### TEMPERATURE MONITORING AND ALERT SYSTEM

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**Abstract**

The government declared the following rules for manufacturing tablets/medicine in all pharmaceutical companies:

• While the manufacturer can maintain the temperature of the tablets between, -40 and -30 degrees Celsius, the temperature of the tablets should never remain between -33 and -30 degrees for longer than 20 minutes at a time.

• Also, the manufacturer should maintain a log of when the cooling chamber to produce the tablets is opened.

• These rules should be implemented within a month of their declaration. Failing to comply would lead to cancellation of the pharmaceutical production permit.

While the government declared these rules to ensure that the medicine produced at all pharmaceutical companies, was good enough to be used by the public.

This project is related to solving the problem that is faced by many pharmaceutical companies i.e., they have no automated alert system that alert the people responsible for management of cooling the chamber at a certain range of temperature. Because of temperature going below the lower threshold or going above the upper threshold value will cause the damage to tablet or medicine and that will cause a huge lose to the pharmaceutical companies.

The pharmaceutical companies use a cooling chamber which is like a refrigerator to keep the tablets and maintain the temperature in the required limits. However, since we do not have a cooling chamber which can maintain a temperature in the range, of -40 to -30 degrees Celsius, you can instead use a regular refrigerator at your home for this project.

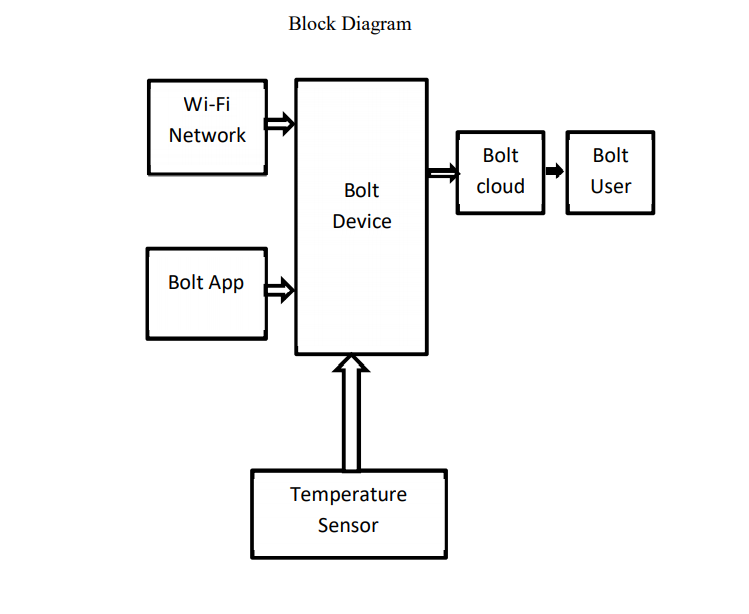
# Introduction

Internet of Things is one of the most important topics for today's world. The whole world depends on internet. So, project on Internet of Things seems to be one of the most interesting for all. Keeping that in my mind, I have created my project on IOT where I have made temperature monitoring system which will alert us whenever any disturbance take place in temperature. That means, we will easily get notified whenever the temperature crosses the limit of required temperature, through any means like email, SMS, as well as WhatsApp message.

This project has real time example, which is in pharmaceutical company, where medicines are stored at a standard temperature and here IOT can be used to get notified if the temperature crosses the limit for any reason. and by this, we can take recovery steps for future.

* 1. **Initial Needs**

Starting from the traditional crops to the artificial ones in food industries, from drugs to chemical manufactured in the pharmaceutic al industries, all of them need the right amount of temperature to be maintained for manufacture. Our homes too had thermostat installed which monitor and regulate the temperature. Maintaining using this project, you will be able to build such a monitoring system where you will be able to monitor the temperature of the environment in the form of visual graphs. This project can then be extended to predict the future sensor values via Machine Learning over the Bolt cloud. The advancement in technology, Internet of things is the next great thing with increased demand of automation and smart appliances at industrial level as well as personal home level, Internet of Things the need to make the objects smart.



# Customer Needs Assessment

According to the data collected by customer reviews the product is portable as one can carry it any where and there is no risk of short-circuiting as it only requires a USB cable to connect to power source. Its highly durable, all the sensors including Bolt Wi-Fi module, jumper wires and breadboard are durable and the USB cable provided is also highly elastic and durable. This product does not require maintenance and is very easy to operate, user just need to sign into his/her BOLT account and he/she can view the data along with the graph and can also download it into Excel file. Besides these this device also sends alerts if it detects anomaly in temperature. User can handle it remotely by viewing data collected by sensor on his phone as access to Bolt cloud will be given where data is stored.

**Table 1.Initial Customer Needs List Obtained from Interviews and Observations**

|  |
| --- |
| Portable |
| Protection from short circuiting |
| Durable |
| Free Maintenance |
| Easy to operate |
| Easy access to data |
| Alerts Access |
| Handled remotely |
| Eco-friendly |
| Pocket friendly |
| Safe |

**3.0 Target Specifications**

Most of the products that we produce have a very crucial factor that is temperature. From drugs to chemical manufactured in the pharmaceutical industries, all of them need the right amount of temperature to be maintained for manufactured in the pharmaceutical industries; all of them need the temperature part of these sectors. Maintaining the right temperature is required for the medicine so as it can withstands for months. If the right temperature is not maintained, the medicines will expire. This project can be extended to predict the future sensor value via Machine Learning over the Bolt Cloud. The drawbacks of using that it has a greater number of pins and it cannot store more values. By using Arduino, we cannot store the information on Cloud as the cloud technique\is not supported for the Arduino. So, the task of completing this project will be complex while using Arduino the humidity sensor is used so as to calculate the temperature. Code has to be coded so that it may function effectively. Input pins need to be set correctly so that the power supply is given to perform well.

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# External Search

This Bolt Wi-Fi module is the controller which is used for the cloud saving. Python is the programming language which is utilized in Bolt Wi-Fi module. LM35 sensors is a temperature sensor which is used here for detecting temperature. This comprises of temperature ascertaining capacity and favorable fundamental position of utilizing these sensors, which boasts of less weight and ease of use. The sensor is associated with utilizing connecting wires. Temperature sensor lm35 sensors is utilizing is perused put away and shown in the Bolt Cloud. The sensor analyzes the graphical representation of the observed data in every user-defined format wherever in the world. In this work, IoT based Bolt Wi-Fi module microcontroller is used. Temperature monitoring using Bolt Wi-Fi module is an exciting and secure process. Furthermore, this flexible system obtains more values in calculating the actuator from the data saved on the internet.

The project deals with the sensing of temperature with the help of LM35 in nay industrial level, say any pharmaceuticals company, which manufactures medicines. It is mandatory for the pharmaceuticals companies to keep track of the temperature they are using for the manufacturing purpose of medicines. Bolt cloud one can control and monitor devices over the internet, create personalized dashboards to visualize the data, monitor the device health, run machine learning algorithms etc. Internet of Things is the usage pf computing devices via the internet. The utilization of Machine Learning in prediction of temperature in short period of time, which can on less resource-intensive Computing system. This project can be extended to predict the future sensor values via Machine Learning over the bolt cloud.

## Benchmarking

I have benchmarked my product with 2 other products available in the market which have same features the only difference is of IOT modules used in it. I have used BOLT Wi-Fi module whereas Product 2 operates on Arduino and Product 3 operates on Raspberry Pi.

### Table 4. Benchmarking of Products

|  |  |  |  |
| --- | --- | --- | --- |
| **Feature** | **My product** | **Product 1** | **Product 2** |
| Data intervals (in sec) | 5 | 30 | 60 |
| Weight (in grams) | 75 | 80 | 95 |
| Cost (in Rs) | 1700 | 2500 | 2800 |
| Durability | High Durable | Comparatively less durable | Comparatively less durable |
| Alert Access | Available | Not Available | Available |
| Accuracy | High | Low | High |
| Precision | Up to 2 decimal places | Up to 1 decimal place | Up to 3 decimal place |

So according to the above data we can observe that product is highly reliable and durable and give accurate results and cost less as compared to other products. In addition to this we also get access to Bolt Cloud Pro where all the data gets uploaded as soon as device starts taking readings and we can also plot the graph for the data for better understanding and relating data and Bolt Cloud also allows us to download the data in Excel File. All these features are not provided by Arduino and Raspberry Pi.

## Applicable Constraints

This device works in specific temperature range that is from -20 C to 40 C. As the refrigerator’s temperature is between this range only it works fine for it and also Bolt Wi-Fi module requires 10 volts as given by normal adapters if very high voltage passes through device it can harm the device. It is preferred to have a good internet connection having speed of at least 1 Mbps for proper working of device. Besides this device does not require anything else to be taken care of and is very easy to use. This can be used for home purposes as well as industrial purposes only requirement is to have a good network connection and user should take care that all the connections are made correctly and tightly as if wires are loosened or the connections are not made correctly then the device fails to do it’s task the data recorded by it will be wrong and making wrong connections can also lead to short-circuiting thereby harming device , so users should carefully make the connections as mentioned if they are purchasing just the kit instead of device.

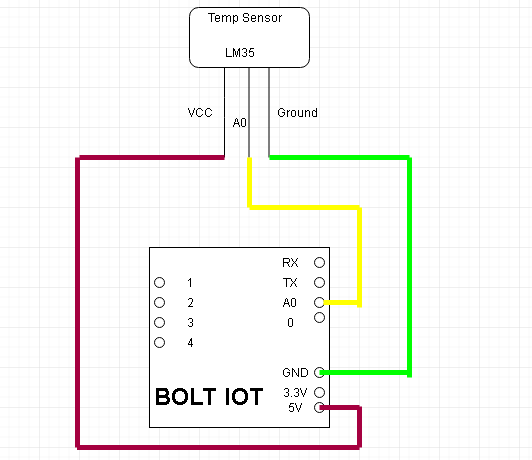
# Concept Generation

Firstly, a thorough research was done to find the most effective design that can is cost effective and more advanced than present products in the market. So, I selected Bolt Wi-Fi module that is more efficient than Arduino and Raspberry Pi. Then assembled all the equipment’s needed. Finally made all the connections and tested the efficiency of the device.

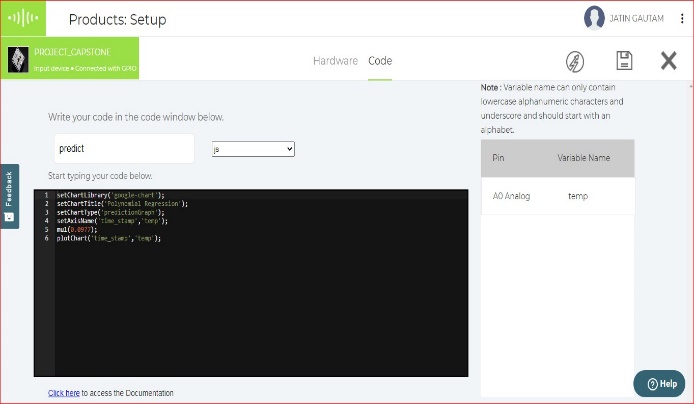
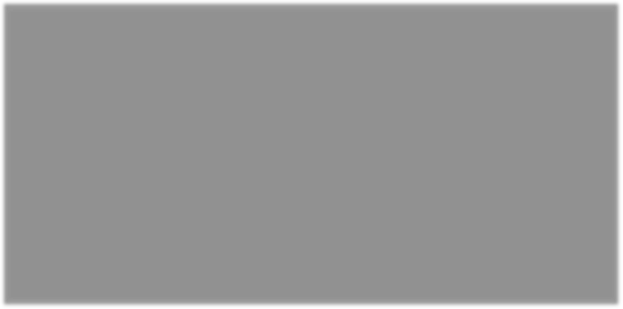
## Concept Selection And Data Calculation

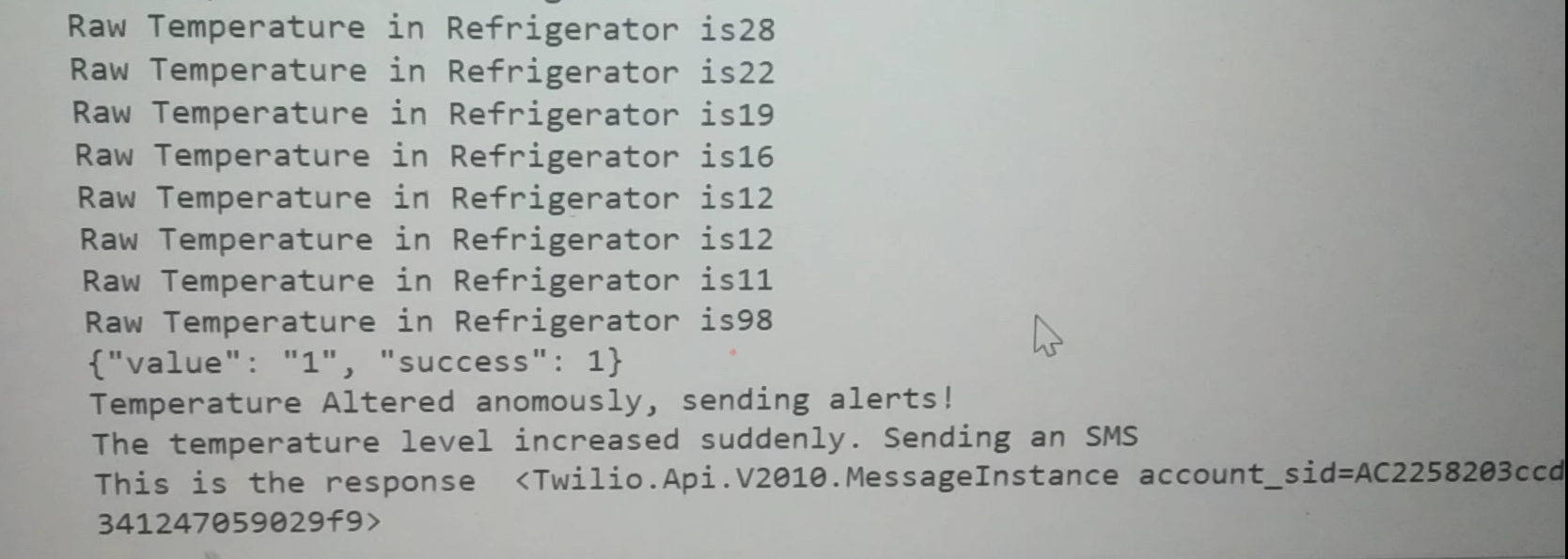
# The data and calculations recorded by device are shown here for customer feedback. As we can notice data collected is precise and accurate that makes the device more efficient than other devices and also data is collected in every 30 seconds so that if there is anomaly users get notified asap.

# 

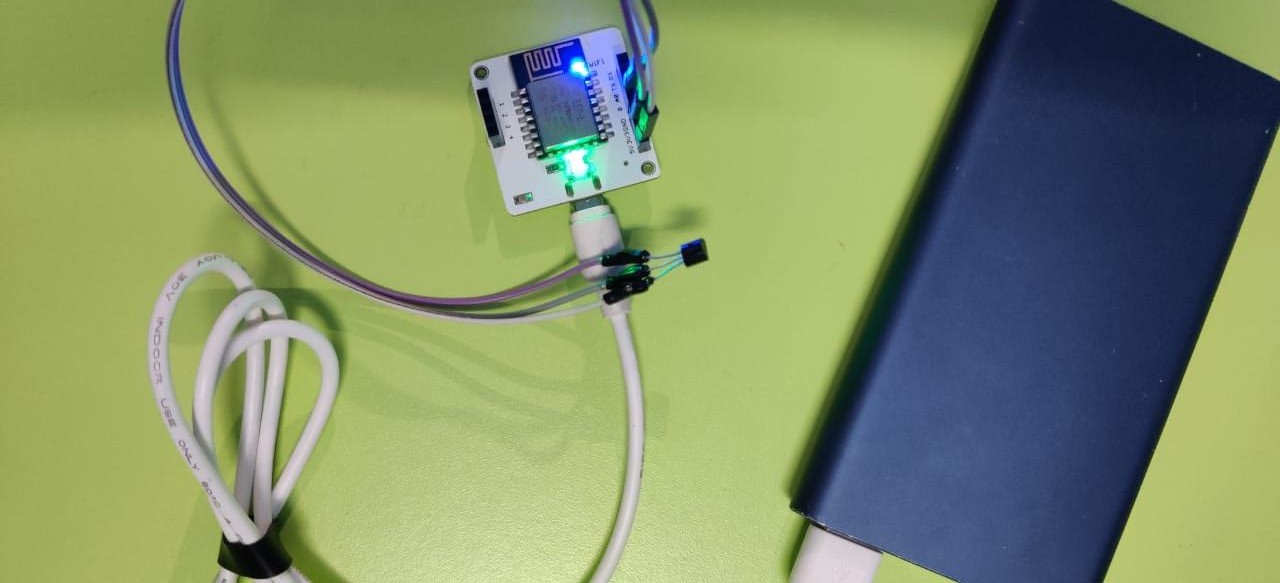
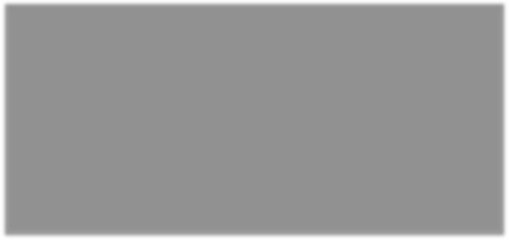
 



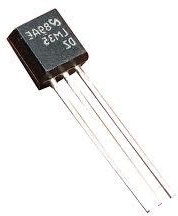


# Final Design



LM35 SENSOR

*LM35 Sensor has three terminals - supply, output and ground. It is a temperature monitoring sensor and it can be used in Pharmaceutical companies to maintain the temperature of the medicines .*



Where,

= VCC



= OUTPUT



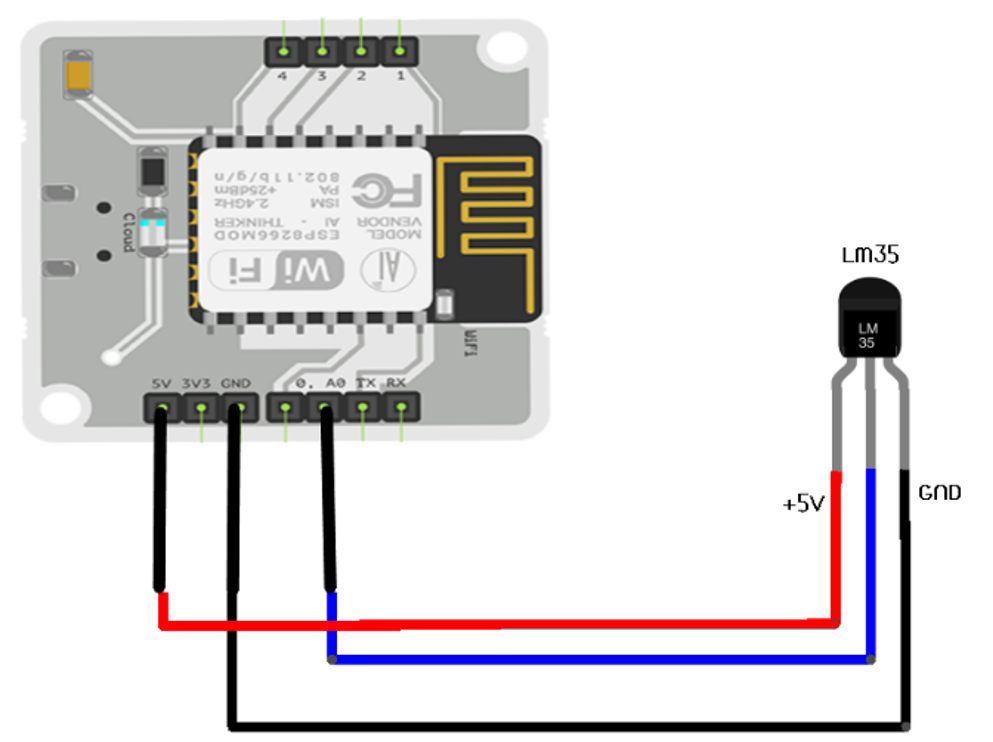
= GND

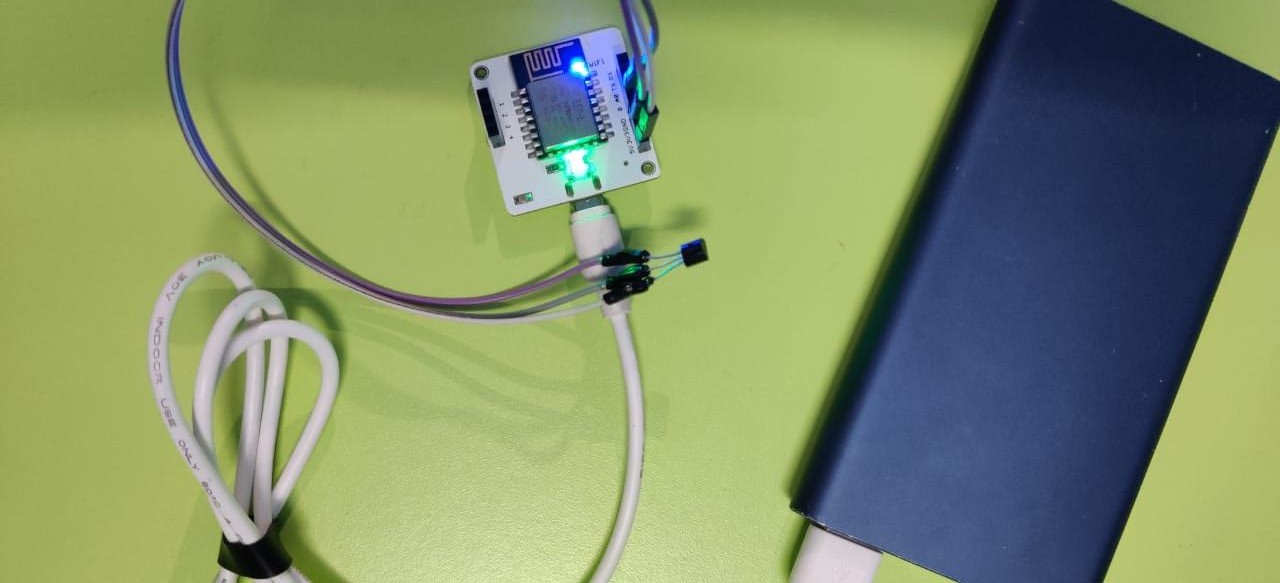
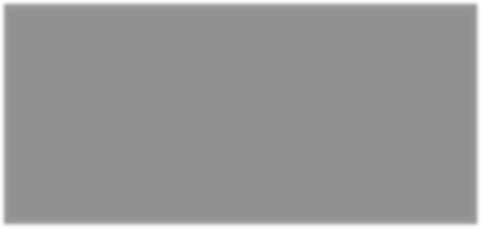


* 1. VCC pin of the LM35 connects to 5V of the BOLT WIFI MODULE.
  2. Output pin of the LM35 connects to A0 (Analog input pin) of the BOLT WIFI MODULE. 3.GND pin of the LM35 connects to the GND of the BOLT WIFI MODULE.

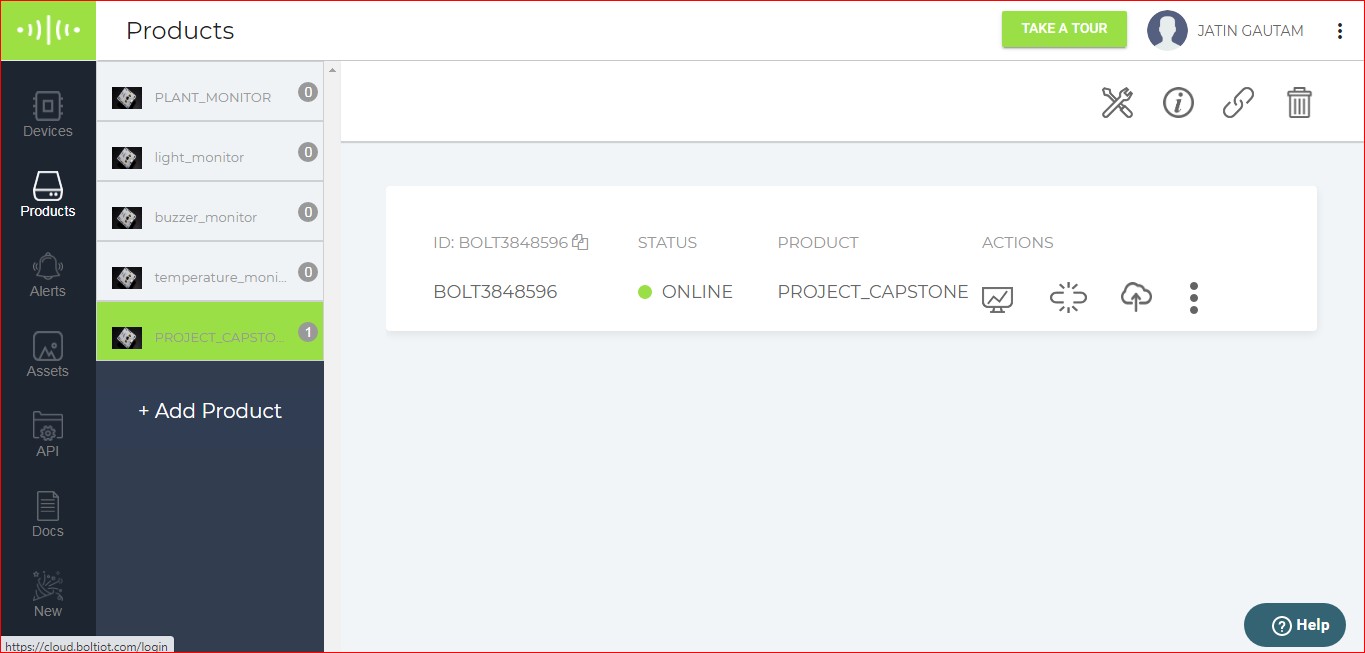
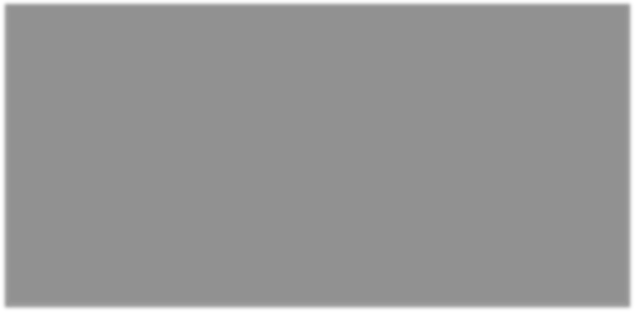
# SCHEMATICS :

### Build the circuit for temperature monitoring system, using the Bolt and LM35 sensor.





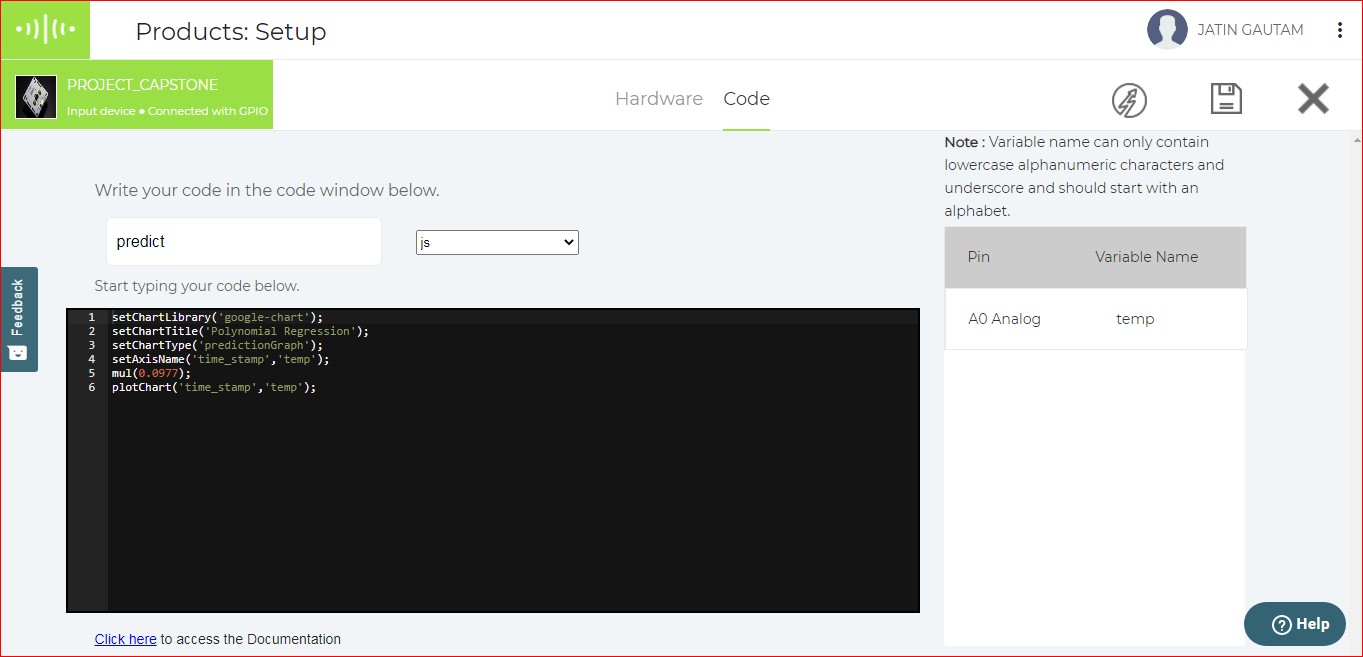
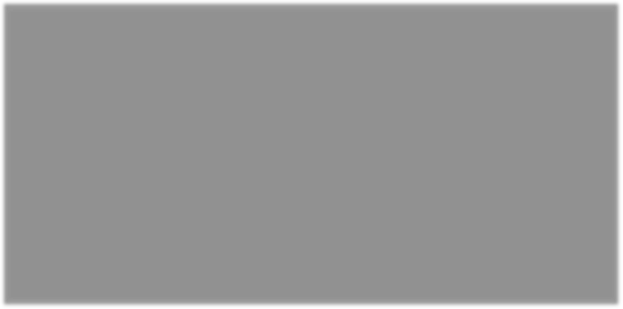
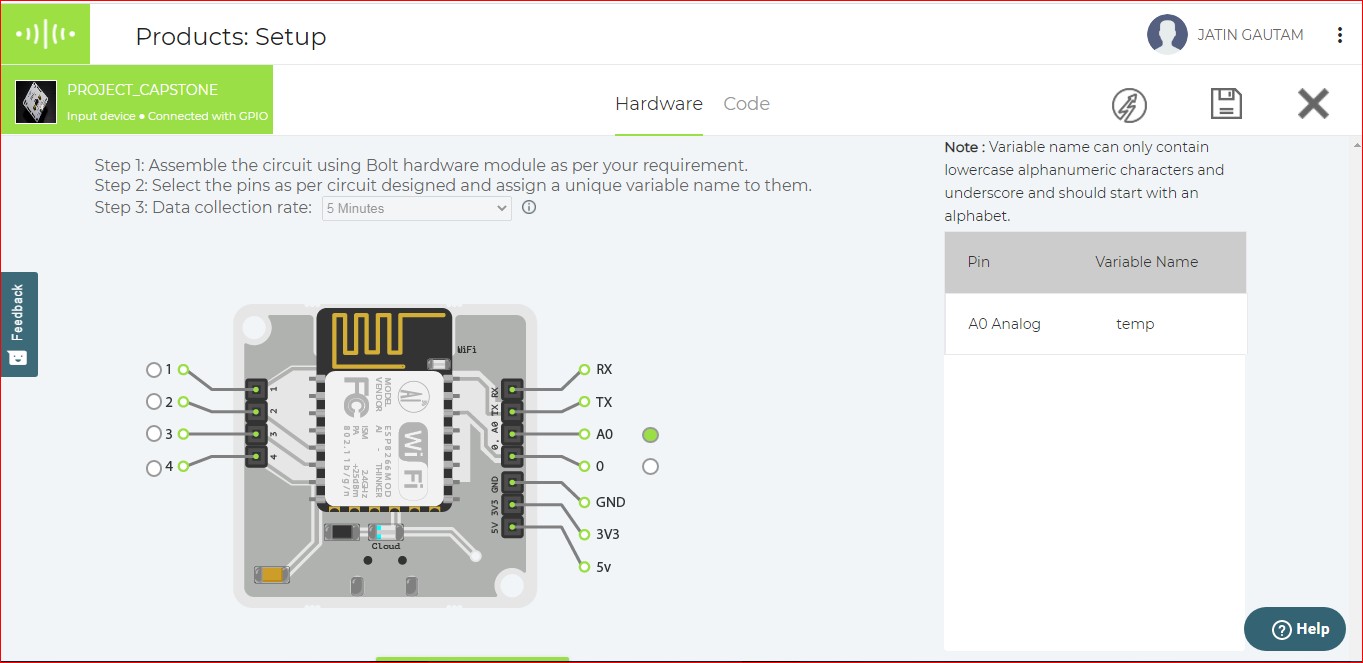
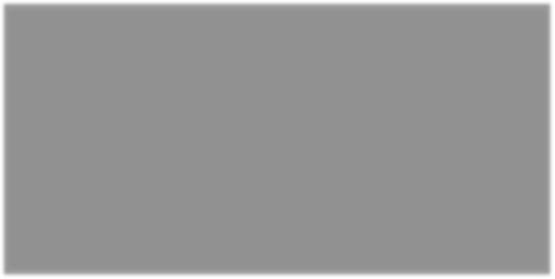
1. **Create a product on the Bolt Cloud, to monitor the data from the LM35, and link it to your Bolt.**



*In the above image, we are creating a new Product named as Project Capstone. Than we are linking this product to BOLT WIFI MODULE.*

1. **Write the product code, required to run the polynomial regression algorithm on the data sent by the Bolt.**

Using the prediction data, we are able to take early action, whenever the graph predicted that the temperature would be maintained within the -33- and -30 -degrees Celsius range for longer than 20 minutes.



Similarly, In the above image shown we are writing the code to run the Polynomial Regression on the data sent by the BOLT.

CODE :

*setChartLibrary('google-chart'); setChartTitle('Polynomial Regression'); setChartType('predictionGraph'); setAxisName('time\_stamp','temp'); mul(0.0977);*

*plotChart('time\_stamp','temp');*

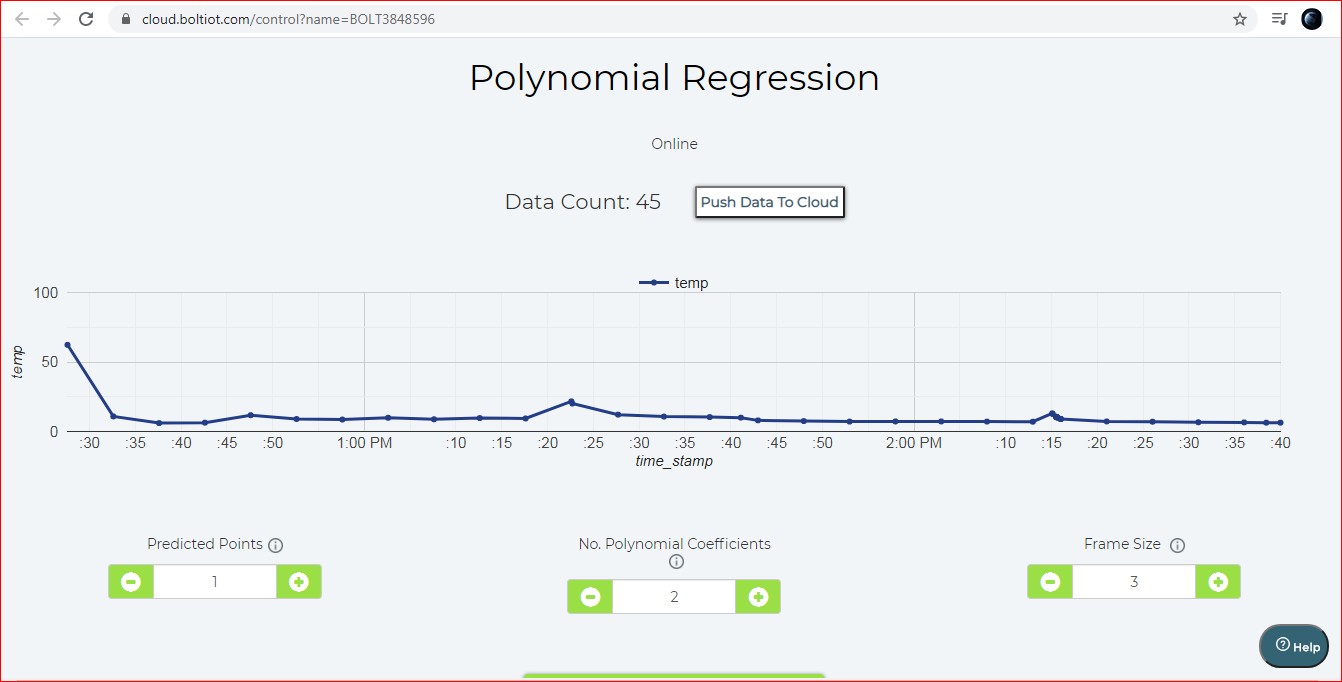
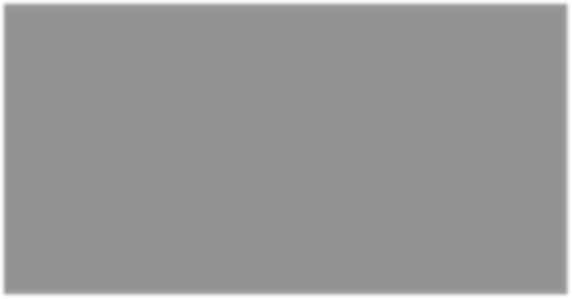
Polynomial Regression:

Polynomial Regression is a form of regression analysis in which the relationship between the independent variable x and the dependent variable y is modeled as an nth degree polynomial.

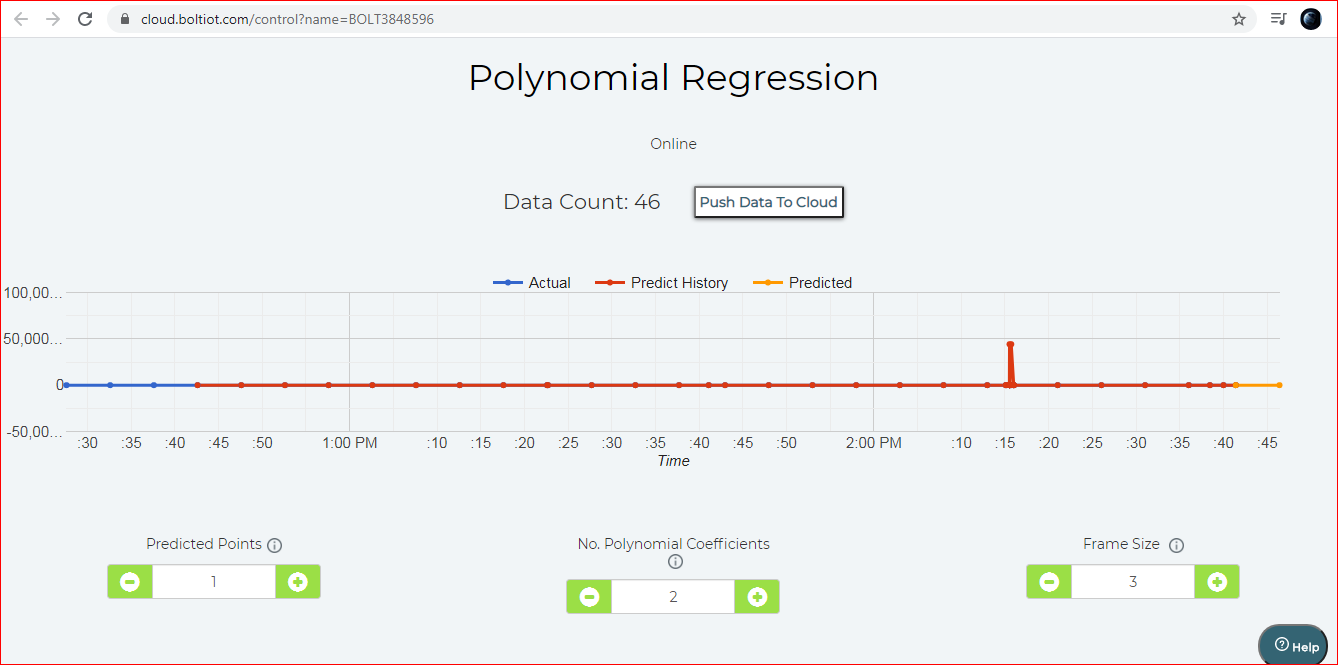
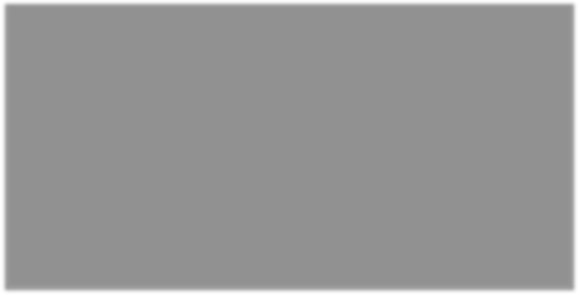
Parameters used in Polynomial Regression : 1.Prediction points

2. Number of polynomial coefficients 3.Frame Size

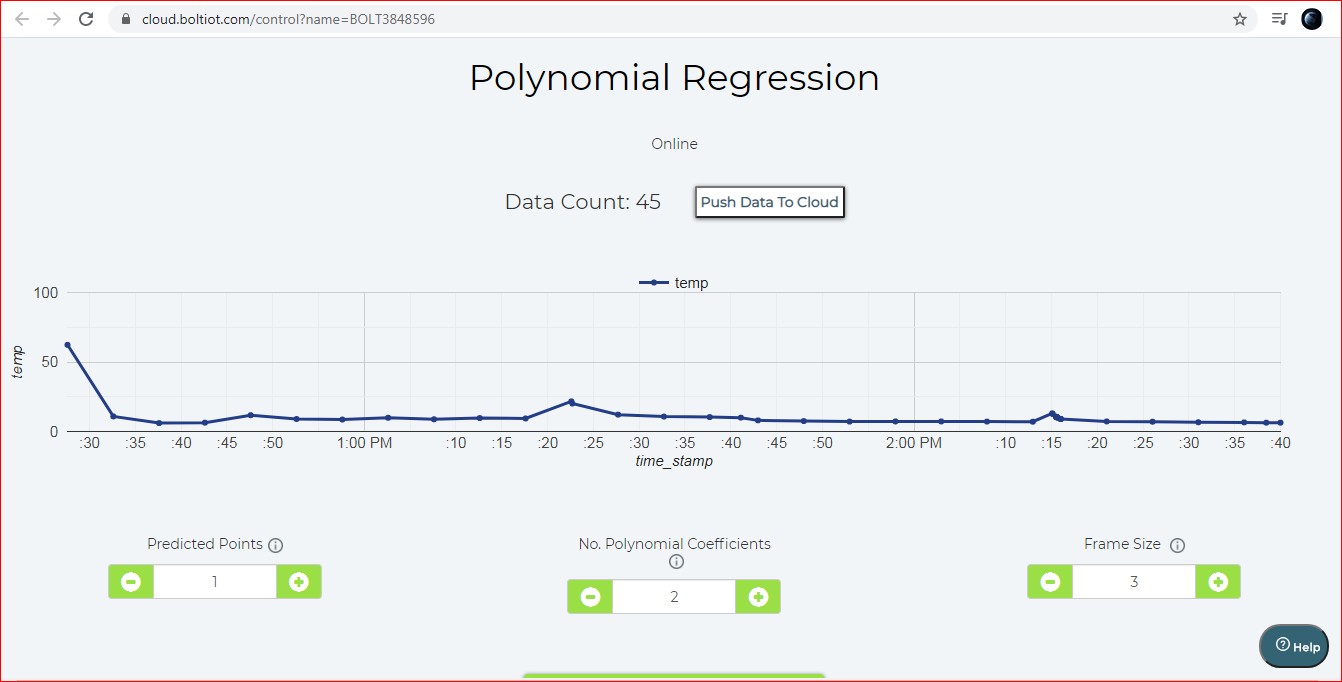
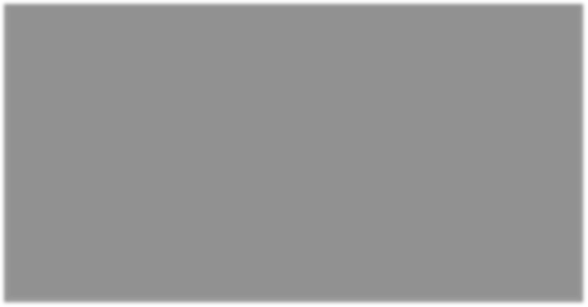
https://hackster.imgix.net/uploads/attachments/1112725/polynomial_rLRPYsBGMu.png



After applying Polynomial Regression :



1. **Keep the temperature monitoring circuit inside your fridge with the door of the fridge closed, and let the system record the temperature readings for about 2 hours.**



1. **Using the reading that you received in the 2 hours, set boundaries for the temperature within the fridge**

## 7.1 Working Principle

The working principle of the system is quite easy.

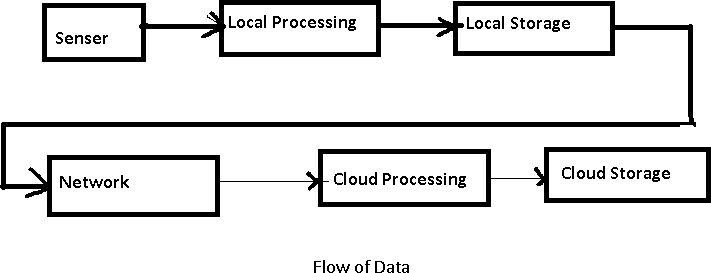
Here in my device, LM35 is the sensor that senses the temperature of its environment and based on its value it generates an Analog output voltage. This Analog voltage produced by the LM35 is then given as input to the Bolt A0 pin. The Bolt then converts the Analog value into a 10-bit digital value that varies from 0-1023. This digital data is sent to the cloud via Bolt device.

Hence, while plotting the temperature, it is required to convert the raw sensor values into the actual temperature value, which is done using the given formula:

**temp = (analog\_value100)/1023\***  
The converted digital data is then plotted for visual representation.

## 7.2 How does it work?

The setup comprises of: The sensing stage Local processing, logging, and storage Transmission of useful information to the cloud It is proposed to make extensive use of microcontrollers for local processing of the collected data for detection of threshold breaches and generation of alerts thereof on detecting critical events. SD memory cards are proposed for local storage of data/logs. Sample layout of the proposed IoT device is shown in the diagram below:



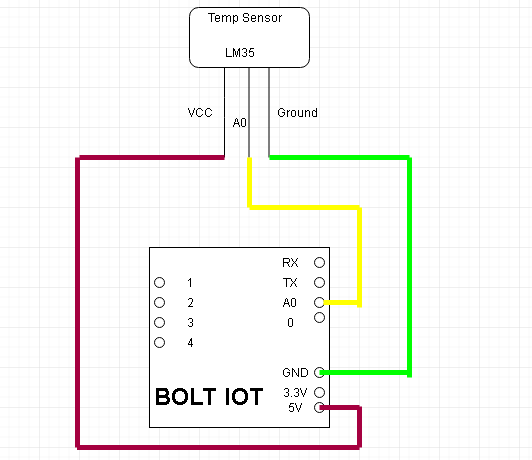
The processed data is pushed to the cloud which is then pulled by the backend application for reporting and generation of alerts. The backend application shall also have the feature to sync directly with the IoT devices fetch the entire logs for archival purpose if required. The sections below detail a partial implementation of the above-mentioned proposed work. C) Boltiot: - Bolt is an Internet of Things. It provides the platform (Hardware + Software) makes to connect their devices to the internet through easily and quickly. It contains Wi-Fi/ GSM chip to connect the sensor to the internet. It operates at 2.4 GHz Frequency, 802.11 b/g/n model. It is based on ESP8266 module based 32 Bit RISC processor, Process all the command send into the web execute as per need, this process freq. 80 MHz, ESP Voltage level operates at 3.3V. It can take less than 1 sec boot time, It contains 5 Digital GPIO ( General purpose 1/O pins) work with 3.3V output give 1, 0V output gives 0, 1 Analog Input pin work with 1V, 1 Serial UART (Universal Asynchronous Receiver -Transmitter) port. It converts 5V (1A) to 3.3V (1A) so the device is not damaged.

Fig1: Bolt back side Fig2: Bolt front side

**Temperature Sensor circuit:-**

Step-1: Connecting the LM35 sensor to the Bolt VCC pin of the LM35 connects to 5v of the Bolt module. The Output pin of the LM35 connects to A0 (Analog input pin) of the Bolt module. GND pin of the LM35 connects to the GND. A schematic representation is given in Figure-5 below.



Step-2: Run the program.

Step-3: Graphical output generated from Step-2, is as shown below .



### Temperature Graph

Step-4: now run following code for detecting temperature and sending alerts-

**Code**

import conf, json, time, math, statistics

from boltiot import Sms, Bolt,Email

def compute\_bounds(history\_data,frame\_size,factor):

if len(history\_data)<frame\_size :

return None

if len(history\_data)>frame\_size :

del history\_data[0:len(history\_data)-frame\_size]

Mn=statistics.mean(history\_data)

Variance=0

for data in history\_data :

Variance += math.pow((data-Mn),2)

Zn = factor \* math.sqrt(Variance / frame\_size)

High\_bound = history\_data[frame\_size-1]+Zn

Low\_bound = history\_data[frame\_size-1]-Zn

return [High\_bound,Low\_bound]

mybolt = Bolt(conf.API\_KEY, conf.DEVICE\_ID)

sms = Sms(conf.SSID, conf.AUTH\_TOKEN, conf.TO\_NUMBER, conf.FROM\_NUMBER)

history\_data=[]

while True:

response = mybolt.analogRead('A0')

data = json.loads(response)

if data['success'] != 1:

print("There was an error while retriving the data.")

print("This is the error:"+data['value'])

time.sleep(10)

continue

print ("Raw Temperature in Refrigerator is"+data['value'])

degree=(float(data['value'])/10.24)

sensor\_value=0

try:

sensor\_value = int(data['value'])

except e:

print("There was an error while parsing the response: ",e)

continue

bound = compute\_bounds(history\_data,conf.FRAME\_SIZE,conf.MUL\_FACTOR)

if not bound:

required\_data\_count=conf.FRAME\_SIZE-len(history\_data)

print("Not enough data to compute Z-score. Need ",required\_data\_count," more data points")

history\_data.append(int(data['value']))

time.sleep(10)

continue

try:

if sensor\_value > bound[0] :

buzz=mybolt.digitalWrite('1',"HIGH")

print(buzz)

print("Temperature Altered anomously, sending alerts!")

""" SMS """

print ("The temperature level increased suddenly. Sending an SMS")

response = sms.send\_sms("Someone Opened the Refrigerator, The temperature has raised to:"+str(sensor\_value))

print("This is the response ",response)

""" MAIL """

elif sensor\_value < bound[1]:

buzz=mybolt.digitalWrite('1',"HIGH")

print(buzz)

print("Temperature altered anomously, sending sms and mail alert!")

""" SMS """

print ("The temperature level decreased suddenly. Sending an SMS")

response = sms.send\_sms("The temperature has decreased to : "+str(sensor\_value))

print("This is the response ",response)

""" MAIL """

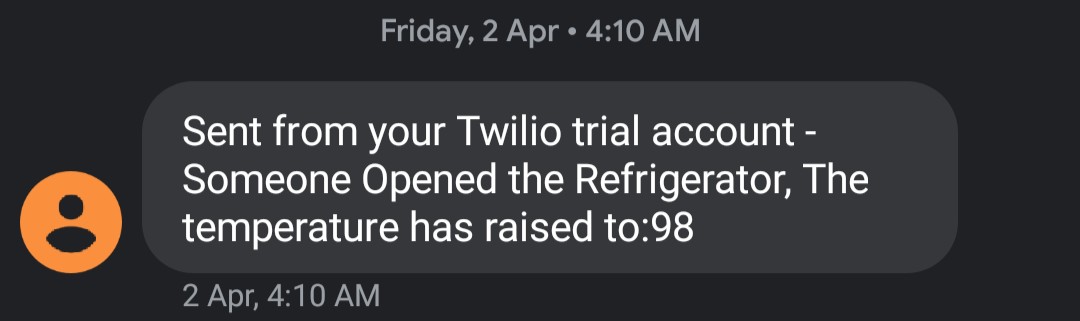
history\_data.append(sensor\_value);

except Exception as e:

print ("Error",e)

time.sleep(10)

Step-5: when the temperature rises above a threshold then SMS alerts are generated. A sample SMS generated from the system is as given in Fig.



So this is how device works and sends alert if there is an anomaly in temperature.

## What does it cost?

|  |  |
| --- | --- |
| **EQUIPMENTS** | **COST PER UNIT (in Rs)** |
| Bolt Wi-Fi Module | 1700 |
| Breadboard | 120 |
| Jumper Wires | 20 |
| LM35 Sensor | 50 |

Total cost of the product => Rs1900

## 7.4 CHALLENGES AND LIMITATION

The challenges envisaged for the proposed implementation are: Powering of IoT devices, as replenishment of battery could pose a major challenge. The direct power supply cannot be entirely relied on. The local storage embedded within the IoT device can be a challenging proposition. The connectivity through Wi-Fi or GSM for communicating with the cloud may pose hurdles in achieving 100% efficiency in the regions where signal strength is poor.

**7.5. FURTHER WORK**

The proposed work can be further pursued with the actual implementation and further enhancements like storage on the edge and design of interactive IoT devices with remote control from users.

# 8.0 Conclusions

The IOT based embedded system has facing many challenges in difficult IOT applications. The Field Programmable Gate array structure is the alternate arrangement to overcome the problem which is facing in GUI processor. In this report, I have introduced the study of technology paradigm for IOTs. The IOT includes communication protocols, Data Acquisition and controlling systems. The temperature has been monitored with the combination of IOT and for every second time period the temperature has been updated in the CLOUD. There are various business spaces it needs you to observe temperature and update the status to the cloud. The temperature must be maintained at the lowest level for ensuring safety of medicines. IOT based temperature monitoring system also helps us to monitor the food preservation system temperature and update the data to the cloud at the regular interval.

**APPLICATIONS:**

There are Temperature Sensor applications in many industries including **medical, motorsport, HVAC, agriculture, industrial, aerospace and automotive.**

Some of the specific temperature sensor applications which we have come across :

**• Motors–** There are many different aspects of motors and most of these require temperature measurement to ensure the motor itself does not overheat.

**• Surface plates –** Ring terminal temperature sensors are often used on surface plates as they can be mounted onto a flat surface and measure temperature effectively.

**• Home appliances –** Kettles, toasters, washing machines, dishwashers and coffee machines will all contain temperature sensors.

**• Computers–** Within computers there are temperature sensors to ensure system does not overheat.

**• Industrial equipment –** Temperature sensors used within these applications will need to be robust as the environment can be very demanding.

**• Warming Electrical Radiators –** NTC thermistors are used to control the heat on electric radiators.

**• Exhaust Gas Monitoring on Motorsport Vehicles –** Motorsport temperature sensors need to be highly reliable and durable to ensure performance is not compromised in this harsh environment.

**• Food Production; 3D printed chocolates –** Temperature sensors are used to monitor the temperature of the melted chocolate for 3D printing

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