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SMART-ISOLATION CHARGER FOR LITHIUM-ION BATTERIES USING IOT

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Abstract: **In the modern world, the most electric system that powered by stored energy in Lithium-ion batteries, and a maximum of them are rechargeable, there should be a specific charger for charging Li-ion cells because their highly reactive and volatile which brings a condition that Li-ion cells need to be charged only with the Li-ion charger which will protect cells from failure due to overcharging, overheating, and discharging, etc. These conditions have paved a path to more and more advanced chargers with advanced charging techniques. One of the advanced chargers for Li-ion is Smart-Isolation Charger for Lithium-Ion Batteries Using IoT. This Li-ion charger has individual charging ability, a Remote monitoring system, and a remote operating system to toggle between charging modes.**

***Keywords*:** SOC, EV, BMS, GPS, ICSP, AC, CSS

I. Introduction

Nowadays, Lithium-ion as a source of energy is becoming popular since the other conventional and non-conventional energy source are not convenient and efficient. Due to this scenario, many vehicles manufacturer looking for alternatives to energy sources other than gas. The use of electrical energy sources may improve the environment since there is less pollution. In addition, there are backup power grids which contain numerous numbers of large batteries (lead acid) used as a backup power to operate the control systems are now replaced by lithium-ion batteries due to their high energy density.

There are also used in household and mini level renewable energy grids which has renewable energy source mostly solar and wind which is stored in lithium-ion battery packs. The battery is the most important component, and it is important to monitor the voltage level. Most EVs used rechargeable batteries which is the lithium-ion battery. It is smaller to be compared with lead-acid. It has constant power and energy's life cycle is 6 to 10 times greater compared with a lead-acid battery. Lithium-ion battery life cycle can be shortened for some reasons such as overcharging and deep discharges.

There is a separate charging system to charge lithium-ion batteries, called Lithium-ion charging modules which are specially made to charge the lithium-ion batteries/cells because of their highly volatile in nature, any mischarging that are overflow of current or voltage may cause serious damage to the environment which they are placed. [Monitors all the properties of the battery pack like the voltage, current, temperature, etc. The previous battery monitoring systems only monitor and detect the condition of the battery and alarm the user via battery indicator. Due to the advancement in the design of notification systems, internet of things (IoT) technology can be used to notify the manufacturer and users regarding the battery status. This can be considered as one of the maintenance support procedures that can be done by the manufacturer. IoT utilizes internet connectivity beyond the traditional application, where a diverse range of devices and everyday things can be connected via the internet, making the world at the user's fingertips. Motivated by the stated problems, in this work, the design and development of a battery monitoring system using IoT technology is proposed. In this project, isolating charging method will charge the battery by charging each unique cell in a battery until it attains full charge that is 100% State of Charge and disconnects the cells which are fully charged individually. This will work using IoT with User Interface and graphical representation to view and operate the isolation charger.

II. Literature Survey

Anjali Vekhande, Ashish Maske [1]– IOT based battery parameter monitoring system for the electric vehicle, In this paper, an indication of the battery's voltage, current, and the remaining charge capacity is calculated in a real-time scenario. To monitor these battery parameters, we have developed a data acquisition system by building a PIC-based system A Lithium-ion battery real-time monitoring system was proposed based on the on-board monitoring device with various Sensors connected to it, an android smartphone with a Web-based Application displays Battery Parameter Values with and Without Load. It can collect and display the voltage, current, and temperature parameters of batteries by a phone Harish N, Prashal V, and Dr. D. Sivakumar – [2] IOT Based Battery Management System This BMS aims at detecting the emission of the gases from the battery when it is overcharged and monitors the parameters such as Voltage, Current, and Temperature of the battery using an STM controller and sensors. It is also equipped with a GPS module, which enables the tracking of vehicles. Also, these values are displayed in the Cloud, which brings the concept of Internet of Things (IoT). Bharathi S.H1, Y.V Nitin Reddy, Dinesh3, Ram Gopal [3]-IoT-Based Battery Monitoring System. The IoT-based battery checking framework is comprised of three significant parts observing device, noticing the device and UI. In this research paper, we can monitor the battery condition through the IoT using an android phone. It monitors the battery cells constantly to avoid the occurrence of failure or explosion. H. C. Lin, Y. J. He, and C. W. Liu [4] Design of An Efficient Battery Charging System Based on Ideal Multi-state Strategy. This paper aims to design a current-controllable self-managing battery charging system, especially for lead-acid batteries. The proposed charger is based on an ideal multistate strategy, and it can provide a predefined constant current for both charging and holding currents. Additionally, the battery equalization circuit is also proposed to equalize every battery voltage at the same level before charging. This mechanism ensures the charging time is well controlled so that each battery can reach 80% charged capacity within a reasonable time. Besides, all charging information can be displayed on LCD online for easily tracking the charging status. Chynoweth, Joshua, et al. [5] "Smart electric vehicle charging infrastructure overview." In this paper, a software-based EV charging system has been built. It has the ability to optimally schedule charging in order to safely maximize the use of available grid resources for charging EVs and thereby maximizing the number of EVs that can be connected to the grid while enhancing grid stability. The control system is both network and hardware neutral and can connect to other devices and systems through the internet for data gathering and information exchange.

III. Proposed System

This chapter enclose the features possessed the Smart-Isolation charger for lithium-ion batteries and their description. There are functional block diagrams separated by the decomposition levels and Systematic diagram, to show the basic construction, power flow and signal flow of the charger, respectively. The hardware components which are utilized to model the Lithium-ion charger are depicted individually with their specification and operating conditions. Along with the hardware, software applications which are used as the tools to build the webpage for both monitoring and operating is also decoded.

3.1 The Features in Smart-Isolation Lithium-Ion Charger Using IoT

This project will introduce a Smart Isolating charger for Lithium-Ion Batteries using IoT. That can charge each lithium-ion cells of the battery pack individually and disconnect from the charging circuit once the cell attains 100% SOC. Apart from the simply charging the cells, the smart charger can show the crucial data of the cells and the other important parameters are calculated and made as a graphical visualization for better monitoring. These parameters can also be stored in the cloud for record or future analysis. This smart charger possesses multi-charging techniques which are Slow (default), Fast, and Adaptive modes. Trickle charging mode can be combined to any of the two modes (Slow/Fast), which the user desires. Whilst adaptive mode will be the combination of all the three modes working one after the other in a pre-set condition. This charger can charge each individual cell/battery with two or more type of charging modes for high performance and efficiency at the same time. Remote access will help in monitoring and operating the crucial parameters and charging mode, respectively from a very long distance. More number of batteries packs can be monitored at the same time.

3.1.1 Battery Monitoring System for Lithium-Ion Batteries

This system will show the crucial data of the batteries by measuring them using the sensors connected parallel and series to the cells. These sensors will send the analogue signal to the Arduino Mega 2560 which will send the data to the online platform. This platform will act as the database for the parametric values of the cells individually. These values are then called to our own monitoring webpage for the visualization.

Date	S.no	Voltage-1	Current-1	Voltage-2	Current-2
2022-04-30T11:30:52Z	557	3.28	51.79	3.46	96.18

FIGURE 3.1 MONITORING

The figure 2.1 shows the monitoring parameters of the cell one and two that are current and voltage, respectively.

3.1.2 Modes of Operation

There are mainly 3 different types of charging methods which are combined to form 5 types of charging techniques in total. The basic types are Slow, Fast and Trickle charging modes. Slow will be the default charging method in charging initially, then it can be changed as per user's desire through the online mode (IoT) the button will be available on the website, which will allow the user to toggle between the modes without any physical interference to the charger or charging circuit itself. The command will be received as digital signal by the Node MCU through the online platform ThingSpeak with the help of Wi-Fi module and that digital signal is sent to the Mega for the switching of the charging power

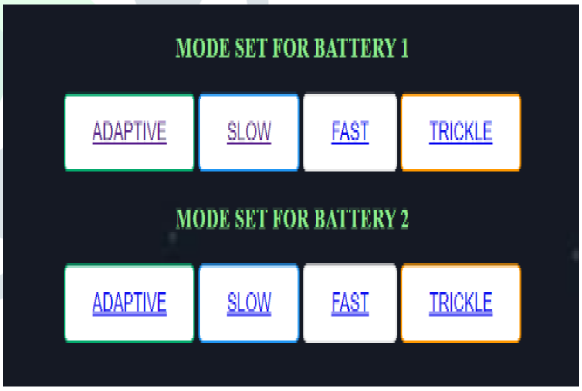


FIGURE 3.2 CHARGING MODE OF SMART-ISOLATION CHARGER

3.1.3 Graphical Visualization and Data Storage

IOT with Cloud control and monitoring will allow the user to visualize the data of the parameters in graphical format and it also can be stored. And the charging mode will be displayed. On the screen. With real time SOC estimation.

There are totally six graph which represent Battery Voltage, Charging current and Stored Power to the

State of Charge respectively. This graphical representation will help the user to easily analyse the battery characteristics. This is done in Colaboratory

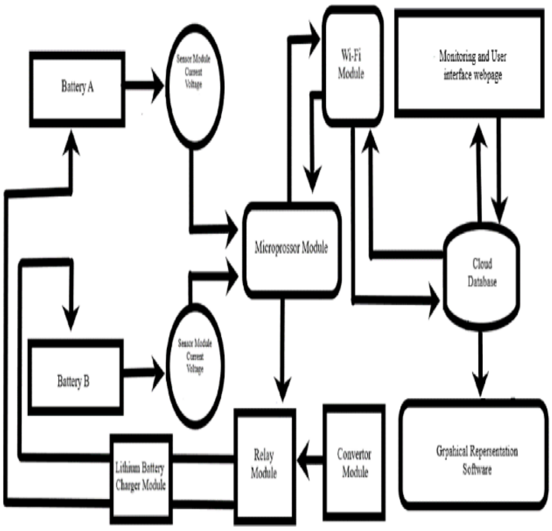
Software powered by Google which will operate in python.

FIGURE 3.3 GRAPHICAL REPRESENTATION USING COLABAROTRY

3.2Functional Block at Various level of Smart-Isolation-Charger

3.2.1 Level Zero Decomposition

The battery pack consists of individual cells. The BMS measures the voltage of each cell bank (here cells), current entering the lithium-ion cells. It accepts user settings to determine operating mode and outputs the protected power from the charging circuit to the cell/battery. The monitoring system in the charger also provides real time measurements and data.



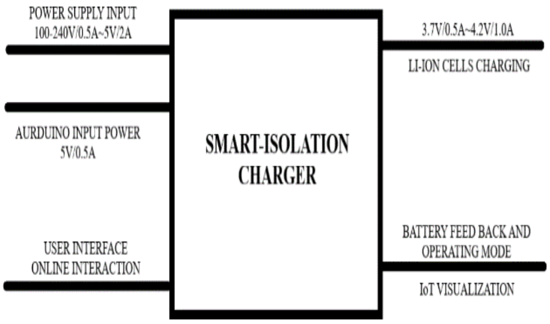


FIGURE 3.4 ZERO LEVEL BLOCK DIAGRAM

3.2.2 Level One Decomposition

Figure 2.5 on the following page shows the internal modules of the design. The subcomponents fall under three main categories: user interface software, smart battery charging, and the microcontroller

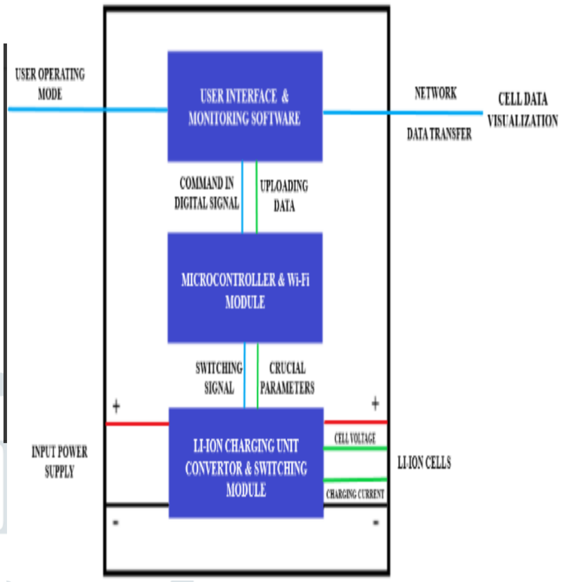


FIGURE 3.5 LEVEL ONE BLOCK DIAGRAM

3.2.3 Integral Block Diagram of Smart-Isolation Charger

FIGURE 3.6 FUNCTIONAL BLOCK DIAGRAM

The project's goal is to charge the lithium ion cells individually and effectively there by the battery A and B are charged by the Li-ion charger module will limit the charging current to 1A for the safety of the cell and the module is inbuilt with the trickle charging technique. The lithium-ion charger module is powered by relay module because these relay modules are used to toggle between the 2 different outputs namely fast and slow as per their output power and these relay modules are controlled by the digital signal from microprocessor which get command from the user operations on webpage via Wi-Fi module. The sensor module will measure the crucial parametric values of the cells and then it is sent to the microprocessor as an analog signal then it is converted to digital to upload to database via Wi-Fi module, then that data is displayed on the monitoring webpage. The graphical representation is done in separate software tool by retrieving the data from the database.

3.2.4 System Level Diagram

FIGURE 3.7 SYSTEM DIAGARAM

The System Diagram shows the power flow throughout the charger the power line are red and black symbolically showing the Vcc voltage as 5V and GRD respectively. This also shows the signals flow across the Arduino and the other modules.

3.3 *Hardware Component of smart-Isolation Charger*

3.3.1 Arduino Mega

The Arduino Mega 2560 is a microcontroller board based on the Atmega It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Mega 2560 board is compatible with most shields designed for the Uno and the former boards Duemilanove or Diecimila.

3.3.2 DC/DC Buck Convertor

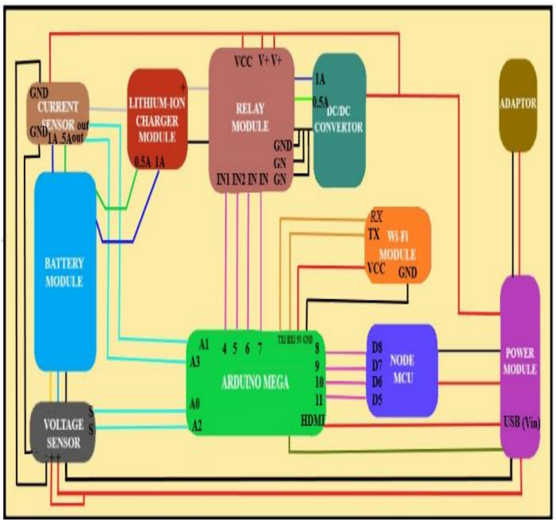
The buck converter is a very simple type of DC-DC converter that produces an output voltage that is less than its input. This component will step down the voltage and current into two variations Slow and Fast and then it is connected to the relay module. It is operated in 5V/2A

3.3.3 Voltage Sensor

A voltage sensor is a sensor used to calculate and monitor the amount of voltage in an object. Voltage sensors can determine the AC voltage or DC voltage level. The input of this sensor is the voltage, whereas the output is the switches, analog voltage signal, a current signal, or an audible signal. This is used to measure the Cell Voltage and produce an Analog output of 0.00489V resolution. It is operated in 5V/GND.

3.3.4 Current Senor

A current sensor is a device that detects and converts current to an easily measurable output voltage, which is proportional to the current through the measured path. : This will sense the amount of current flow that is charging current with a sensitivity of 100mV/A. it is



operated in 3.7V/0.5A fixed

3.3.5 Wi-Fi Module

Wi-Fi module ESP-01S ESP8266: The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Here the values of both batteries are written to the ThingSpeak database. Pin name in Arduino Mega is 5v & GND [Power] TXI & RXI [Communication], Input/output in the components is Vcc & GND RX & TX.

3.3.6 Li-ion Battery Charger Module

This is a safety device with trickle mode built within and the output charging current can be adjusted by R-program, here the approximate inputs are fixed to stranded outputs. It is operated in 3.7V/0.5A Approx. [Slow] ~ 3.7V/0.5A fixed

3.4 *Software and webpage in smart isolation charger*

In the Smart-Isolation Charger, Internet of Things plays the vital role in uploading the data of the cells while charging in real time to the database. Data base is an online platform posse the cloud storage access. These data are then called by the webpage which contain both Monitoring and User interface of the Li-ion charging Unit. Along with the Webpage, another platform is used to generate graphical visualisation plus estimation of other crucial data of the Li-ion cells.

3.4.1 Webpage for Monitoring and User Interface

The Webpage designed in the format that it can possess both monitoring and user interface thereby this will be primary application which is exhibited on the front play. The webpage is created by the

HTML (Hypertext Mark-up Language) is the most basic building block of the Web. It defines the meaning and structure of web content. Other technologies besides HTML are generally used to describe a web page's appearance/presentation (CSS) or fun

CSS stands for Cascading Style Sheets. It describes how Html elements should be displayed on screen. It is a powerful tool for web designers to change the design and control over web pages that how it should be displayed. It is supported by all browsers and is designed primarily to separate the document content from document presentation.

3.4.2 ThingSpeak IOT Cloud Database

ThingSpeak provides instant visualizations of data posted by your devices to ThingSpeak. With the ability to execute MATLAB® code in ThingSpeak you can perform online analysis and processing of the data as it comes in. ThingSpeak is often used for prototyping and proof of concept IoT systems that require analytics.

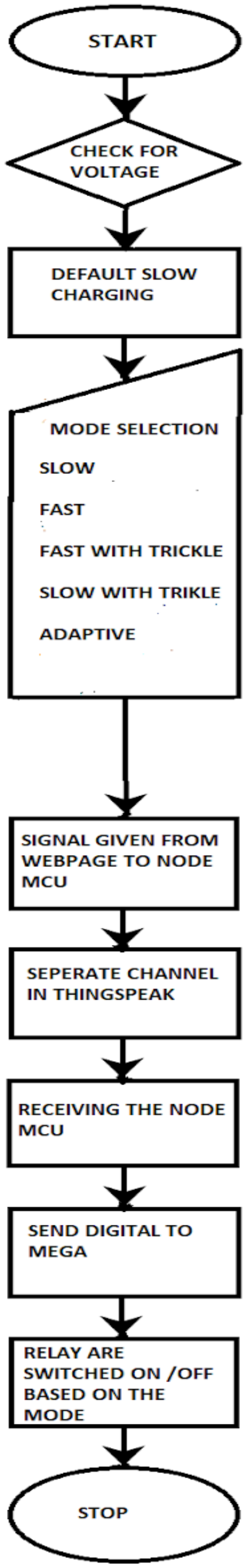
3.4.3 Colaboratory graphical visualization tool

Colaboratory, or "Colab" for short, is a product from Google Research. Colab allows anybody to write and execute arbitrary python code through the browser, and is especially well suited to machine learning, data analysis and education.

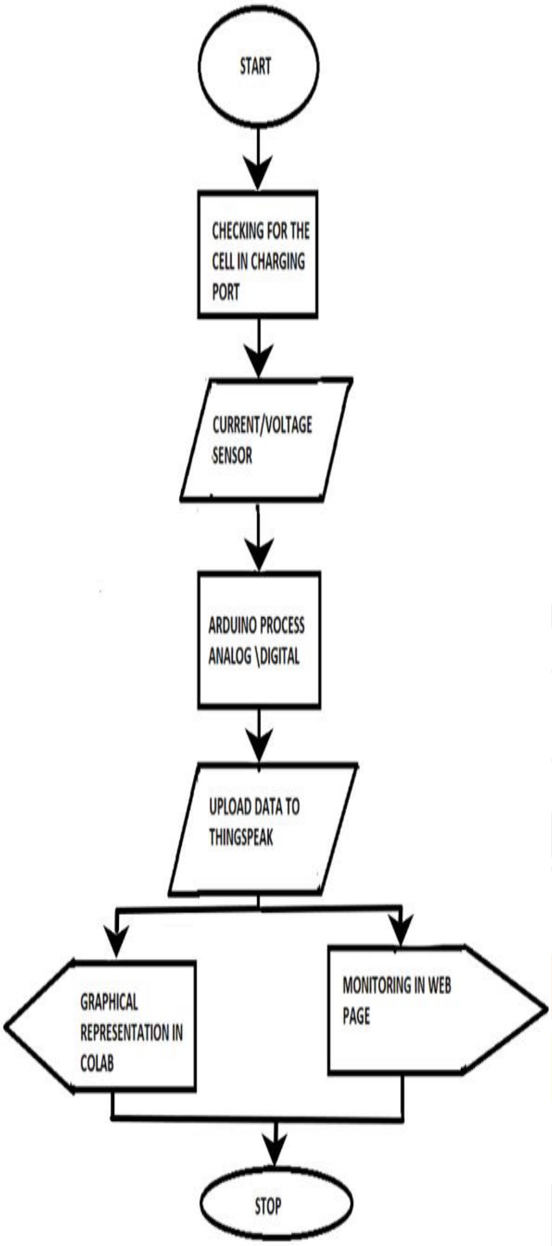
Colab focuses on supporting Python and its ecosystem of third-party tools. And the library of the Python is also available with the compiler and there is also visualization line plot, scatter plot, histogram, box plot, bar chart.

IV. Flowchart

4.1 Flowchart for User Interface



4.2 Flow Chart for Battery Management System



V. Result and working of Operating System

The charging mode is toggles between the operating modes is done through the user interface available on web page. The modes are classified in to slow, fast, adaptive and combination trickle mode at the end charging phase to keep the cell from discharging itself due to aging or other factors. The DC/DC buck convertor will step down the power supply voltage to two different variant which are then switched as Slow and Fast charging according to the output power. These two outputs are combined with another technique to form other two method of charging which is slow with trickle and fast with trickle, and these three modes are combined to form adaptive charging technique

5.1 Default/Slow Charging

This is the method will be the initial mode of charging before the user selects any of the modes. Slow charging will be turned on once the voltage and current signal from the sensors are feed to the analog pins of the Arduino, then the condition will be checked that weather the cell I is fully charged or not, if not then the cells will be charged individually. The input charging voltage will be 3.7V the standard slow charging voltage for lithium-ion cells with the current of 0.5 ampere

For the slow mode charging initially the Digital pins which switch on/off the relay are 4, 5, 6, and 7 [PWM] which acts as the actuators of the replay. At this mode pin number 4 & 6 are set high to close the relay which passes the low charging power through them.

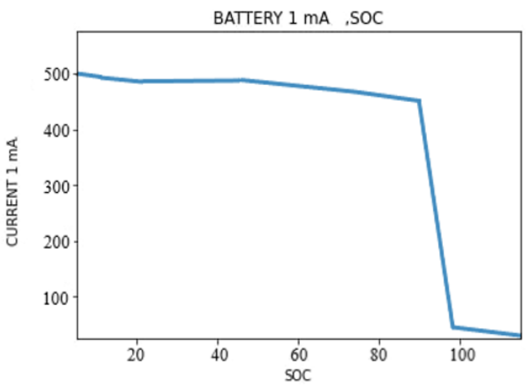


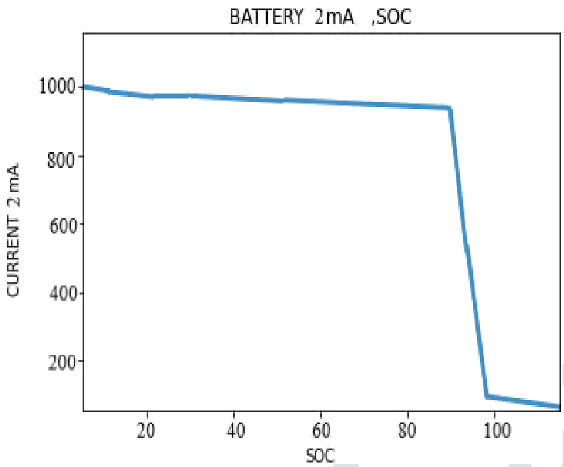
FIGURE 5.1 SLOW CHARGING CURRENT CHARACTERISTIC GRAPH

5.2 Fast Charging

This is the method will be the selection mode of charging by the user. Fast charging will be turned on once the voltage and current signal from the sensors are feed to the analog pins of the Arduino, then the condition will be checked that weather the cell is fully charged or not, if not then the cells will be charged individually. The input charging voltage will be 4.2V the standard fast charging voltage for lithium-ion cells with the current of 1.0 ampere.

For the fast mode charging initially the Digital pins which switch on/off the relay are 4, 5, 6, and 7 [PWM] which acts as the actuators of the replay. At this mode pin number 5 & 7 are set high to close the relay which passes the high charging power through them

. FIGURE 5.2 FAST CHARGING CURRENT



CHARACTERISTIC GRAPH

5.3 *Adaptive Charging*

This is the method will be the selection mode of charging by the user. Slow & Fast charging will be turned on sequence one after another once the voltage and current signal from the sensors are feed to the analog pins of the Arduino, then the condition will be checked that weather the cell is fully charged or not and also the voltage level to select the charging mode, if all the factors satisfy this charging mode's condition, then the cells will be charged individually. The input charging voltage will be 4.2V the standard fast charging voltage for lithium-ion cells with the current of 1.0 ampere which will charge the cell till the cell voltage reaches the cell maximum voltage that is 4.2V and then it will be charged in slow mode i.e., 3.7V with 0.5A till it reaches full charge where the current will become 1% of the initial charging current.

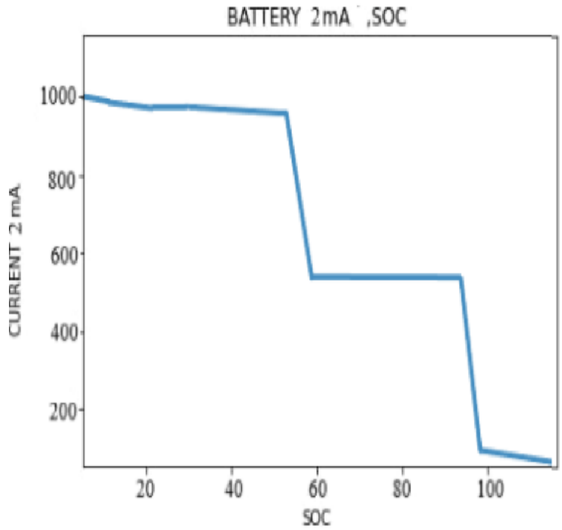


FIGURE 5.3 ADAPTIVE CHARGING CURRENT CHARACTERISTIC GRAPH

5.4 Trickle charging

Trickle charging is done at two different times to ensure the safety of the Lithium-ion battery by reducing the current to less than 1% of the initial charging current that flowed. The tow conditions where trickle charging is ensured are when the cell is drained beyond the low voltage will suffer drain voltage level from that till the low voltage trickle charging is done to ensure battery safety and longevity. This is also done in the refilling the battery or mainly known as topping up the self-discharge SOC because of aging, temperature etc. the trickle charging is inbuilt in the Li-ion charging module when the charge of the battery goes beyond 95% then charging will be maintained by Trickle mode.

5.5 Operating Mode Switching

The command is passed from the user on the webpage and that is obtained by the separate channel then that is reived by Node MCU. This module has a sperate Wi-Fi module in built which will connect to the local LAN and receive the command in the communicable format using API Key to access the data. Then the signal received is sent to the Arduino through digital pins, theses pins [D5, D6, D7, D8] are assigned as output of the Node MCU and Arduino pins as input [11, 10, 9, 8] respectively. These pins have binary format of command which will be 8-bit binary code and each number is assigned to a unique mode of action. Arduino will turn on and off the relay module by the PWM output signal.

VI. CONCLUSION

The idea of Smart-Isolation Charger for Lithium-Ion Batteries Using IoT is charging the Li-ion cells individually as user desired mode of operation as slow charging, fast charging, adaptive charging, and trickle charging is also combined has been done. This charger works as a monitoring device both the process are exhibited remotely through webpage which is achieved by Internet of Things platform with the help of Arduino, node MCU and Wi-Fi module. Data are transferred from sensor module to the Arduino as analog signal then it is converted to communicable format to upload on the data base. The graphical representation of the crucial data and the characteristic graph of all the charging modes are also obtained for in-depth visualization is also achieved using Colab, a Google software which retrieve stored data from the ThingSpeak using the same procedure as monitoring webpage.

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REFERENCES

[1] Asaad, Mohammad, et al. "IoT enabled electric vehicle’s battery monitoring system." EAI, SGIOT 8 (2017).

[2]Chynoweth, Joshua, et al. "Smart electric vehicle charging infrastructure overview." ISGT 2014. IEEE, 2014

[3]Lin, H. C., Y. J. He, and C. W. Liu. "Design of an efficient battery charging system based on ideal multi-state strategy." 2016 International Symposium on Computer, Consumer and Control (IS3C). IEEE, 2016.

[4] Amanor-Boadu, Judy M., Mohamed A. Abouzied, and Edgar Sánchez-Sinencio. "An efficient and fast Li-ion battery charging system using energy harvesting or conventional sources." IEEE Transactions on Industrial Electronics 65.9 (2018): 7383-7394.

[5] Sabarimuthu, M., et al. "Battery Monitoring System For Lithium Ion Batteries Using IoT." 2021 Innovations in Power and Advanced Computing Technologies (i-PACT). IEEE, 2021**.**

[6]Klein, Reinhardt, et al. "Optimal charging strategies in lithium-ion battery." Proceedings of the 2011 American Control Conference. IEEE, 2011.

[7]Tomaszewski, Anna, et al. "Lithium-ion battery fast charging: A review." ETransportation 1 (2019): 100011.

[8]Carreras, Mª Antonia Martínez, et al. "COLLABORATIVE LEARNING IN VIRTUAL LABORATORIES." e-Society 2004 (2004): 942.

[9]Nizami, Tousif Khan, and Chitralekha Mahanta. "An intelligent adaptive control of DC–DC buck converters." Journal of the Franklin Institute 353.12 (2016): 2588-2613.