NEW HORIZON
COLLEGE OF ENGINEERING
Autonomous College Permanently Affiliated to VTU, Approved by AICTE & UGC
Accredited by NAAC with 'A' Grade.

LITHIUM-ION BATTERY MANAGEMENT SYSTEM

A MINI PROJECT

REPORT

Submitted by:

ADITYA JAKKARADDI (1NH18EC700)

In partial fulfillment for the award of the degree of

BACHELOR OF ENGINEERING

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

NEW HORIZON
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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

CERTIFICATE

Certified that the mini project work entitled "**LITHIUM ION BATTERY MANAGEMENT SYSTEM**" carried out by **ADITYA JAKKARADDI (1NH18EC700),** bonafide students of Electronics and Communication Department, New Horizon College of Engineering, Bangalore.

The mini project report has been approved as it satisfies the academic requirements in respect of mini project work prescribed for the said degree.

Project Guide

RAJANI K V
Assistant Professor
Dept. of ECE
NHCE

HOD ECE

DR. SANJEEV SHARMA
Professor and HoD
Dept. of ECE
NHCE

<u>External Viva</u>

Name of Examiner | Signature with Date

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ACKNOWLEDGEMENT

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ADITYA JAKKARADDI **1NH18EC700**

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ABSTRACT

Battery management system for lithium ion cells, it is used to keep battery operation more efficiency and safe. This circuit is for rechargeable battery. It going to monitor the state of the battery, calculating secondary data and controlling the cells and it balances.In this circuit it monitors the various state of the battery such as:

Voltage: total voltage, voltages of individual cells, minimum and maximum cell voltage.

Temperature: temperature of individual cells.

State of charge and depth of discharge, it indicates the remaining capacity of the battery in percentage of the original capacity.

This battery management system will protect from the over discharge, over charge and short circuit protection

CHAPTER 01

INTRODUCTION

A lithium (Li)-ion battery is a rechargeable battery which is mostly commonly used in electronic devices such as mobile phones, laptops, Ipods, as well as in electric vehicles like the electric cars, trucks, etc. It contains two electrodes between which an electrolyte facilitates the movement of Li-ions. While discharging the electrons move from the negative electrode towards the positive electrode and while charging the electrons move in the opposite direction. But they are also considered to be hazardous as the electrolyte contained in the batteries is inflammable. Hence, the protection as well as the monitoring of the state of the battery becomes of paramount importance. This is where a BATTERY MANAGEMENT SYSTEM come into the picture.

A battery management system is a combination of hardware as well as software which is basically used to monitor the state of the battery at any given point in time. The battery needs to be connected to the hardware of the system which is already programmed in order to specifically monitor the required conditions of the battery. The system also contains a screen which displays the state of each cell connected in the battery as well as of the entire battery.

A BMS may screen the condition of the battery as spoke to by different things, for example,

Voltage: complete voltage, voltages of individual cells, least and most extreme cell voltage or voltage of occasional taps

Temperature: normal temperature, coolant consumption temperature, coolant yield temperature, or temperatures of individual cells

Condition of charge or profundity of release, to demonstrate the charge level of the battery

Condition of health (SOH), a differently characterized estimation of the rest of the limit of the battery as % of the first limit

Condition of intensity (SOP), the measure of intensity accessible for a characterized time interim given the present power use, temperature and different conditions

Current: current in or out of the battery

Figure 1.1 – Battery management system daily life

The battery management system performs the following functions when we say that it is monitoring the state of the battery:

1. Calculating the current across each cell
2. Calculating the voltage of each cell
3. Protect the cells against any short circuit
4. Protects from overcharge and over discharge
5. It balances each cell to its maximum voltage.

CHAPTER 02

LITERATURE SURVEY

Lithium ion battery

A lithium-particle battery or Li-particle battery (contracted as LIB) is a kind of battery-powered battery. Lithium-particle batteries are regularly utilized for convenient gadgets and electric vehicles and are developing in prominence for military and aviation applications.[9] The innovation was to a great extent created by John Goodenough, Stanley Whittingham, Rachid Yazami and Akira Yoshino during the 1970s–1980s, and afterward popularized by a Sony and Asahi Kasei group drove by Yoshio Nishi in 1991.

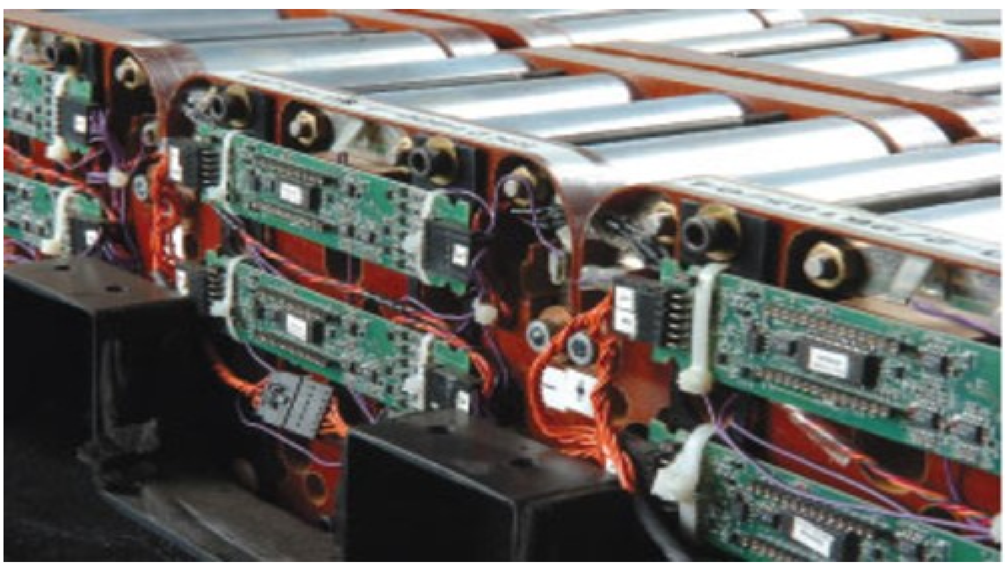

Figure 2.1 – Lithium ion battery with Battery management system

The three essential utilitarian parts of a lithium-particle battery are the positive and negative anodes and electrolyte. For the most part, the negative anode of a traditional lithium-particle cell is produced using carbon. The positive terminal is a metal oxide, and the electrolyte is a lithium salt in a natural solvent. The electrochemical jobs of the cathodes invert among anode and cathode, contingent upon the heading of current course through the cell.

The most financially prevalent anode (negative cathode) is graphite. The positive terminal is for the most part one of three materials: a layered oxide, (for example, lithium cobalt oxide), a polyanion, (for example, lithium iron phosphate) or a spinel, (for example, lithium manganese oxide). Recently, graphene containing cathodes (in view of 2D and 3D structures of graphene) have additionally been utilized as segments of anodes for lithium batteries.

The electrolyte is regularly a blend of natural carbonates, for example, ethylene carbonate or diethyl carbonate containing buildings of lithium ions.These non-watery electrolytes for the most part use non-planning anion salts, for example, lithium hexafluorophosphate

Contingent upon materials decisions, the voltage, vitality thickness, life, and wellbeing of a lithium-particle battery can change significantly. Current exertion has been investigating the utilization of novel designs utilizing nanotechnology have been utilized to improve execution. Regions on intrigue incorporate nano-scale anode materials and elective terminal structures.

Unadulterated lithium is profoundly responsive. It responds vivaciously with water to shape lithium hydroxide (LiOH) and hydrogen gas. In this manner, a non-fluid electrolyte is regularly utilized, and a fixed compartment inflexibly rejects dampness from the battery pack.

Lithium-particle batteries are more costly than NiCd batteries yet work over a more extensive temperature extend with higher vitality densities. They require a defensive circuit to constrain top voltage.

BASIC FUNTIONALITY

- Condition of charge estimations.
- Cell over-voltage and under-voltage insurance.
- better battery balancing
- Battery charger control.
- Pack temperature observing.
- Screens soundness of battery pack.

Cells are shielded from over-voltage, under-voltage, over-current, over-temperature, and under-temperature dependent on the customized least and greatest qualities in the battery profile.

Intelligent, productive cell by cell adjusting is given to augment the usable scope of the battery. The BMS likewise screens the wellbeing of both individual cells and the complete pack and will trigger mistake issue codes if either the pack or individual cells are in unexpected frailty.

PROGRAMABLE

- Minimum and most extreme voltages
- Maximum current points of confinement
- Open cell voltages for condition of charge float
- Temperature versus voltage remuneration tables
- Weak cell thresholds
- Charger control settings
- Selected current sensor

CHAPTER 03

PROPOSED METHODOLOGY

3.1 BLOCK DIAGRAM

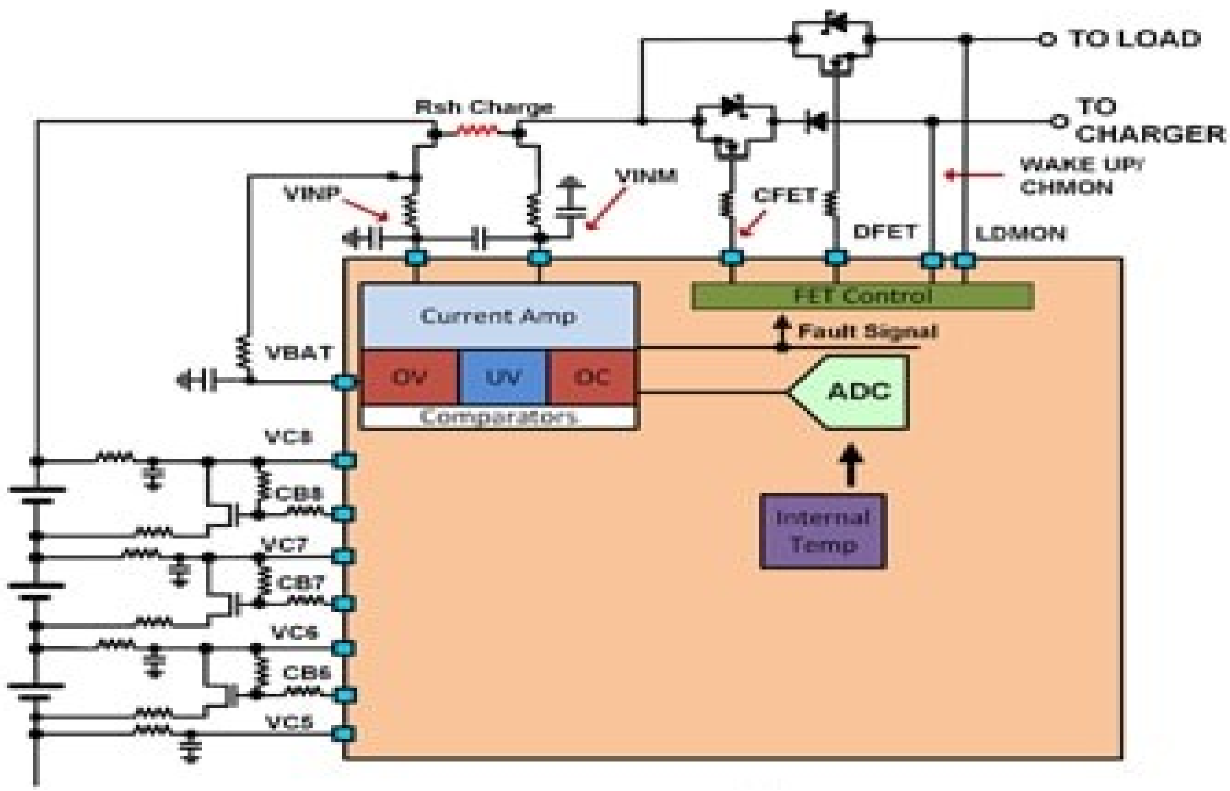

Figure 3.1 – Basic block diagram

Hear, we used lithium ion cells which are connected in series. At each point of connection, it is connected to the analog pin of the microcontroller, the lithium ion battery maximum voltage is 4.2v and 2.5v is minimum to be maintained. The microcontroller checks voltage if voltage is higher then the max value then that cell will get discharge through corresponding mosfet, this way it keeps 4.2 volts while charging if all the cells are reached 4.2 volts then the mosfet connected to charging pin get turned off. If the any one of the cell voltages comes to less then 2.5 the discharge pin mosfet is turned off. And this way if there any short circuit this also turn off the discharge pin of the mosfet. The battery voltages and current to load are measured by the microcontroller ADC pin. The microcontroller will calculate the total charge remaining charge in the battery will be printed on the oled display.

The current drained by load is calculate by using shunt resistor. From ohms law we know that V=I*R the voltage across the resistor is directly proportional to current flowing through resistor. Voltage drop across the resistor will be measured by the ADC of the microcontroller, So I=V/R

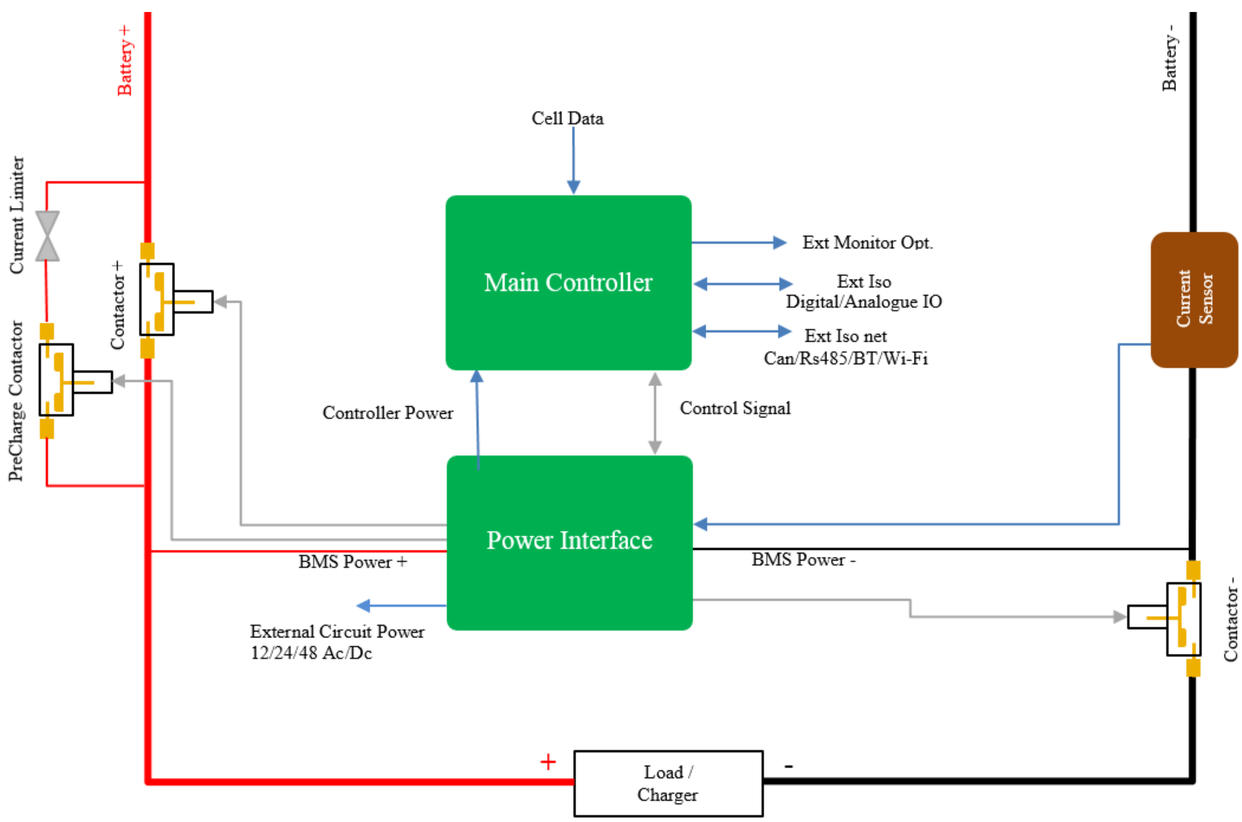

Figure 3.2 – BMS main controller

Battery association with loads circuit

A BMS may likewise highlight a precharge framework enabling a sheltered method to interface the battery to various loads and taking out the over the top inrush flows to stack capacitors.

The association with loads is ordinarily controlled through electromagnetic transfers called contactors. The precharge circuit can be either control resistors associated in arrangement with the heaps until the capacitors are charged. Then again, an exchanged mode power supply associated in parallel to loads can be utilized to charge the voltage of the heap circuit up to a level close enough to battery voltage so as to permit shutting the contactors among battery and burden circuit. A BMS may have a circuit that can check whether a hand-off is now shut before precharging (because of welding for instance) to counteract inrush flows to happen.

Optimization

Circulated Battery Management framework

So as to boost the battery's ability, and to avoid limited under-charging or over-charging, the BMS may effectively guarantee that every one of the cells that make the battery are kept at a similar voltage or State of Charge, through adjusting. The BMS can adjust the cells by:

Squandering vitality from the most charged cells by interfacing them to a load

Rearranging vitality from the most charged cells to the least charged cells (balancers)

CHAPTER 04

PROJECT DESCRIPTION

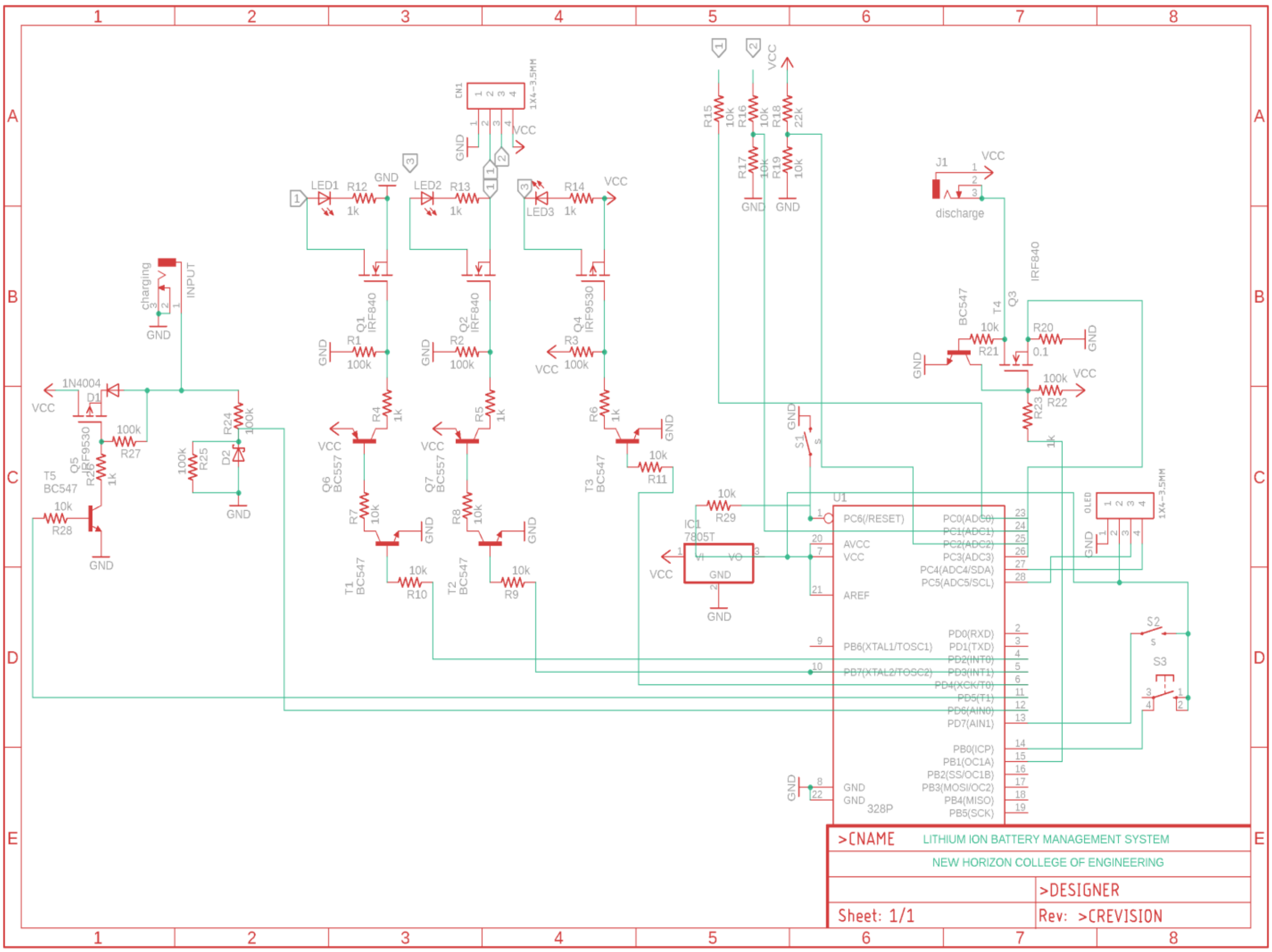

Figure 4.1 – Circuit diagram

4.1 HARDWARE DESCRIPTION

COMPONENTS USED

- ATMEGA328P MICROCONTROLLER
- OLED DISPLAY
- MOSFETS
- RESISTOR
- POWER RESISTOR
- LITHIUM ION BATTERYS
- TRANSISTOR
- LEDS
- ZENER DIODE
- DIODE
- SHUNT RESISTOR
- BREAD BOARD
- WIRES
- PUSH SWITCH

DESCRIPTION OF MAJOR COMPONENT

- **ATMEGA328P**

 The Atmega 328p is 8 bit AVR RISC based microcontroller. It has 32 KB flash memory with 23 general input and output pins with 6 analog to digital read pins of 10 bit conversion. This microcontroller can be operated at the voltage from 1.8V to 5.5V.

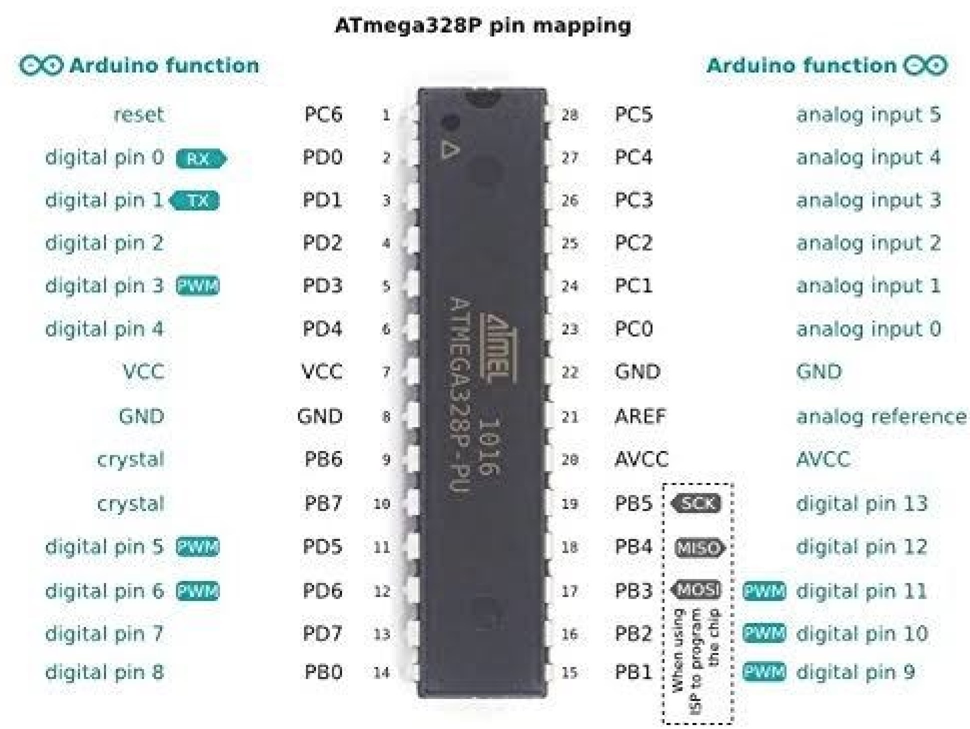

Figure 4.2 – Atmega328p microcontroller

- **OLED DISPLAY**

Figure 4.3 – OLED display

OLED (Organic Light Emitting Diodes) is a level light transmitting innovation, made by setting a progression of natural dainty films between two conductors. At the point when electrical flow is applied, a brilliant light is transmitted. OLEDs are emissive presentations that don't require a backdrop illumination as are more slender and more proficient than LCD display. We are using 0.96 oled display module.

- **MOSFET**

Figure 4.4 - MOSFET

MOSFET (Metal Oxide Semiconductor Field Effect Transistor). It is low power consumption device. We are using N channel. (IRFZ44N) And P channel (IRF9540N) MOSFETS. This is used to turn on charging, discharging and balancing cell voltage by discharging through power resistor. Field-effect transistor that has an insulated and is created by the controlled oxidation of a semiconductor, ordinarily silicon. The voltage of the secured gate decides the electrical conductivity of the gadget; this capacity to change conductivity with the measure of applied voltage can be utilized for intensifying or exchanging electronic signals.

RESISTOR

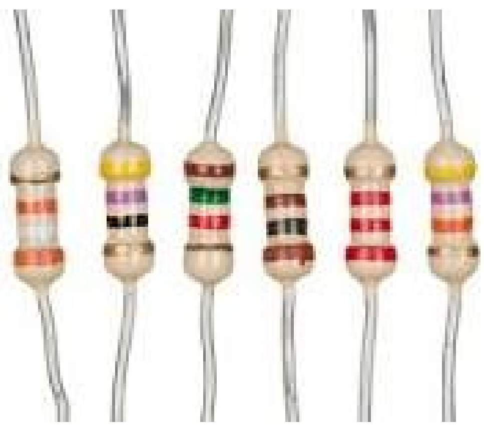

Figure 4.5 - Resistor

Resistors are electronic parts which have a particular, failing to change electrical opposition. The resistor's opposition restricts the progression of electrons through a circuit.

They are aloof segments, which means they just consume power (and can't create it). Resistors are generally added to circuits where they supplement dynamic segments like operation amps, microcontrollers, and other incorporated circuits. Ordinarily resistors are utilized to constrain current, partition voltages, and draw up I/O lines.

POWER RESISTOR

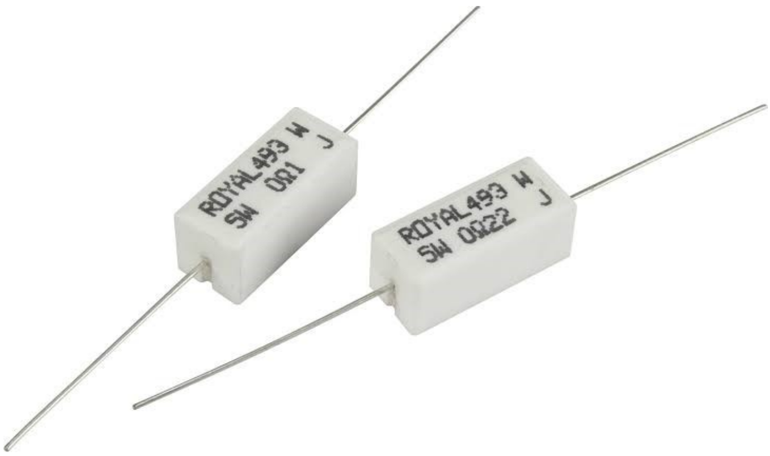

Figure 4.6 – Power resistor

Power resistor is resistor it has capability to decapitate large amount of power. Here we are using this to discharge the cells when they reached more then maximum voltage. We are using 4.7 ohm power resistor.

LITHIUM ION BATTERYS

Figure 4.7 – Lithium ion battery

Lithium ion battery are rechargeable basically it's a secondary battery where this cells can be reused and this can be rechargeable. This is used is electric vehicles, and power backups. Lithium ion cell as the voltage of 3.7 volts and the 1000 cycles of charging and discharging life span.

TRANSISTOR

Figure 4.8 - Transistor

Transistor is a semiconductor device. We are using transistor as switch. This are used to drive the mosfets. We are using npn transistor (BC547) and pnp transistor (BC557). Transistors are three terminal active device produced using distinctive semiconductor materials that can go about as either a separator or a conductor by the utilization of a little sign voltage. The transistor's capacity to change between these two states empowers it to have two fundamental capacities: "exchanging" (computerized hardware) or "intensification" (simple gadgets). At that point bipolar transistors can work inside three unique regions.

LED

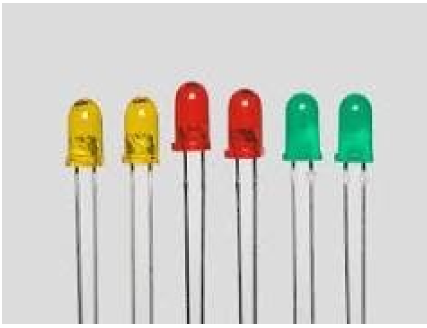

Figure 4.9 - LED

Fundamentally, LEDs are simply modest lights that fit effectively into an electrical circuit. Be that as it may, in contrast to conventional radiant bulbs, they don't have a fiber that will wear out, and they don't get particularly hot. They are lit up exclusively by the development of electrons in a semiconductor material, and they keep going similarly up to a standard transistor. The life expectancy of a LED outperforms the short existence of a glowing bulb by a huge number of hours

ZENER DIODE

Figure 4.10 – Zener diode

A heavily doped semiconductor diode which is designed to operate in reverse direction is known as the Zener diode. When forward one-sided voltage is applied to the zener diode it permits enormous measure of electric flow and squares just a limited quantity of electric flow.

Zener diode is vigorously doped than the ordinary p-n intersection diode. Consequently, it has slender consumption locale. Thusly, zener diodes permit more electric flow than the ordinary p-n intersection diodes.

Zener diode permits electric flow forward way like a typical diode yet in addition permits electric flow in the switch heading if the applied invert voltage is more noteworthy than the zener voltage. Zener diode is constantly associated backward bearing since it is explicitly intended to work backward course.

DIODE

Figure 4.11 - Diode

The key capacity of a perfect diode is to control the bearing of current-stream. Current going through a diode can just go in one bearing, called the forward course. Current attempting to stream the switch heading is blocked. They're similar to the single direction valve of gadgets.

On the off chance that the voltage over a diode is negative, no current can flow*, and the perfect diode resembles an open circuit. In such a circumstance, the diode is said to be off or turn around one-sided.

For whatever length of time that the voltage over the diode isn't negative, it'll "turn on" and direct current. Ideally* a diode would act like a short out (0V crosswise over it) on the off chance that it was directing current. At the point when a diode is leading current it's forward one-sided

BREAD BOARD

Figure 4.12 – Bread board

A breadboard is a rectangular board with many mounting gaps. They are utilized for making electrical associations between electronic parts. The associations aren't perpetual and they can be evacuated and set once more. Indeed, you can even supplant segments to redo your venture or work on a totally extraordinary one, utilizing a similar breadboard.

The vertical segments of the breadboard are called terminals, while the flat long columns are called power rails since they are for the most part used to associate the power supply to the breadboard. The positive rails are shown by red lines, while the negative rails are demonstrated by dark ones.

4.2 SOFTWARE DESCRIPTION

Software we used for programing atmega328p is Arduino IDE. We are programming using c language.

Arduino is an open-source platform utilized for building gadgets ventures. Arduino comprises of both a physical programmable circuit board (regularly referred to as a microcontroller) and a bit of programming, or IDE (Integrated Development Environment) that keeps running on your PC, used to compose and transfer PC code to the physical board.

USED library's are

- LowPower.h
- Wire.h
- Adafruit_GFX.h
- Adafruit_SSD1306.h

LowPower.h library

This library will allow the microcontroller to go to sleep mode in which the power consumed by the microcontroller is very less while the circuit is running using batterys.

Wire.h library

This library allows you to communicate with I2C / TWI devices. On the Arduino boards with the R3 layout (1.0 pinout), the SDA (data line) and SCL (clock line) are on the pin headers close to the AREF pin.

Adafruit_GFX.h library

The Adafruit_GFX library for Arduino provides a common syntax and set of graphics functions for all of our LCD and OLED displays. This allows Arduino sketches to easily be adapted between display types with minimal fuss…and any new features, performance improvements and bug fixes will immediately apply across our complete offering of color displays

We are programming microcontroller with FTDI usb to serial converter.

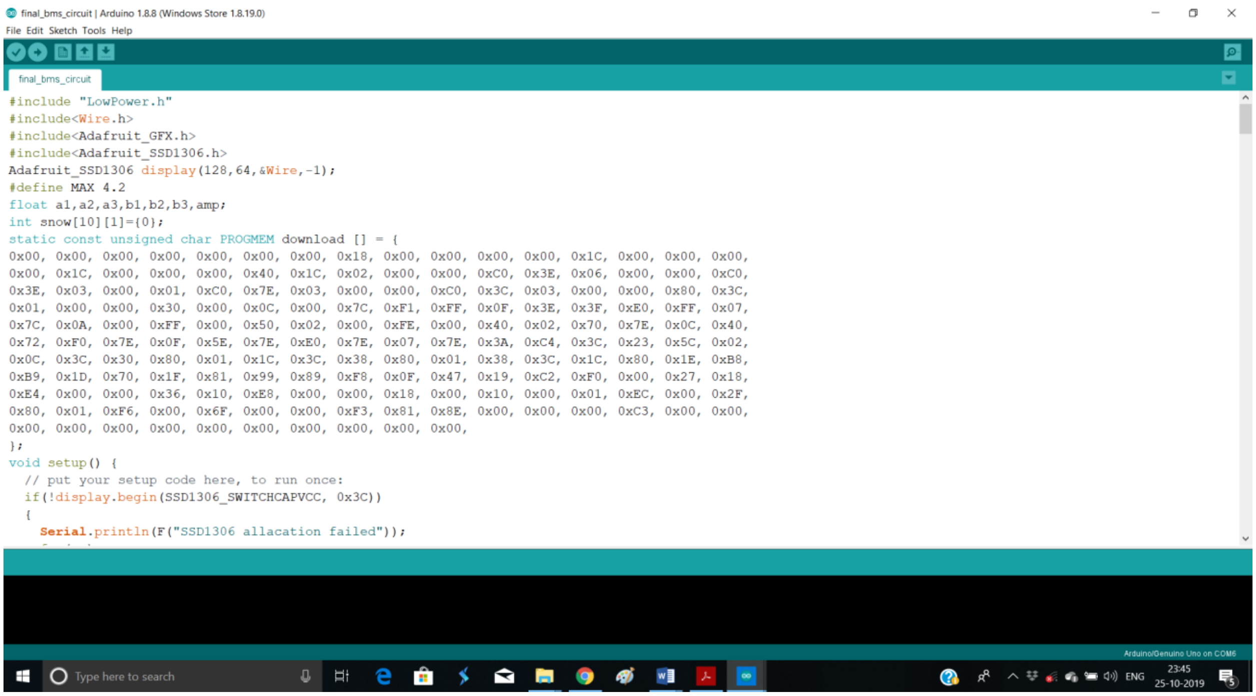

Figure 4.13 – Arduino software

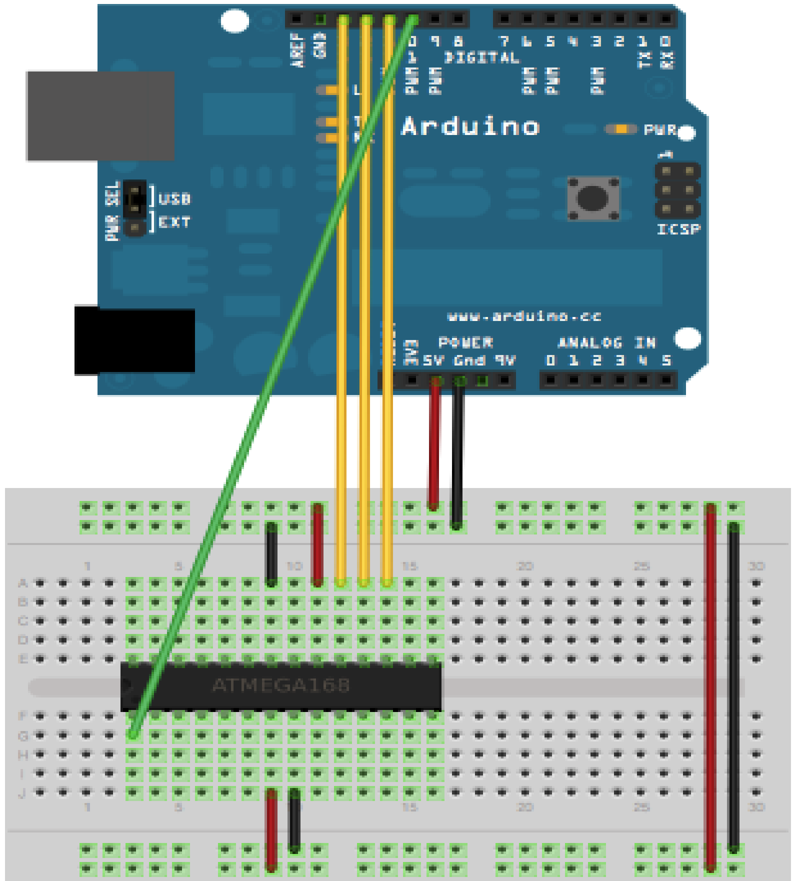

Figure 4.14 - Using an Arduino board to burn the bootloader onto an ATmega328P on a breadboard (w/o an external clock).

We need to make the connection as per the circuit shown in above. After that we need to select Arduino as ISP programmer then we need burn bootloader for the atmega328p .

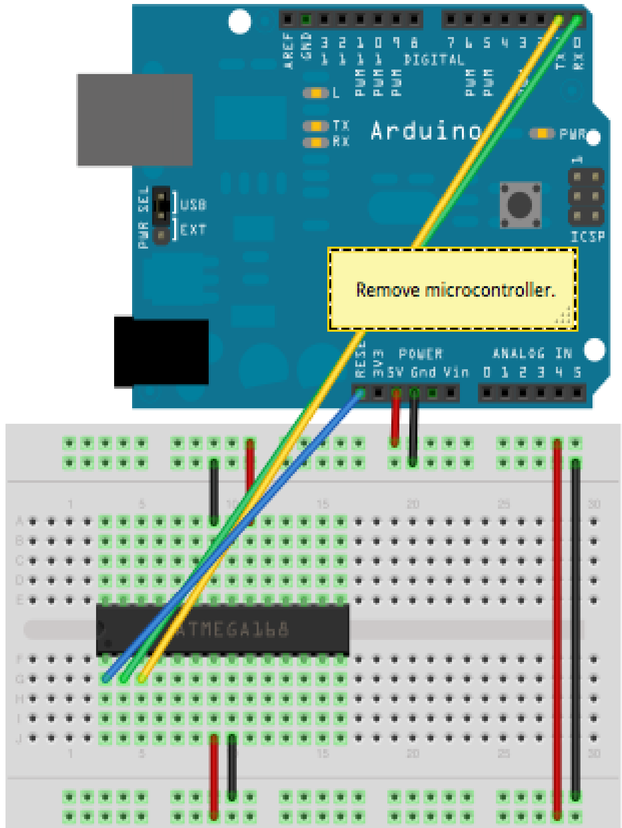

Figure 4.15 - Uploading sketches to an ATmega328P on a breadboard

At first we need to connect atmega 328p as per first circuit and we need to burn the bootloader.

Then we need to connect microcontroller as per circuit then we need to upload the program.

CHAPTER 05

RESULT AND DISCUSSION

The result which we got after the project is that the Battery Management System has controlled the battery pack and the voltage of every cell is monitored properly. And the most important result is that the efficiency for Lithium-ion batteries in a BMS is high and far better than any other cells/batteries.

The operations involved during the testings were safe and there were no case of short circuit and overcharge.

All the various parameters such as total voltage, individual cell's voltage, minimum and maximum voltage were monitored and displayed on the OLED screen attached on the bread board and the animated representation is also displayed. The state of charge and the depth of discharge were also monitored.

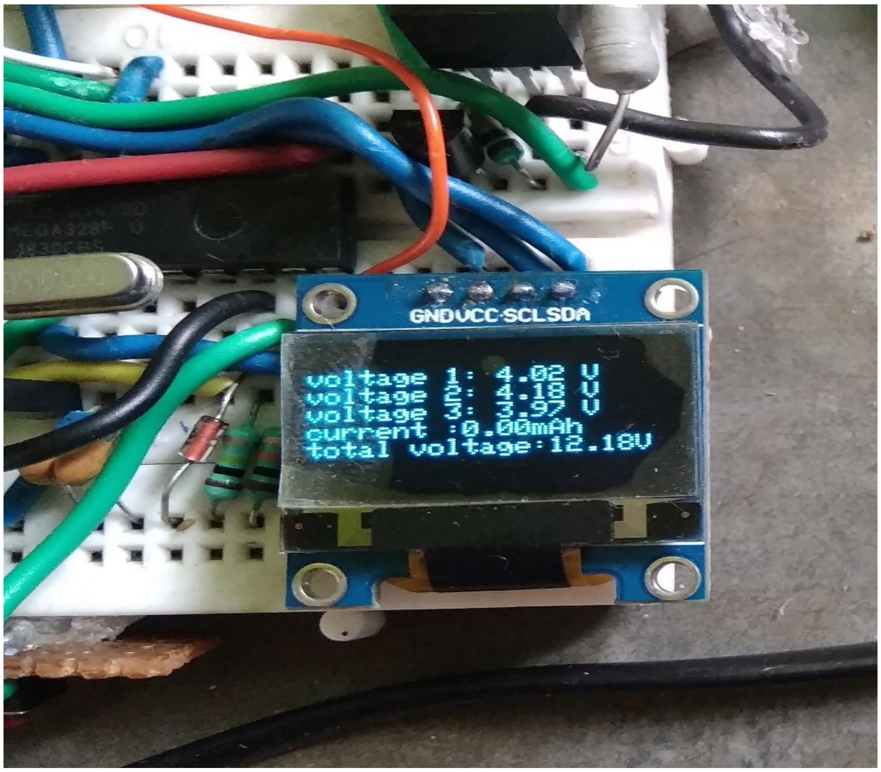

Figure 5.1 – Displaying all the voltages in OLED

The above mentioned image is showing all the battery voltage and total voltage of battery pack and we can see curent draind by load from battery pack that is 0 mah.

The performance of the cell is distributed. At time equals zero, the charging and discharging rates of the cells within the battery packs are same. As each cell goes from charging to discharging or vice-versa, the rate at which each cell charges or dicharges changes resulting in a spread distribution across a battery pack.

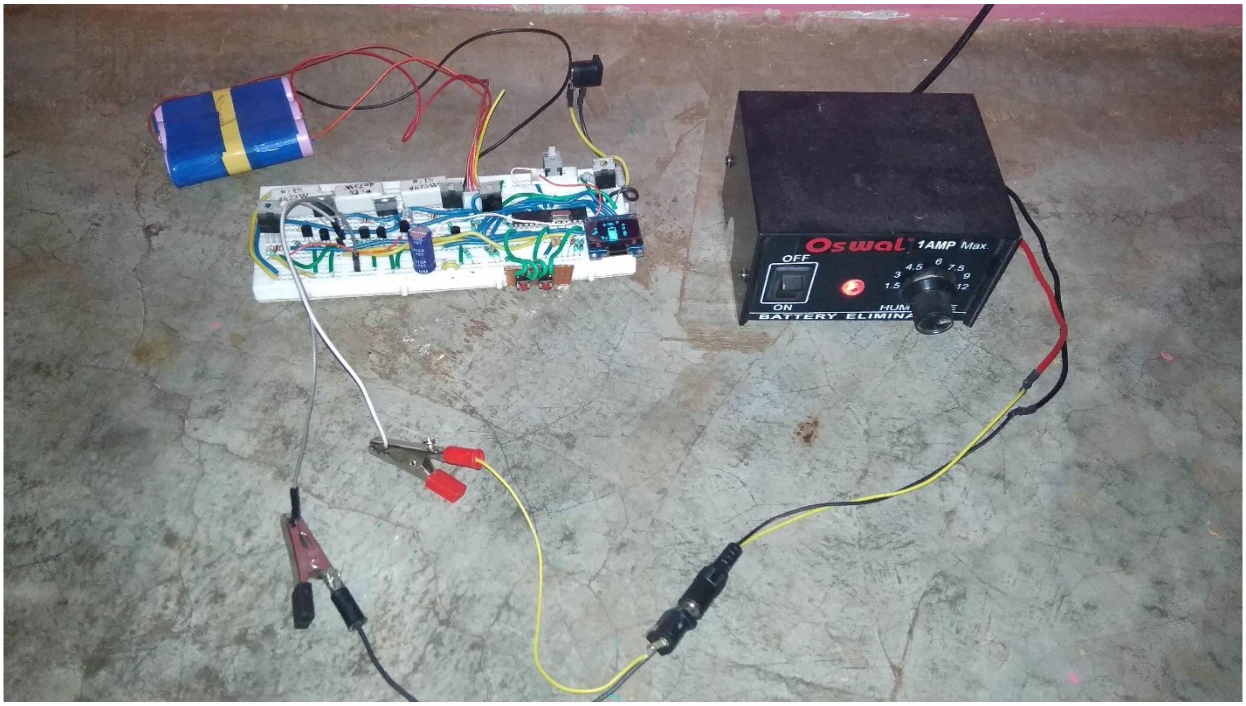

Figure 5.2 – Charging the lithium cells with BMS circuit

The above picture is showing the 3s battery pack is charging from battery eliminator. When battery pack is in charging mode we can see the charging animation on oled display.

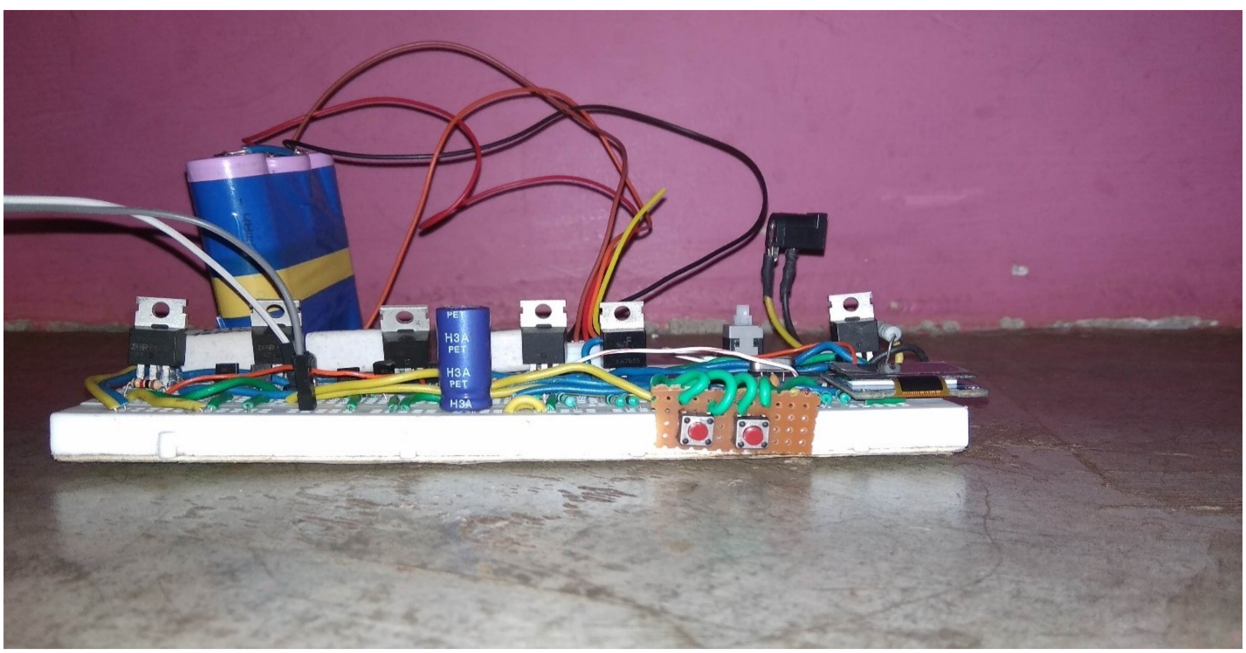

Figure 5.3 – Front view of BMS circuit

The above mentioned figure is the front view of out circuit. Where we can see clear pitcher of components.

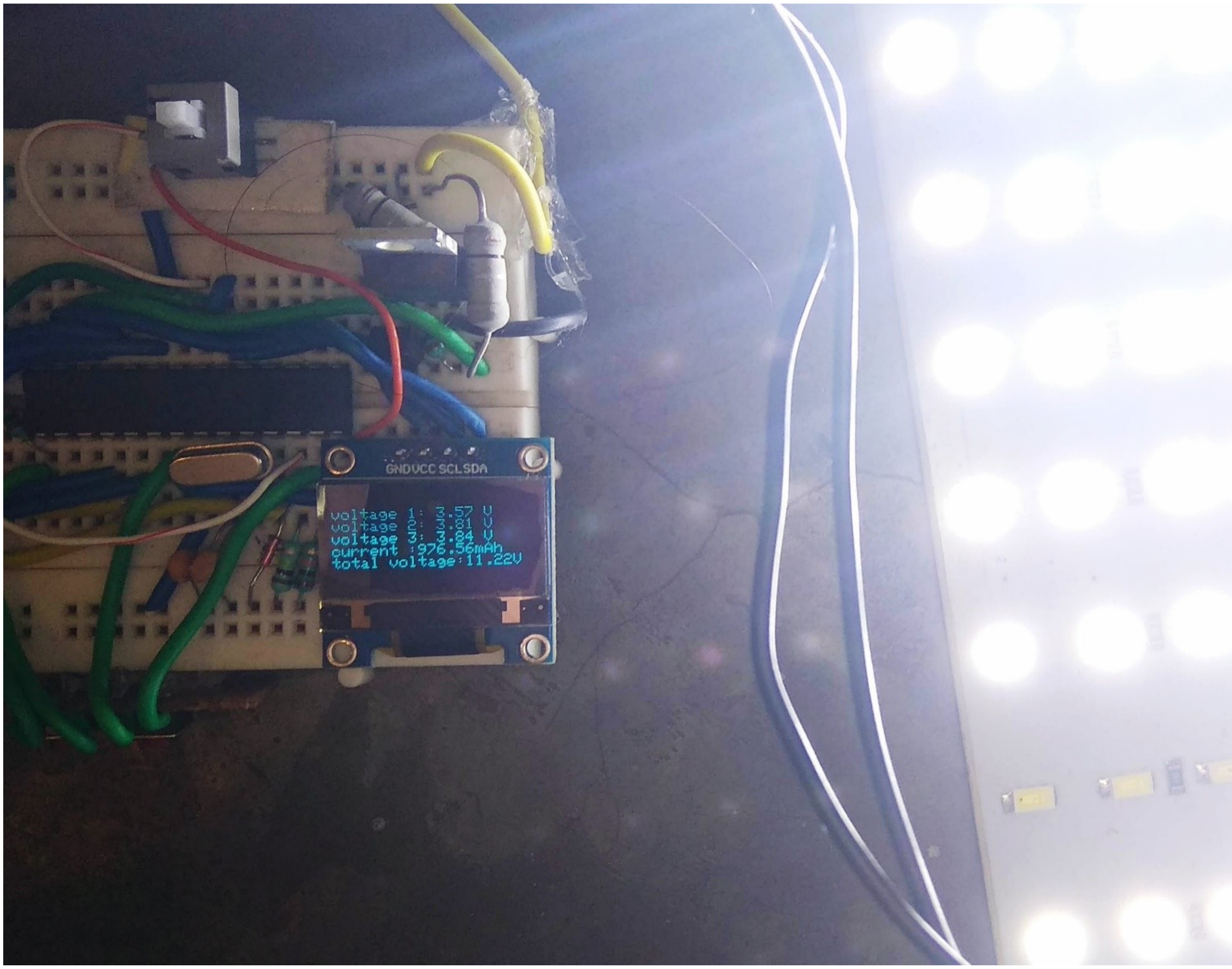

Figure 5.4 – Load connected to the circuit

The above mentioned picture we can see the BMS circuit is connected to the load that is LEDs. hear LEDs are glowing the current drained by load is show in oled display. The current is measured across the shunt resistor where the voltage drop due to current flow is very less

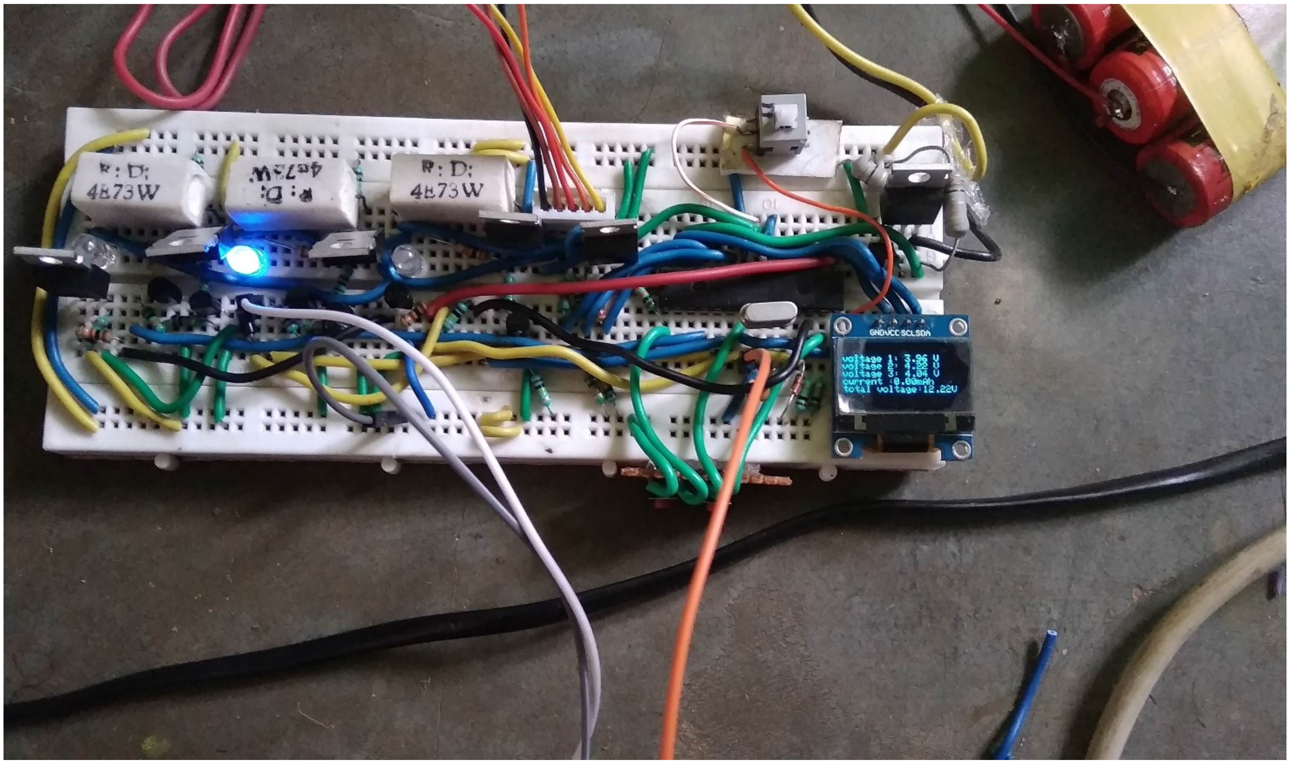

Figure 5.5 – balancing the cells while charging

In above mentioned image the 2nd led is glowing it means 2nd cell of battery pack is reached its max voltage and its getting discharged through the power resistor. The second cell reached voltage is 4.22 volts its greater then the max(4.20) volts .

CHAPTER 06

CONCLUSION AND FUTURE SCOPE

Conclusion:

Battery management systems may be as simple as electronics to measure voltage and stop charging when the desired voltage is reached. At that point, they might shut down the power flow; in the event of irregular or dangerous conditions they might issue an alarm. A more complex BMS monitors many factors that affect battery_life and performance as well as ensuring safe operation. They may monitor one-cell or multi-cell battery systems. Multi-cell systems may monitor and control conditions of individual cells. Some systems connect to computers for advanced monitoring, logging, email alerts and more.

At the end we were able to monitor various conditions of the battery such as total voltage, voltages of individual cells, minimum cell voltage and maximum cell voltage.

We could also monitor the state of charging and the depth of discharging of each cell.

Battery management systems for certain applications like the one for this hand-held point-of-sales terminal also include an embedded charger consisting of a control device, an inductor (which is an energy storage device), and a discharger. The control device manages the charging algorithm. For lithium-ion cells, the ideal charging algorithm is constant current and constant voltage.

The one major conclusion that can be drawn from this experiment is that BMS protects the batteries from over charging, over discharging and it also prevents the circuit from short circuiting.

Figure 6.1 – Tesla powerwall power backups

Future Scope:

- The demand for BMS will increase as there will be an increase in demand for electric vehicles (EVs), plug-in hybrid vehicles (PHVs) and Hybrid electric vehicles (HEVs).
- All these vehicles consists of a series of battery pack which require efficient monitoring
- . Factors monitored and controlled by battery management systems include:

    i. Main power voltage.

    ii. Battery or cell voltage.

    iii. Charging and discharge rates.

    iv. Temperatures of the batteries or cells.

v. Battery and cell health.

vi. Coolant temperature and flow for air or liquid cooling.

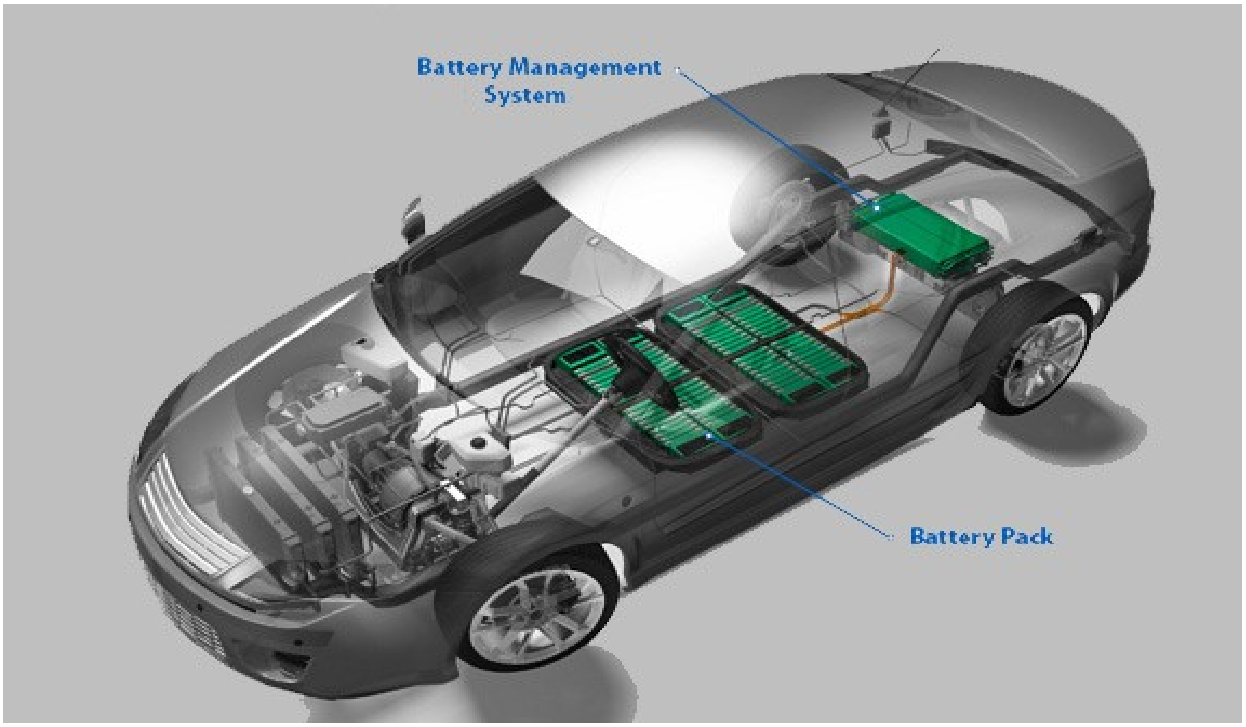

Figure 6.2 – BMS application in electric vehicle's

- BMS is the brains behind the battery pack and no battery will function as per the expectancy if BMS isn't included.
- As mentioned above BMS not only helps in monitoring the function of the battery.
- It also protects the cells in the battery pack by taking required action as per specified by the user or as per the specifications of the cells in the battery pack

REFERENCES

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https://www.youtube.com/watch?v=rT-1gvkFj60

Eman2000 Arduino BMS:

https://www.youtube.com/watch?v=MRjxQVYBM_k&list=PLKs13xje3QqQ0RkARzCQ8lr5z54pQdRd

Battery University:

https://batteryuniversity.com

APPENDIX

CODE FOR ATMEGA328P

```
#include "LowPower.h"
#include<Wire.h>
#include<Adafruit_GFX.h>
#include<Adafruit_SSD1306.h>
Adafruit_SSD1306 display(128,64,&Wire,-1);
#define MAX 4.2
float a1,a2,a3,b1,b2,b3,amp;
int snow[10][1]={0};
int pre;
static const unsigned char PROGMEM download [] = {
0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x18, 0x00, 0x00, 0x00, 0x00, 0x1C, 0x00, 0x00,
0x00,
0x00, 0x1C, 0x00, 0x00, 0x00, 0x40, 0x1C, 0x02, 0x00, 0x00, 0xC0, 0x3E, 0x06, 0x00, 0x00,
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0x72, 0xF0, 0x7E, 0x0F, 0x5E, 0x7E, 0xE0, 0x7E, 0x07, 0x7E, 0x3A, 0xC4, 0x3C, 0x23, 0x5C,
0x02,
0x0C, 0x3C, 0x30, 0x80, 0x01, 0x1C, 0x3C, 0x38, 0x80, 0x01, 0x38, 0x3C, 0x1C, 0x80, 0x1E,
0xB8,
0xB9, 0x1D, 0x70, 0x1F, 0x81, 0x99, 0x89, 0xF8, 0x0F, 0x47, 0x19, 0xC2, 0xF0, 0x00, 0x27,
0x18,
0xE4, 0x00, 0x00, 0x36, 0x10, 0xE8, 0x00, 0x00, 0x18, 0x00, 0x10, 0x00, 0x01, 0xEC, 0x00,
0x2F,
0x80, 0x01, 0xF6, 0x00, 0x6F, 0x00, 0x00, 0xF3, 0x81, 0x8E, 0x00, 0x00, 0x00, 0xC3, 0x00,
0x00,
0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
};
void setup() {
  // put your setup code here, to run once:
  if(!display.begin(SSD1306_SWITCHCAPVCC, 0x3C))
```

```
  {
   Serial.println(F("SSD1306 allacation failed"));
   for(;;);
  }
  pinMode(2,OUTPUT);
  pinMode(3,OUTPUT);
  pinMode(4,OUTPUT);
  pinMode(5,OUTPUT);
  pinMode(6,INPUT);
  pinMode(7,INPUT);
  pinMode(8,INPUT);
  pinMode(9,OUTPUT);
  display.clearDisplay();
  display.display();
   nhce();
 delay(3500);
 guide();
 delay(3500);
 team();
 delay(3500);
 pre=1;

}

void loop() {



// put your main code here, to run repeatedly:
digitalWrite(2,LOW);
digitalWrite(3,LOW);
digitalWrite(4,LOW);
digitalWrite(5,LOW);
delay(20);

a1=analogRead(A0);
delay(15);
a2=analogRead(A1);
delay(15);
a3=analogRead(A2);
delay(15);
amp=analogRead(A3);
delay(15);
```

```
//delay(50);
digitalWrite(5,pre);
delay(15);
a1=5*a1/1024;
a2=5*2*a2/1024;
a3=5*3.2*a3/1024;
amp=50000*amp/1024;
b1=a1;
b2=a2-a1;
b3=a3-a2;
delay(10);

if(b1>MAX)
{
  digitalWrite(2,HIGH);

}
else
{
  digitalWrite(2,LOW);

}
if(b2>MAX)
{
  digitalWrite(3,HIGH);

}
else
{
  digitalWrite(3,LOW);

}
if(b3>MAX)
{
  digitalWrite(4,HIGH);
}
else
{
  digitalWrite(4,LOW);
}
if(b1>(MAX-0.1) && b2>(MAX-0.1) && b3>(MAX-0.1))
{
  digitalWrite(5,LOW);
```

```
  pre=0;
}
else
{
  digitalWrite(5,HIGH);
  pre=1;
}
if(b1<2.5 || b2<2.5 || b3<2.5)
{
  digitalWrite(9,HIGH);

}
else
{
  digitalWrite(9,LOW);
}
if(digitalRead(6) == HIGH && digitalRead(8)== LOW)
{
  if(digitalRead(7) == HIGH)
  {
    delay(50);
   all(b1,b2,b3,amp,a3);
   delay(2000);
  }
  else
  {
    for(int aa=0;aa<2;aa++)
     animation(a3);

  }
}
else if(digitalRead(8) == LOW and digitalRead(6) == LOW)
{
  if(digitalRead(7) == HIGH)
  {
    display.clearDisplay();
    animation(a3);
    delay(1000);
    all(b1,b2,b3,amp,a3);
    delay(4000);


  }
```

```
  else
  { display.clearDisplay();
    display.display();
    delay(100);
    LowPower.powerDown(SLEEP_4S,ADC_OFF,BOD_OFF);
    delay(100);
  }
}
else
{   display.clearDisplay();
   all(b1,b2,b3,amp,a3);
   delay(4000);
}



}
void nhce()
{
  display.clearDisplay();
  display.drawBitmap(0,10,download,40,34,1);
  display.setCursor(45,12);
  display.setTextColor(WHITE);
  display.setTextSize(1);
  display.println("NEW HORIZON");
  display.setCursor(45,22);
  display.println("COLLEGE  OF");
  display.setCursor(45,32);
  display.print("ENGINEERING");
  display.display();
}
void guide()
{
  display.clearDisplay();
  display.setCursor(0,10);
  display.setTextColor(WHITE);
  display.setTextSize(1);
  display.println("     LITHIUM-ION");
  display.println("  BATTERY MANAGEMENT");
  display.println("       SYSTEM");
  display.display();
  delay(2500);
  display.clearDisplay();
```

```
  display.setCursor(0,0);
  display.setTextSize(2);
  display.println("Guided By");
  display.setTextSize(2);
  display.setCursor(0,25);
  display.print("RAJANI K V");
  display.display();
}
void team()
{
  display.clearDisplay();
  display.setTextSize(1);
  display.setCursor(0,5);
  display.println("ADITYA JAKKARADDI");
  display.setCursor(0,20);
  display.println("MANOJ N");
  display.setCursor(0,35);
  display.println("RAJEEV KUMAR");
  display.setCursor(0,50);
  display.print("SHARAN");
  display.display();

}

void animation(float a)
{
  for(int x=0;x<1;x++)
  {snow[0][x]=random(5,115);

  }
  for(int y=0;y<10;y++)
    for(int x=0;x<1;x++)
      {
       snow[9-y][x]=snow[8-y][x];
      }
 display.clearDisplay();
  display.drawRect(50,23,20,40,WHITE);
int k,zz;
  k=charge(a);
  zz=map1(k,0,100,40,0);
   display.setCursor(50,5);
  display.setTextColor(WHITE);
  display.setTextSize(1);
```

```
display.print(k);
display.print("%");
display.fillRect(50,23+zz,20,40,WHITE);
display.drawRect(57,20,6,3,WHITE);
 for(int a=0;a<10;a++)
  for(int b=0;b<1;b++)
  {
    if(snow[a][b]>45 && snow[a][b]<75 )
    {
      if(snow[a][b]<63)
      display.drawCircle(snow[a][b]-20,a*6+3,3,WHITE);
      else
      display.drawCircle(snow[a][b]+20,a*6+3,3,WHITE);
    }
    else
    {
    display.drawCircle(snow[a][b],a*6+3,3,WHITE);
    }
  }
  display.display();
  delay(500);


}




int charge(float ii)
{
  int c;
  if(ii<=9.3)
  {
    return 0;

  }
  else if(ii<=11.04)
  {
    c=map1(ii,9.4,11.04,0,5);
  }
  else if(ii<=11.07)
  {
```

```
  c=map1(ii,11.04,11.07,5,10);
}
else if(ii<=11.13)
{
  c=map1(ii,11.07,11.13,10,15);
}
else if(ii<=11.22)
{
  c=map1(ii,11.13,11.22,15,20);
}
else if(ii<=11.28)
{
  c=map1(ii,11.22,11.28,20,25);
}
else if(ii<=11.34)
{
  c=map1(ii,11.28,11.34,25,30);
}
else if(ii<=11.35)
{
  c=map1(ii,11.34,11.35,30,35);

}
else if(ii<=11.37)
{
c=map1(ii,11.35,11.37,35,40);
}
else if(ii<=11.43)
{
  c=map1(ii,11.37,11.43,40,45);

}
else if(ii<=11.46)
{
  c=map1(ii,11.43,11.46,45,50);
}
else if(ii<=11.52)
{
  c=map1(ii,11.46,11.52,50,55);
}
else if(ii<=11.64)
{
  c=map1(ii,11.52,11.64,55,60);
```

```
  }
  else if(ii<=11.76)
  {
   c=map1(ii,11.64,11.76,60,65);
  }
  else if(ii<=11.85)
  {
   c=map1(ii,11.76,11.85,65,70);
  }
  else if(ii<=11.94)
  {
    c=map1(ii,11.85,11.94,70,75);
  }
  else if(ii<=12)
  {
   c=map1(ii,11.94,12,75,80);
  }
  else if(ii<=12.15)
  {
   c=map1(ii,12,12.15,80,85);
  }
  else if(ii<=12.27)
  {
   c=map1(ii,12.15,12.27,85,90);
  }
  else if(ii<=12.39)
  {
   c=map1(ii,12.27,12.39,90,95);
  }
  else if(ii<=12.54)
  {
   c=map1(ii,12.39,12.54,95,100);
  }
  else
  {
   c=100;
  }
  return c;
}
int map1(float xy,float in_min,float in_max,int out_min,int out_max)
{
  int zz=(xy-in_min)*(out_max-out_min)/(in_max-in_min) + out_min;
  return zz;
```

```
}
void all(float b1,float b2,float b3,float amp,float a3)
{
  display.clearDisplay();
display.setCursor(0,10);
display.setTextColor(WHITE);
display.setTextSize(1 );
display.print("voltage 1: ");
display.print(b1);
display.println(" V");
display.print("voltage 2: ");
display.print(b2);
display.println(" V");
display.print("voltage 3: ");
display.print(b3);
display.println(" V");
display.print("current :");
display.print(amp);
display.println("mAh");
display.print("total voltage:");
display.print(a3);
display.print("V");
display.display();
}
```