5.2 IMPLEMENTATION OF CIRCUIT IN Ki-Cad

KiCad is a free software suite for electronic design automation (EDA). It facilitates the design and simulation of electronic hardware. It features an integrated environment for schematic capture, PCB layout, manufacturing file viewing, SPICE simulation, and engineering calculation.

KiCad can create all the files necessary for building printed boards, Gerber files for photo-plotters, drilling files, component location files and a lot more. Being open source (GPL licensed), it represents the ideal tool for projects oriented towards the creation of electronic hardware with an open-source flavour.

STEP 1:

After the completion of Schematic circuit, footprints need to be assigned to each component, then go to PCB editor click on update PCB with changes made to schematic. If there are no errors then update PCB. The components will arrive on the PCB layout created, then arrange the components according to required design. The arrangement of components is as shown in Fig 5.12.

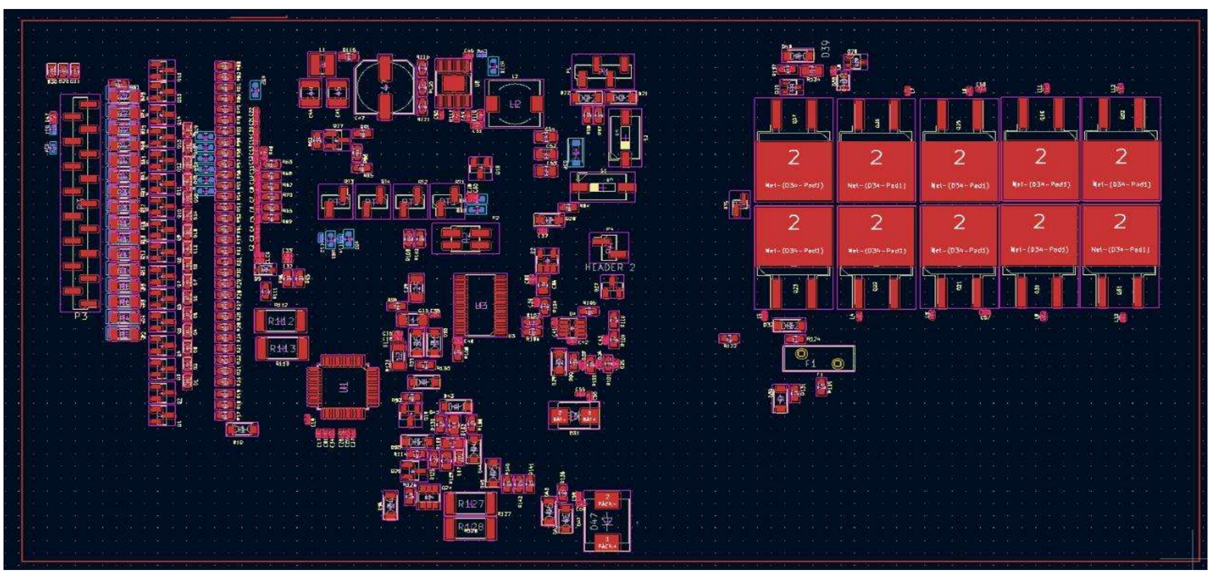

Fig 5.12 Arrangement of Components on PCB Layout

STEP 2:

Once after the completion of arrangement of the components according to the required design, then go for routing of components. Then check for the DRC errors if the errors are zero, the Gerber file and BoM can be generated. The routing of components is shown in Fig. 5.13

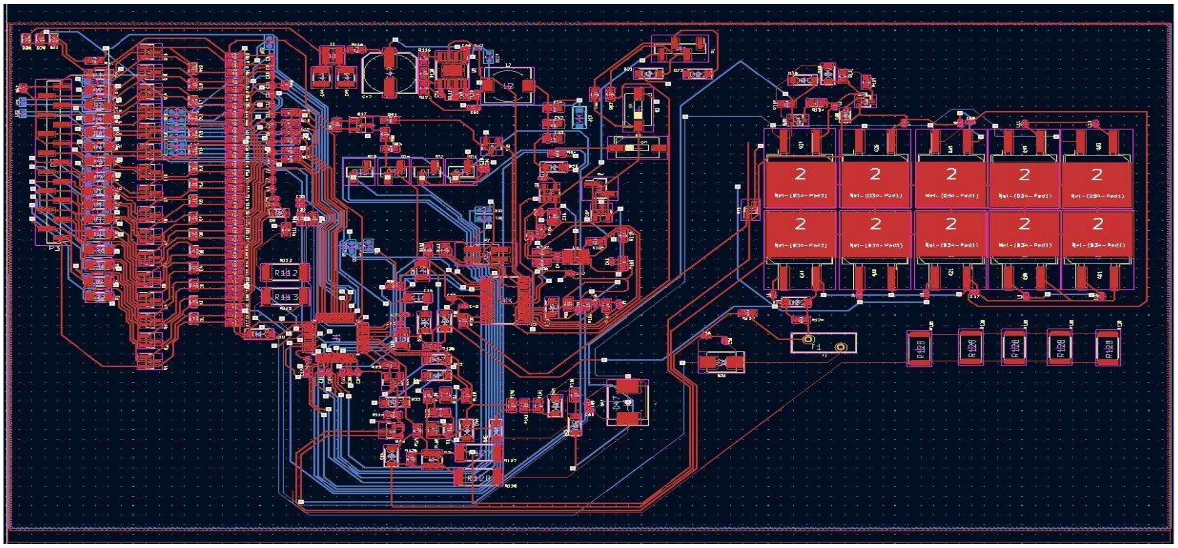

Fig 5.13 Routing of Components on PCB Layout

STEP 3:

After completing the routing Gerber file is generated and given for printing. The Fig 5.14 shows the 3D view of PCB. The PCB of the designed BMS is as shown in Fig 5.16.

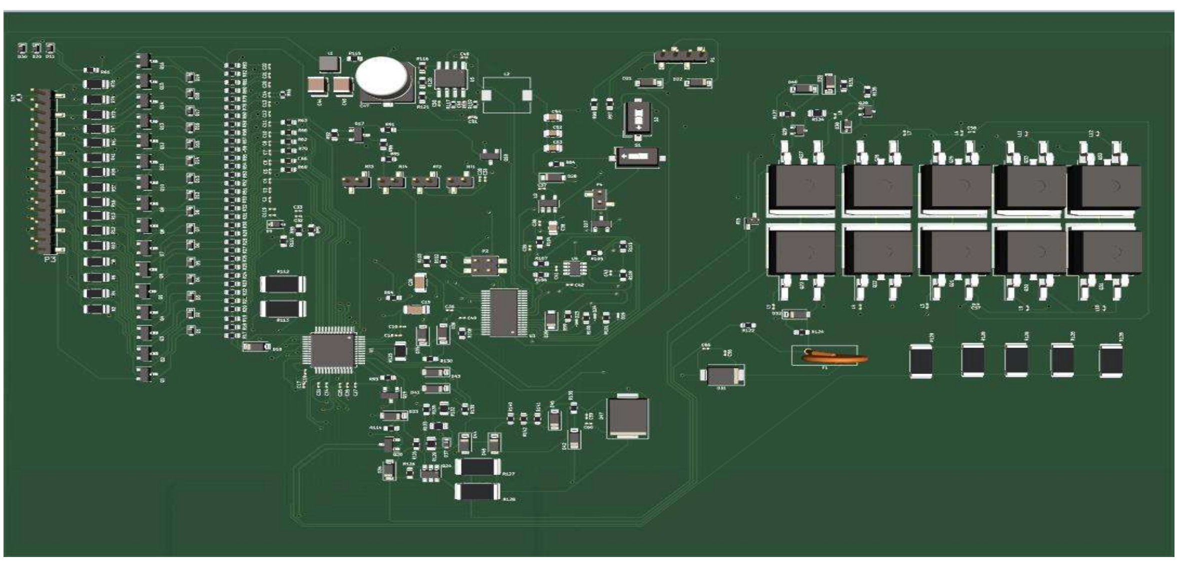

Fig 5.14 3D view of PCB

5.3 Battery pack making using Spot welding Machine

The battery pack of 14.6 V and 48 V has been development using Spot welding machine.

A 48V battery pack consists of :

Cells in series : 13

Cells in Parallel: 10

Total Number of Cells 13*10 = 130 cells

Each Cells Nominal Voltage: 3.6V

Therefore 13*3.6 = 46.8V

Current Capacity of the each cell 2900 mAh = 2.9Ah

Total Current Capacity of the Pack = 2.9*10 = 29Ah

Figure 5.15 shows the Spot welding machine with the level table arrangement.

Fig. 5.15 Spot Welding Machine

The spot welding is a table mounted with a capacity of 5 kVA, operates with single phase AC supply. It has copper wound transformer and operates with pedal in the bottom. Spot welding (or resistance spot welding) is a type of electric resistance welding used to weld various sheet metal products, through a process in which contacting metal surface points are joined by the heat obtained from resistance to electric current. The process uses two copper alloy electrodes to concentrate welding current into a small "spot" and to simultaneously clamp the sheets together. The equipment used in the spot welding process consists of tool holders and electrodes. The tool holders function as a mechanism to hold the electrodes firmly in place and also support optional water hoses that cool the electrodes during welding. Applications of this is to spot weld the straps on nickel–cadmium, nickel–metal hydride or Lithium-ion battery cells to make batteries. The cells are joined by spot welding thin nickel straps to the battery terminals. Spot welding can keep the battery from getting too hot, as might happen if conventional soldering were done. Battery packs are commonly designed and manufactured in a pack–module–cell structure. The actual designs differ mainly in how the desired pack capacity and power is achieved. One may connect fewer large battery cells with a high individual cell capacity in series or parallel as shown in the Fig 5.16 a.

They can be clustered in modules. Alternatively, multiple small battery cells with low individual cell capacity can be connected in parallel and subsequently connected to modules with high capacity. Mixed types where series and parallel connections are combined also exist. Parallel connections ensure the highest capacity and amperage requirements, whereas series connections are used to enhance the supplied power. An insulation sheet covers the designed battery pack, the required terminals are taken out and the complete arrangement is packed using shrink-wrap using hot gun technique.

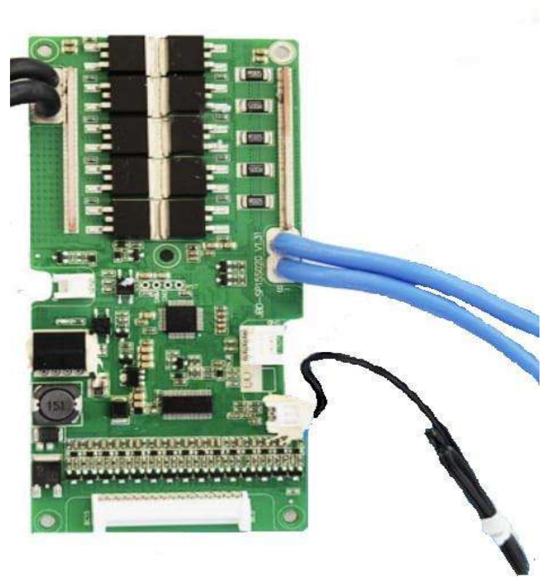

Fig 5.16 a, b Cell arrangement and the BMS

The sealed/protected battery pack is assembled with the designed BMS module with 13 connections from the BMS to the 13 cells and the removable charger pin connection which is set free as shown in the below Fig 5.17

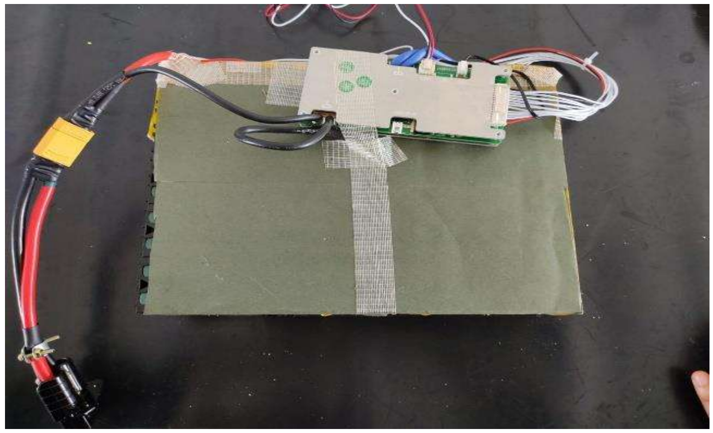

Fig 5.17 Battery Pack with BMS mounted on top

5.4 LOAD CONNECTED TO BATTERY PACK.

5.4.1 Hub Motor

Electric motors are highly efficient devices mainly depending on their operation conditions and the size of the motor. These motors do not use fuel and they do not require engine-oil maintenance like most of the other electrical devices. Brushless motors are found in electric vehicles, hybrid vehicles, personal transporters, and electric aircraft. Most electric bicycles use brushless motors that are sometimes built into the wheel hub itself, with the stator fixed solidly to the axle and the magnets attached to and rotating with the wheel. Under this class Hub motor is the top most priority. One of the biggest advantages of hub motors is that they require little or no maintenance. The Hub motor electromagnetic fields are supplied to the stationary windings of the motor. The outer part of the motor follows, or tries to follow, those fields, turning the attached wheel. Energy is transferred in a brushless motor electronically, eliminating physical contact between stationary and moving parts. The rating of the motor that is used discharging the battery pack is 48V, 530 RPM and 1.2kW is as shown in Fig 5.18.

Although brushless motor technology is more expensive, most are more efficient and longer-lasting than brushed motor systems. There can be three possible configuration in Hub motors; The least practical is an axial-flux motor, where the stator windings are typically sandwiched between sets of magnets. The other two configurations are both radial designs with the motor magnets bonded to the rotor; in one, the inner rotation motor, the rotor sits inside the stator, as in a conventional motor. In the other, the outer-rotation motor, the rotor sits outside the stator and rotates around it. The application of hub motors in vehicular uses is still evolving, and neither configuration has become standard.

Fig 5.18 Hub Motor

5.4.2 Motor Controller.

A motor controller as shown in the figure 5.19 is a device that can coordinate in a predetermined manner the performance of an electric motor. A motor controller might include a manual or automatic means for starting and stopping the motor, selecting forward or reverse rotation, selecting and regulating the speed, regulating or limiting the torque, and protecting against overloads and electrical faults. Motor controllers may use electromechanical switching, or may use power electronics devices to regulate the speed and direction of a motor.

Fig 5.19 Motor controller Unit

Motor controllers are used with both direct current and alternating current motors. A controller includes means to connect the motor to the electrical power supply, and may also include overload protection for the motor, and over-current protection for the motor and wiring. A motor controller may also supervise the motor's field circuit, or detect conditions such as low supply voltage, incorrect polarity or incorrect phase sequence, or high motor temperature. Some motor controllers limit the inrush starting current, allowing the motor to accelerate itself and connected mechanical load more slowly than a direct connection. Motor controllers may be manual, requiring an operator to sequence a starting switch through steps to accelerate the load, or may be fully automatic, using internal timers or current sensors to accelerate the motor. These motor controllers have various pins such as Reverse line, Throttle, Theft alarm, Battery pin, Hall Sensor pin and Motor phase wires.

The limiting values are obtained from the data sheets of the N18560 cell. And also the limiting values of the motor also studied with the available datasheets of the Motor and Controllers. The Li-Ion cell used are rechargeable secondary cells which can be charged again and again after it drains with the aid of rated charger unit which is as shown in Fig 5.20, it can run for 500 such charge and discharge cycle. The Charger used is the 54.2 V, 6A which is shown and the maximum limit output from the Charger is set to 6.35A based on the capabilities of the Battery Pack to absorb the charge from the supply.

Fig 5.20 Charger unit

The Fig 5.21 Shows the complete assembly of the Battery Management System with battery pack connected to the BLDC Hub Motor as the Load. The load is controlled with the throttle arrangement which has three different speed mode, with different consumption rate.

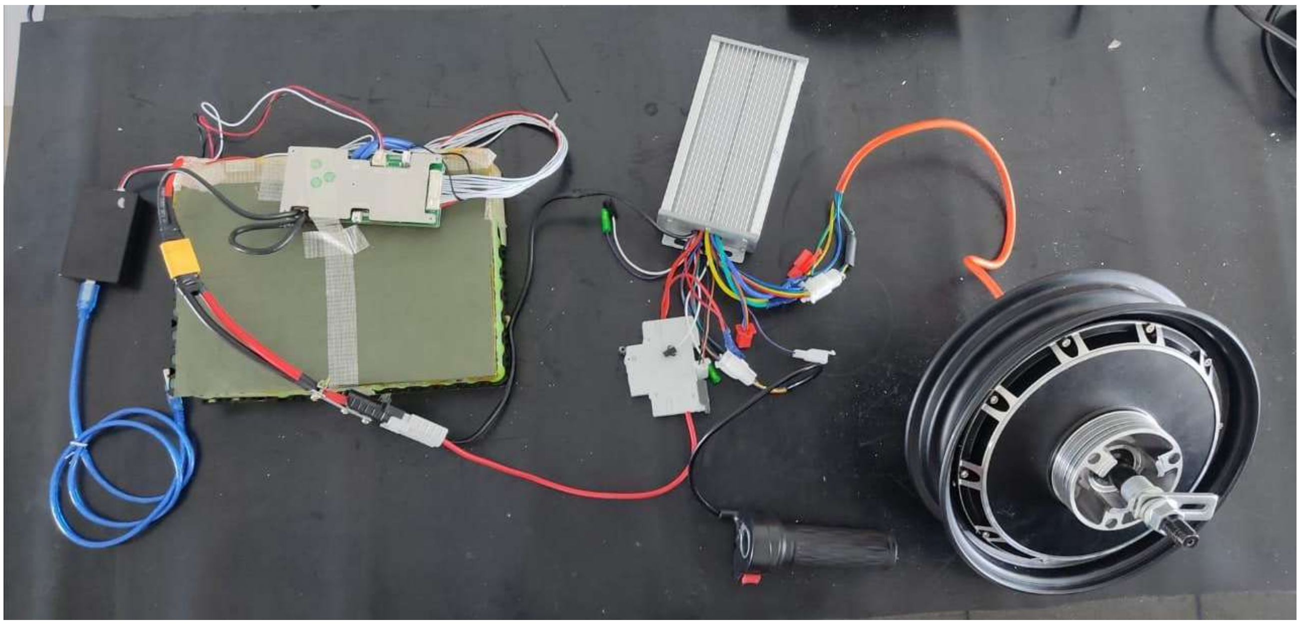

Fig 5.21 Setup of BMS, Battery Pack, Motor, Throttle and Motor Controller

5.5 ABOUT JBD TOOLS

JBD Tools software is an intelligent protection board developed by Dongguan JiaBaiDa Technology Co. Ltd., which is used to monitor the battery data, modify the parameters of the protection board and other functions. The software user interface user-friendly, easy to carry out the operation, the editing interface as shown below Communication is through UART, with the JBDL tools as the software for alerts and indications to monitor the parameters of the Pack. JBDL tools is the free software which can be downloaded free of cost in the PC's (personal computers). This tool displays various parameters such as cell over voltage, cell under voltage, pack undervoltage, pack overvoltage, charge and discharge temperature, charge and discharge overcurrent. JBDTools provide COM port setting. After setting the COM port, click the start button to start communication with the intelligent protection board, you can read the basic information of the battery pack, including: single voltage, capacity, number of cycles, protection status, charge and discharge current, MOSFET status and some basic factory information. There are two MOSFET, one control charge, the other control discharge. If over charged, the charge

MOSFET will turn off, if over discharge, the discharge MOSFET will turn off. The Fig 5.22 shows the basic display at the beginning of JBD tool.

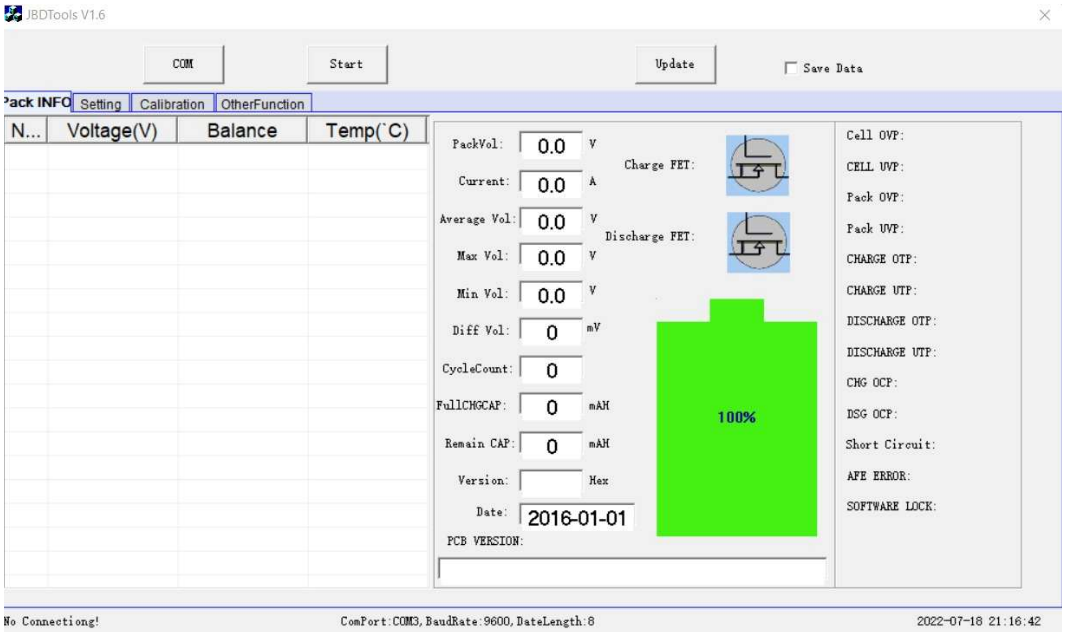

Fig 5.22 Basic Display of JBD tool when opened

For setting the safe limit of the parameters and time delay after which the BMS should restart is given in this Parameter settings page. It is mainly intelligent protection board of some of the protection parameters set, the specific content shown in fig 5.23

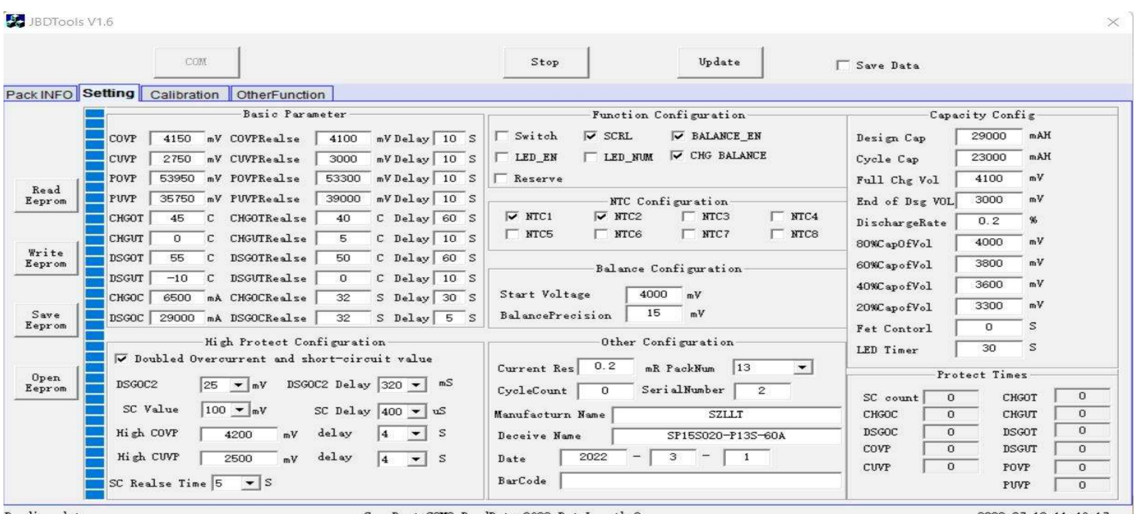

Fig 5.23 Parameter settings screen

Basic protection parameters configuration content: single overvoltage, monomer undervoltage, the whole group overvoltage, the whole group undervoltage, charging high and low temperature, discharge high and low temperature, charge overcurrent and discharge overcurrent protection value, Protection delay. Customers can set parameters according to their own need.

- COVP: Cell Over Voltage Protect, the value of over charge protection.
- CUVP: Cell Under Voltage Protect, the value of over discharge protection.
- COTP: Charge Over Temperature Protect, if detect high temperature, the BMS will enter protect status.
- CUTP: Charge Under Temperature Protect, if detect low temperature, the BMS will enter protect status.
- DOTP: Discharge Over Temperature Protect, if detect high temperature, the BMS will enter protect status.
- DUTP: Discharge Under Temperature Protect, if detect low temperature, the BMS will enter protect status.
- COCP: Charge Over Current Protect, in charge status, if detect high current, the BMS will enter protect status.
- DOCP: Discharge Over Current Protect, in discharge status, if detect high current, the BMS will enter protect status.
- Release: e.g. over charge protect is 4.25V, release is 4.15V, this mean, detect 4.25V, then trigger over charge protect, charge MOSFET turn off, only the voltage discharge to 4.15V, then the charge MOSFET will turn on, then can charge again. 4.25V to 4.15V, the board stop charge

CHAPTER 6

RESULTS AND CONCLUSION

6.1 DISCUSSIONS

The required Battery Pack has been made of 3.6V Lithium-Ion cells using Spot Welding Machine.

- The prototype circuit has been developed for four cells in series and is suitable extended for higher voltage Battery Pack. MATLAB Simulation has been implemented for four series cell pack, monitoring circuit for voltage & current sensing.
- BMS designed can be used successfully to monitor the battery to ensure that it does not exceed preset current limit, voltage limit, temperature limits and SoC
- The temperature of the battery is also displayed.
- MOSFETS are used as switching devices which operate when the parameters exceeds the preset values.
- The final output of the circuit is observed in JBD tools software, in which all the series cell voltage, pack voltage, current drawn, SoC , temperature, cell balancing , charging an discharging FET ON/OFF indication, and all types of alerts are displayed as shown in Fig 6.1

Fig 6.1 Front Screen of the JBD tools

- Figure 6.2 is the display when the battery is in charging process with a charging current of 6.02A and with SOC 45%. As the overcharging current limit is set to 6.5 A the charging FET will set off and the alert will be indicated.

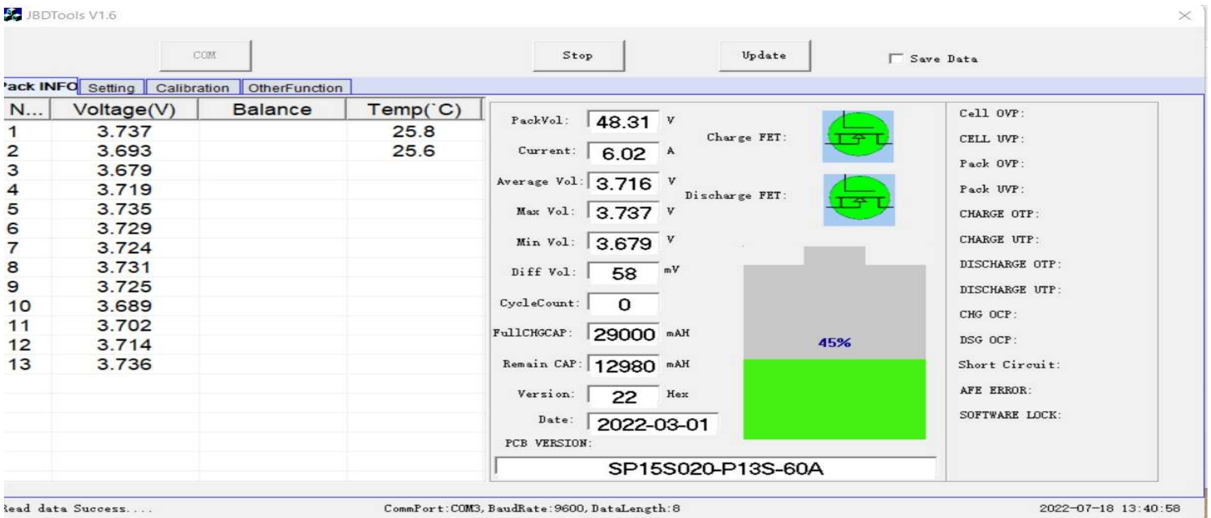

Fig 6.2 Charging Process, which can be seen with current rating

- When the difference in the voltage between any two series line is more than 40 mV, then balancing of the cell starts, the indication is shown as "ON" under the column in the display as shown in Fig 6.3.

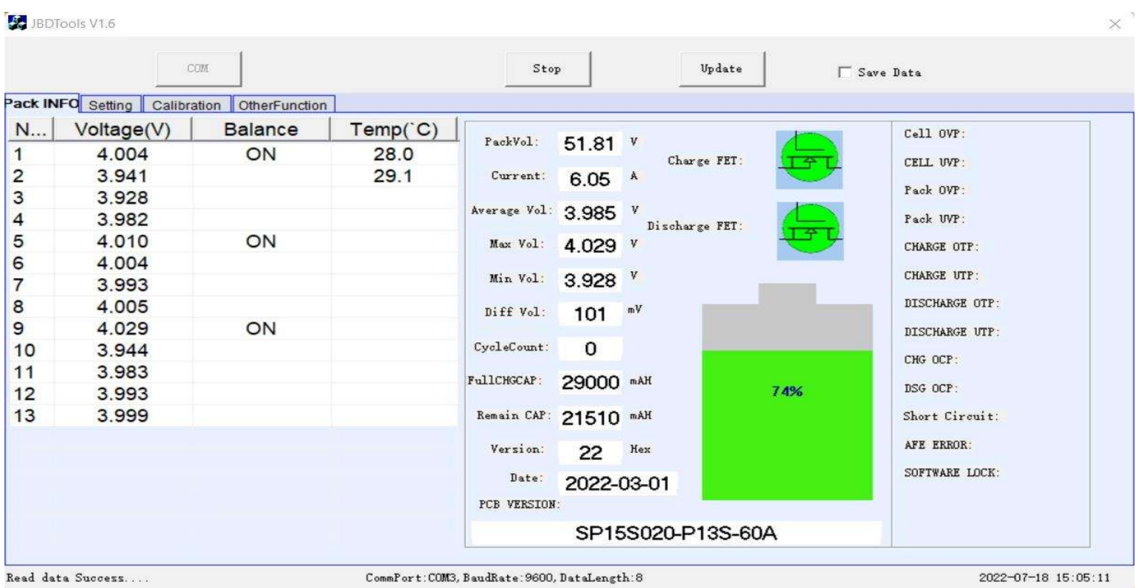

Fig 6.3 Balanced Charging Process

- During the discharging process i.e. when the load is connected, the current drawn is .86A when the motor is running in its lowest speed. As shown in fig 6.4

Fig 6.4 Discharging Process, which can be observed with Negative sign of current

A BMS will ensure protection against any battery system hazards. The BMS safeguard includes (among others) detecting the operating mode, setting fault criteria, authenticating, and identifying the system, predicting the pack/cell overvoltage and overcurrent, predicting the isolation fault, and detecting the high/low temperature. A BMS will protect the battery system from the external event since the external environment of the battery pack causes the changes in the cell/pack parameter

6.2 CONCLUSION

The BMS (Battery Management System) is a performance management framework for monitoring the status of the battery and determining its health and charge status. Battery status can be monitored remotely on-screen/tablet/smartphone. The BMS accurately determines the State of Charge (SOC) and State of Health (SOH) for the battery, which are vital parameters required for ensuring the battery's longevity/battery performance. The continuous monitoring process immunes the battery from overcharging, temperatures, or any short circuits. Whenever the battery exceeds a safe limit voltage, the BMS cuts off the power supply from the battery. It also supports passive cell balancing, crucial when the battery is overcharged or completely discharged.