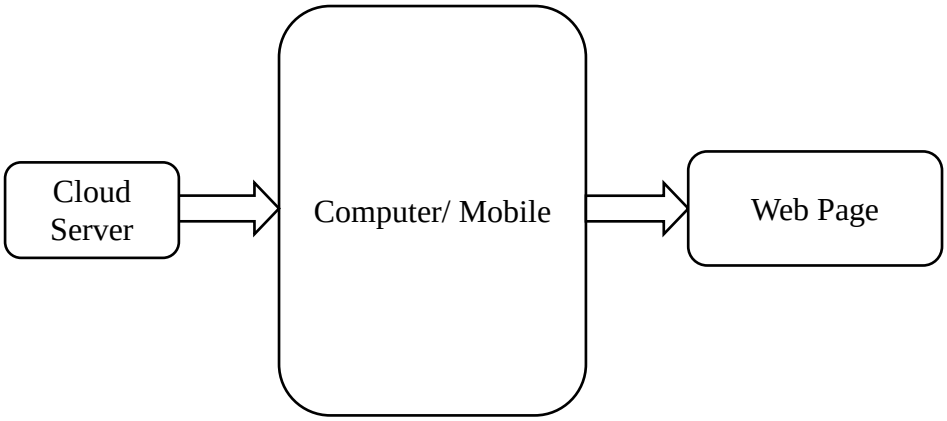

Fig 3.2.2: Block diagram of the system (Receiver Side)

At receiver side, sensor data are fetched from cloud server and hence can be displayed in a webpage from remote computer and mobiles. The module shall give information to the concerned person through the webpage. The webpage can be seen by all the officials. By intimating the notification of waste filled in the garbage, the number of trips of the garbage collecting vehicles can be reduced.

Power Supply

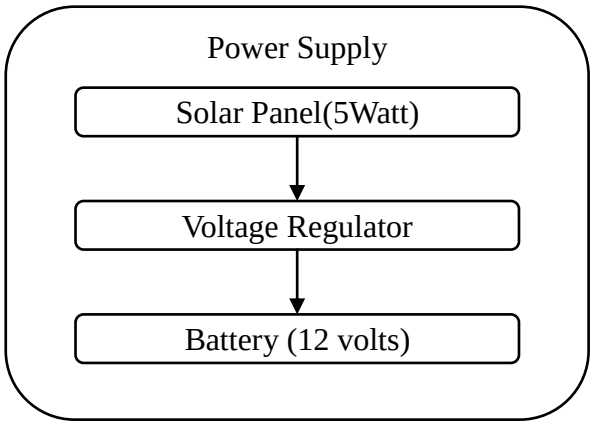

Fig 3.2.3: Block diagram of the Power Supply

For powering raspberry pi, solar energy is should along with battery backup in case of absence of solar energy. Basically, raspberry pi operates on 5 volt and 3.3 volt which is provided by 12-volt battery. And battery is recharged with the help of solar panel (5 Watt).

3.3. Flow Chart of the System

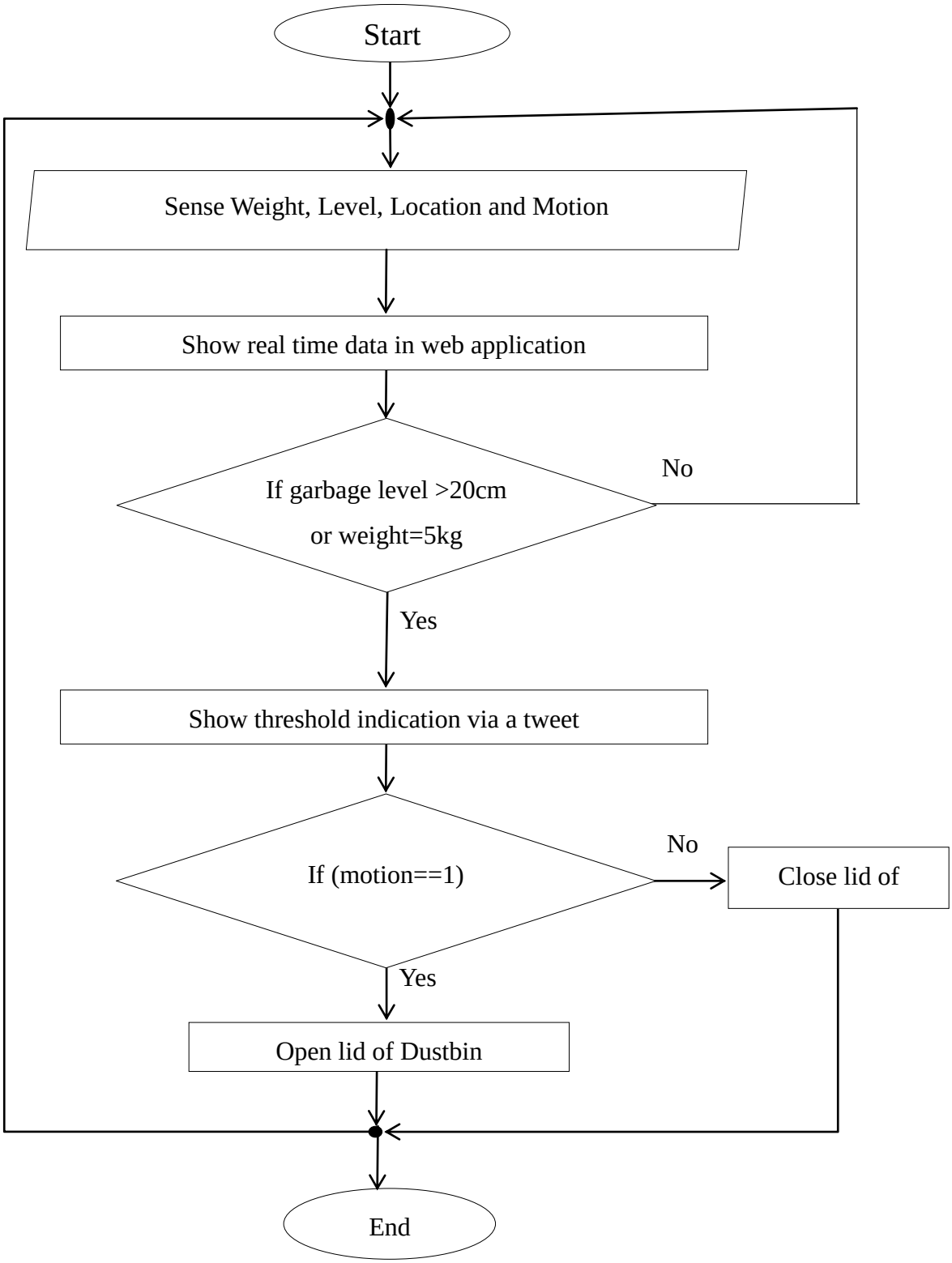

Fig 3.3: Flow chart of the system

Initially Raspberry Pi is interfaced with ultrasonic sensor, proximity sensor, weight sensor and GPS module. After that, garbage level is traced by the ultrasonic sensor. It uses a sound transmitter and receiver. An ultrasonic sensor creates an ultrasonic pulse called ping and listen for the reflection of pulse. The sound pulse is created electronically using a sonar projector consisting of signal generator, power amplifier, and electro-acoustic transducer array. Likewise, location parameter is provided by GPS module and proximity sensor senses values accordingly. Raspberry Pi is employed as fantastic tool for IOT based projects. The proposed project can be accomplished by following steps as shown below:

i. Firstly, individual sensor senses required parameters respectively.
ii. Show sensor data in the web portal.
iii. Check whether threshold values of level and weight are satisfied or not.
iv. If the threshold values are satisfied, send information about the same via the webpage to concerned persons otherwise go to step (i)
v. Check for values changed by proximity sensor.
vi. If the condition is true, open the lid of the container otherwise it remains closed.
vii. The same operation goes on in a loop from (i) to (vi) so that real time data's can be analyzed.

Moreover, the dimension of prototype trash bin is about 25 centi-meter height, 25-centimeter length with maximum capacity of 5 kilograms. Accordingly, threshold values are assumed as mentioned above.

4. Hardware and Software Requirement

4.1. Hardware Requirement

Following are the hardware components required for this project:

- Raspberry pi
- GPS module
- Proximity sensor
- Ultrasonic sensor
- Weight sensor
- Resistor
- Capacitor
- Crystal
- Solar Panel
- Solar Voltage Regulator
- Battery
- Servo Motor

4.2. Software Requirement

Following are the main software requirements:

- Python Editor
- Raspbian OS
- SD card Formatter
- Win32 Disk Imager
- Putty Configuration

4.3. Hardware Description

The Raspberry Pi is contained on a single circuit board and features ports for 1.4GHz 64-bit quad-core processor, dual-band wireless LAN, Bluetooth 4.2/BLE, faster Ethernet,40 pin GPIO,1 GB RAM etc. It is a general-purpose computer, usually with a Linux operating system, and the ability to run multiple programs. It supports micro SD format for loading operating system and data storage. Maximum throughput of ethernet is 300 Mbps.

Fig 4.3.1: Raspberry Pi

[Source: www.raspberrypi.org]

Raspberry Pi 3 GPIO Header

Pin#	NAME	NAME	Pin#
01	3.3v DC Power	DC Power 5v	02
03	GPIO02 (SDA1 , I²C)	DC Power 5v	04
05	GPIO03 (SCL1 , I²C)	Ground	06
07	GPIO04 (GPIO_GCLK)	(TXD0) GPIO14	08
09	Ground	(RXD0) GPIO15	10
11	GPIO17 (GPIO_GEN0)	(GPIO_GEN1) GPIO18	12
13	GPIO27 (GPIO_GEN2)	Ground	14
15	GPIO22 (GPIO_GEN3)	(GPIO_GEN4) GPIO23	16
17	3.3v DC Power	(GPIO_GEN5) GPIO24	18
19	GPIO10 (SPI_MOSI)	Ground	20
21	GPIO09 (SPI_MISO)	(GPIO_GEN6) GPIO25	22
23	GPIO11 (SPI_CLK)	(SPI_CE0_N) GPIO08	24
25	Ground	(SPI_CE1_N) GPIO07	26
27	ID_SD (I²C ID EEPROM)	(I²C ID EEPROM) ID_SC	28
29	GPIO05	Ground	30
31	GPIO06	GPIO12	32
33	GPIO13	Ground	34
35	GPIO19	GPIO16	36
37	GPIO26	GPIO20	38
39	Ground	GPIO21	40

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29/02/2016

www.element14.com/RaspberryPi

Fig 4.3.2: Pin Diagram of Raspberry Pi Model 3(B+)

[Source: Datasheet of Raspberry Pi]

GPS sensors are receivers with antennas that use a satellite-based navigation system with a network of 24 satellites in orbit around the earth to provide position, latitude and longitude coordinates, bearing, and speed, and timing information.Locations are calculated through a process called three-dimensional trilateration, a mathematical formula that uses the positions of the satellites and their distance from the Earth (based on the amount of time the signal takes to reach the receiver) to determine the point at which the satellite signals and the surface of the earth intersect. Gain of antenna used is approximately 28dB.It operates at 3.3-volt power supply.

Fig 4.3.3: GPS sensor

[Source: www.mysensors.org/build/gps]

A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact. It emits electromagnetic field or beam of electromagnetic radiation and then looks for changes in return signal or field. The object that is being sensed is the proximity sensor's target. Proximity sensors can be used to recognize air gestures and hover-manipulations. It can detect a person up to approximately 30 ft away, or up to 15 ft away in reduced sensitivity mode. Jumper selects normal operation or reduced sensitivity. Moreover, this sensor is based on single high or low output.

Fig 4.3.4: Proximity sensor

[Source: www.ifuturetech.org/product/pir-motion-detector-sensor-hc-sr501]

A weight sensor is a transducer which converts force into measurable electrical output. Although there are many varieties of load cells strain gauge-based load cell are commonly used. When weight is applied, the strain changes the electrical resistance of the gauges in proportion to the load.

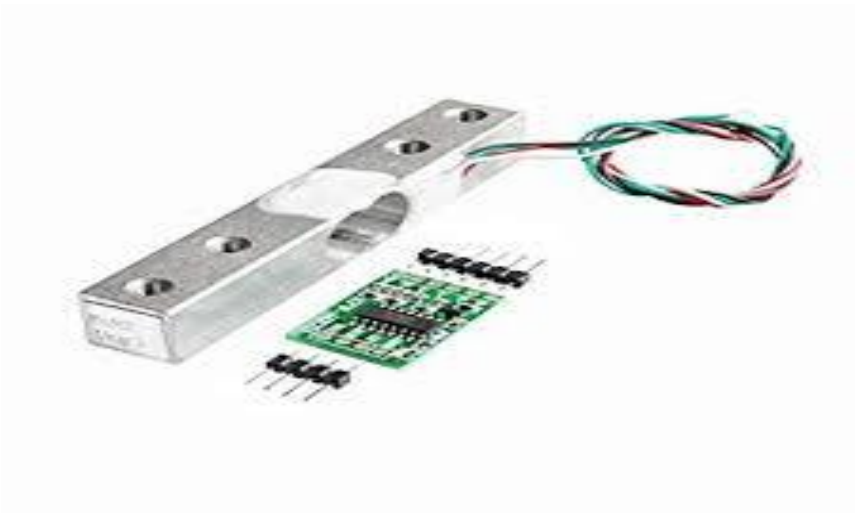

Fig 4.3.5: Weight sensor

[Source: www.engineersgarage.com/hx711 sensor]

An ultrasonic sensor is an instrument that measures the distance to an object using ultrasonic sound waves. An ultrasonic sensor uses a transducer to send and receive ultrasonic pulses that relay back information about an object's proximity. High-

frequency sound waves reflect from boundaries to produce distinct echo patterns. Transducers are the microphones used to receive and send the ultrasonic sound.

Fig 4.3.6: Ultrasonic sensor

[Source: www.engineersgarage.com/HC-SR04 sensor]

Electrical Parameters	HC-SR04 Ultrasonic Module
Operating Voltage	DC-5V
Operating Current	15mA
Operating Frequency	40KHZ
Farthest Range	4m
Nearest Range	2cm
Measuring Angle	15 Degree
Input Trigger Signal	10us TTL pulse
Output Echo Signal	Output TTL level signal, proportional with range
Dimensions	45*20*15mm

Fig 4.3.7: Technical specifications of HC-SR04

[Source: Datasheet of HC-SR04]

Multiple solar cells in an integrated group, all oriented in one plane, constitute a solar photovoltaic module. Photovoltaic modules often have a sheet of glass on the sun-facing side, allowing light to pass while protecting the semiconductor wafers. It provides 5-watt power to the system.

5. Results and Discussion

5.1. Extraction of Sensor's Data and Modelling

Firstly, each sensor needs to be correctly interfaced with raspberry pi so that accurate parameters are measured. For this, raspberry pi is programed with python script to employ this prototype system to produce desired outcome. Sensor network collects necessary parameters required for decision making. GPS, ultrasonic, proximity and weight sensors has been interfaced with raspberry PI. Following illustration depicts the sensor data which is shown in web application:

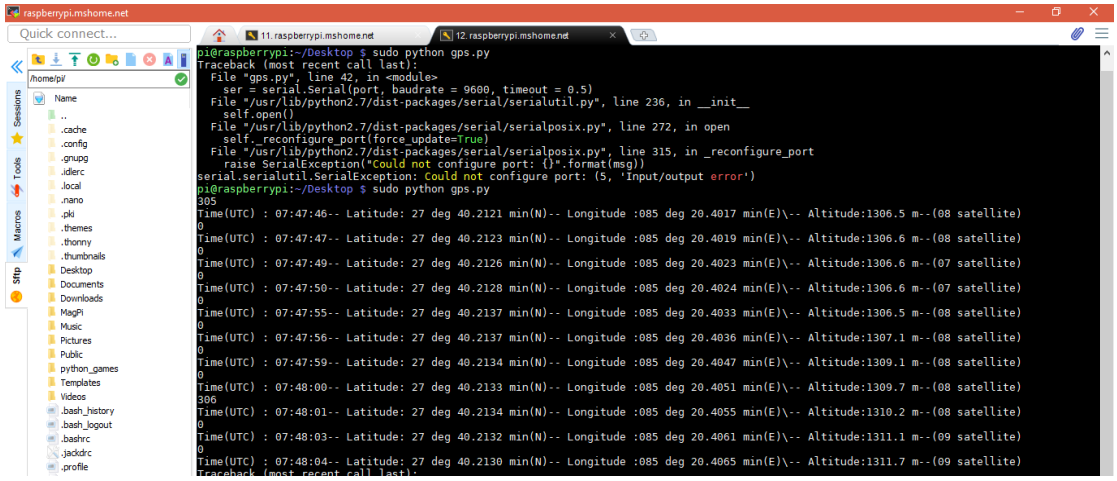

Fig 5.1.1: GPS data via PI

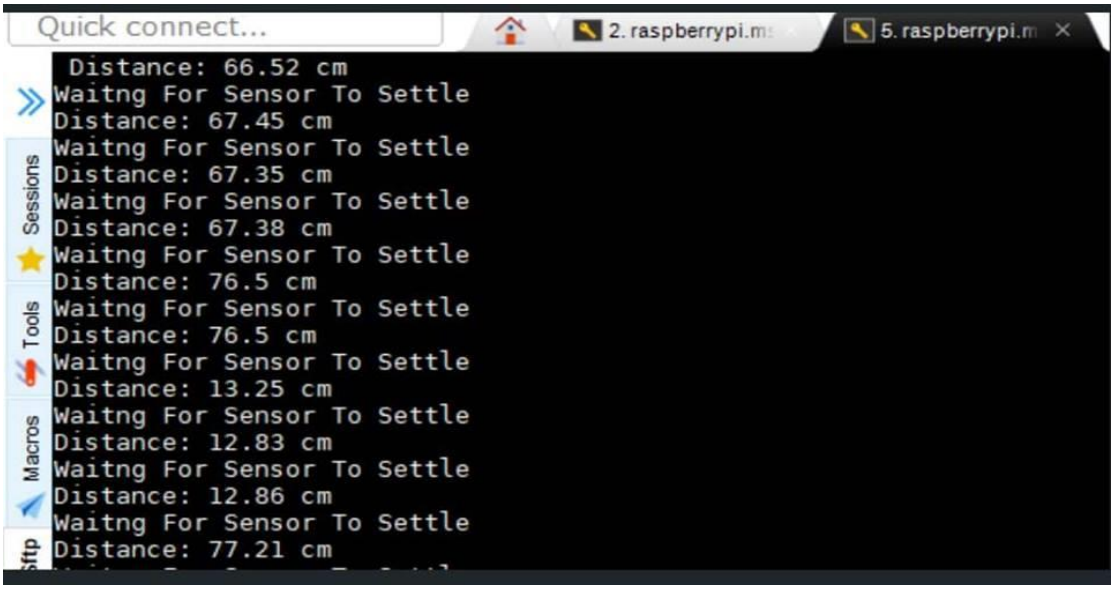

Fig 5.1.2: Ultrasonic sensor data via PI

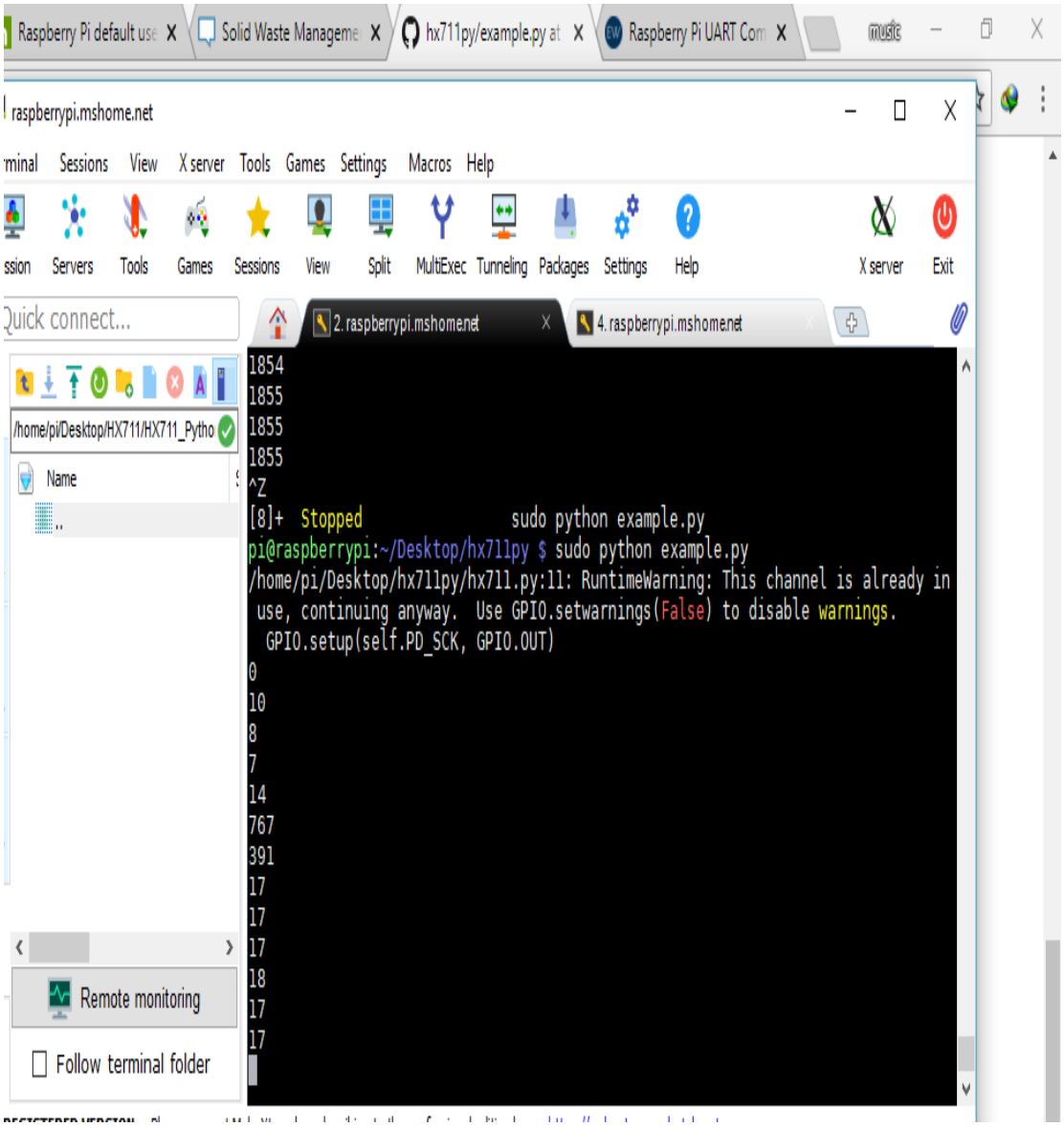

Fig 5.1.3: Weight sensor data via PI

5.2. Transmission of Measured Data to Web Portal

The measured data like weight, level of trashes in dustbin along with location of dustbin during transportation to dumping site is illustrated in following manner in the webpage. Realtime data measured by network of sensors are transmitted to web portal with the help of internet. Each field here demonstrates a plot of sensor real time data. Magnitude versus time graph of each sensors used in the system is illustrated in the webpage as shown below:

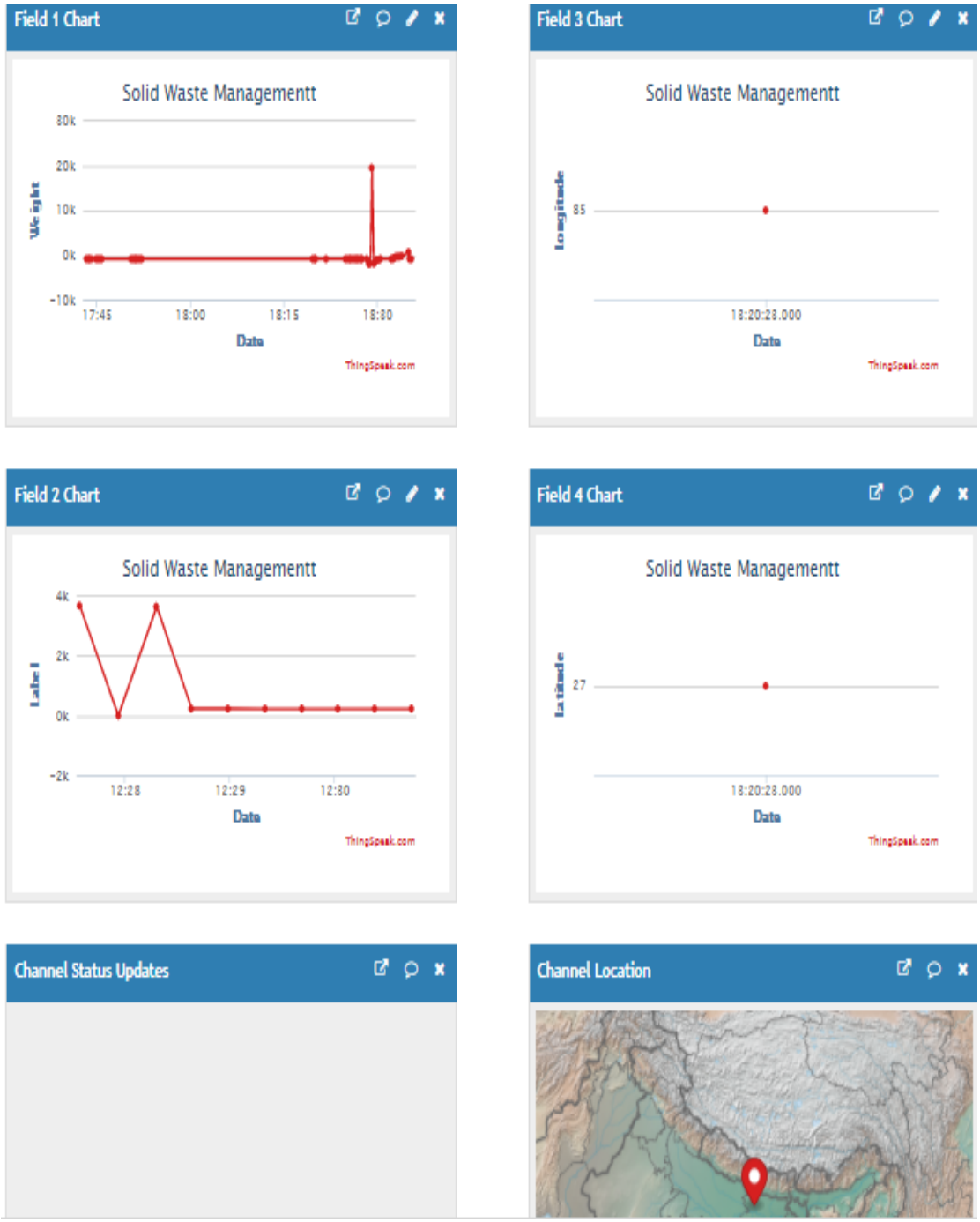

Fig 5.2: Illustration of sensor data in web portal

5.3. Final Prototype Design

After completion of simulation, integration of hardware and software, final prototype of the embedded system is designed that includes proper dimensioning of the dustbin along with efficient placement of different hardware components.

Fig 5.3: Final prototype of project

5.4. Discussion

During the development of a system for real time, different methodologies were studiedand best feasible methodwas chosen. Firstly, interfacing of different sensors with raspberry pi was completed. Integration of individual modules using python script was quite difficult. Moreover, parsing gps data along ultrasonic and weight sensor data in real time to cloud server was most complex part. While merging and final logical coding, there arised different conflicts like syntax error, semantic errors. The tested and debugged code in the final system design was implemented and working prototype was developoed.

6. Conclusion

The objective of the project is for the real time access of information about the dustbin. This system avoids spreading of some deadly diseases by managing the waste containers by monitoring the status of it and accordingly taking the decision. Moreover, this project aids smart city concept as proposed by the government thus making environment neat and clean.

As per the objectives of the project, the design and implementation of IOT based waste management system is completed. Beside this, interfacing of sensor network, extraction of real time data, web application design is also achieved.Thus, giving rise to the working prototype of the system along with status showing feature.

Along with these technical aspects we also learned a lot about how to work efficiently as a team. Teamwork was key in completing a project of such scale within the given constraints of time and budget. This taught about task allocation and efficient time management. Knowledge of efficient troubleshooting techniques by conducting periodic group discussions is learned. Hence, many problems and challenges were encountered throughout the project phase and most of them solved through the group discussions.

7. Limitation and Future Enhancement

7.1. Limitations

- Environmental noise affects the response of the sensors thus overall system's performance lags
- Notification alert system could be added
- Power fluctuation issues due to use of solar power

7.2. Future Enhancements

- It can be upgraded by using features likes email and message alerting
- It can be enhanced by integrating previous data in database for future reference
- Making the web application more user friendly thus displaying more information about the dustbin

8. References

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Appendices

Appendix A1 (Design)

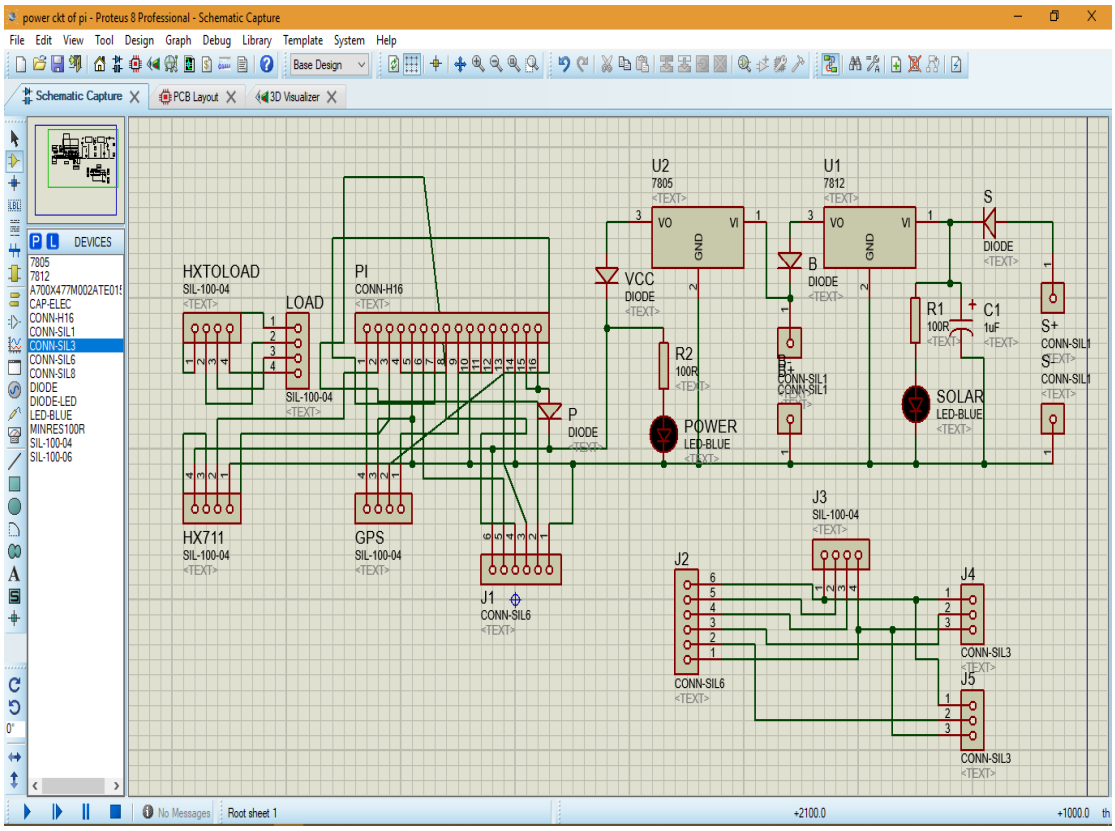

Fig A1.1: Schematic layout of the system

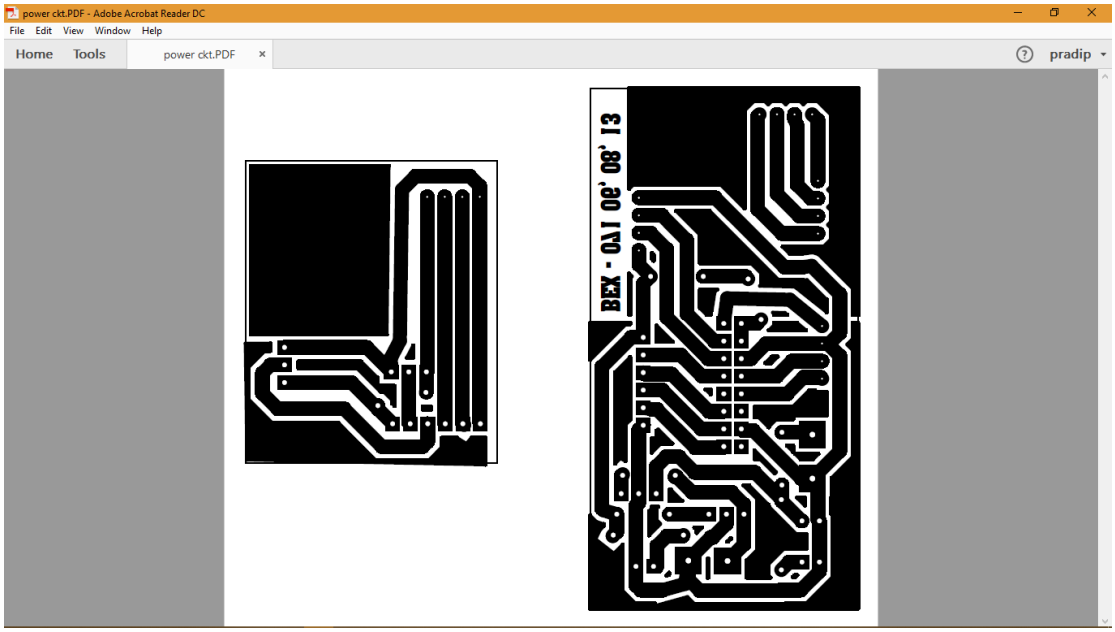

Fig A1.2: PCB layout of the system

Appendix A2 (Snapshots)

Fig A2.1: Drilling of development board

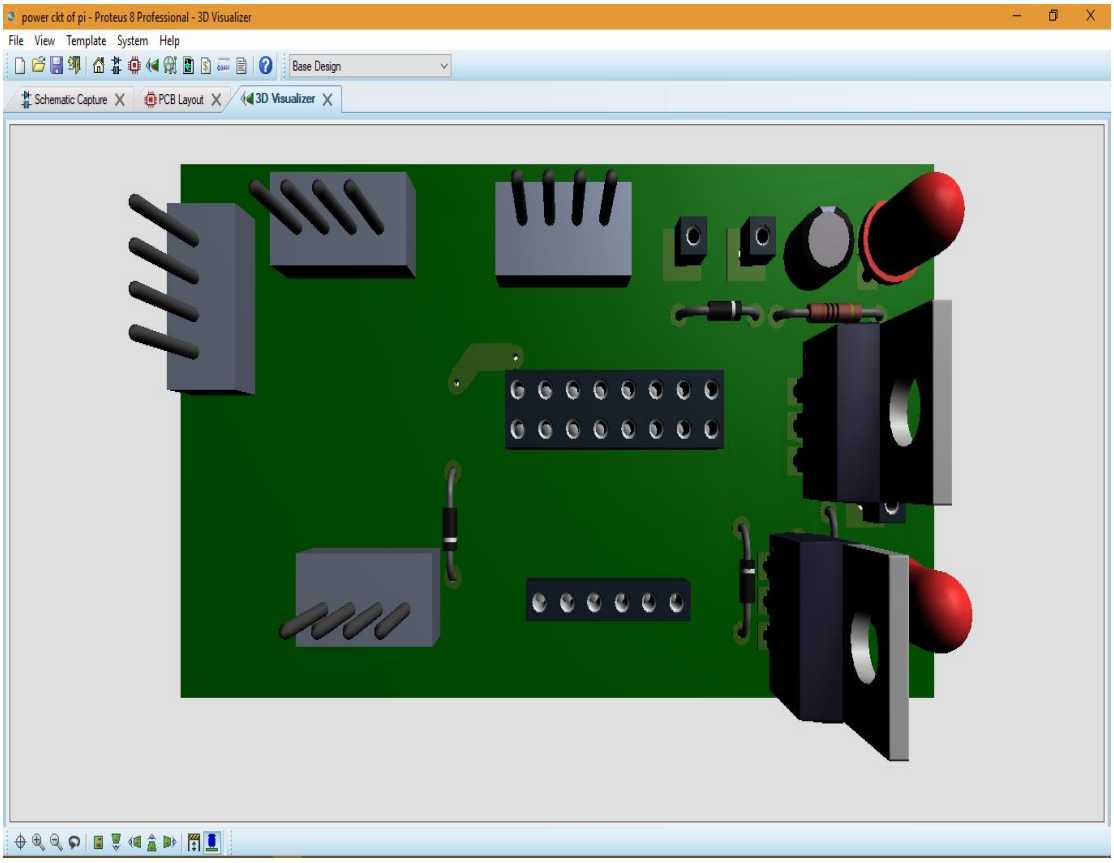

Fig A2.2: 3-D view of development board

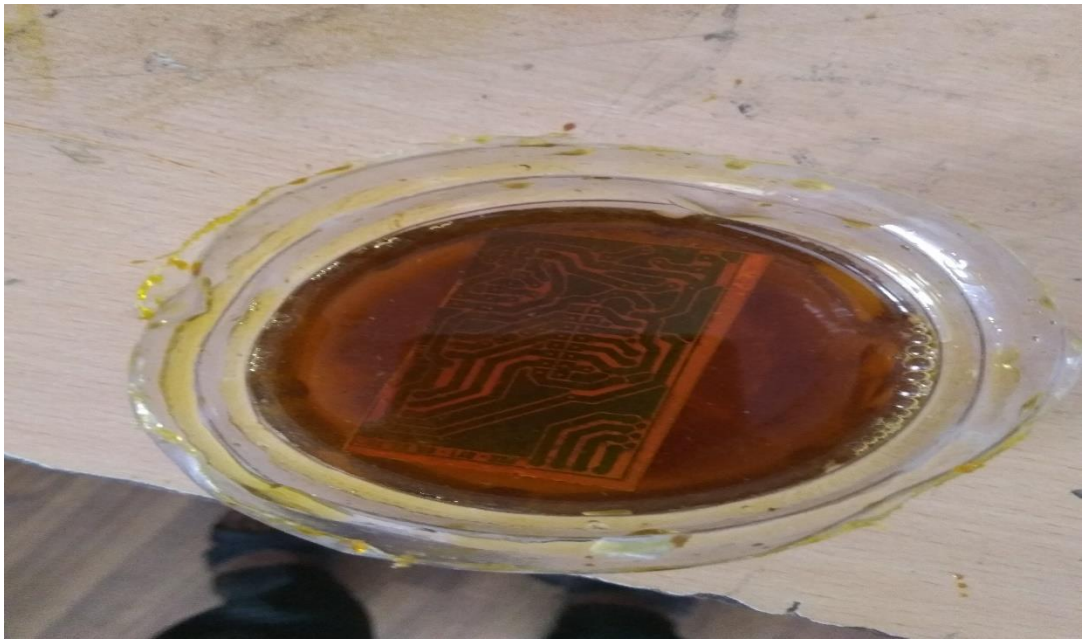

Fig A2.3: Itching of development board

Fig A2.4: Assembling of hardware