Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN: 1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 02-2023
DOI 10.17605/OSF.IO/8NMTC

DESIGN AND IMPLEMENTATION OF LAPTOP BATTERY ANALYSIS TOOL

SOHAIL RANA

Department of Electronic Engineering, Dawood University of Engineering & Technology, Karachi, Pakistan.
Corresponding Author Email: sohail.rana@duet.edu.pk

NADIA MUSTAQIM ANSARI

Department of Electronic Engineering, Dawood University of Engineering & Technology, Karachi, Pakistan.

MAQSOOD UR REHMAN

Department of Electronic Engineering, Dawood University of Engineering & Technology, Karachi, Pakistan.

RIZWAN IQBAL

Department of Telecommunication Engineering, Dawood University of Engineering & Technology, Karachi, Pakistan.

MUHAMMAD ISMAIL

Department of Electronic Engineering, Dawood University of Engineering & Technology, Karachi, Pakistan.

SALMAN AYUB

Department of Electronic Engineering, Dawood University of Engineering & Technology, Karachi, Pakistan.

MAJID AHMED SHAIKH

Department of Electronic Engineering, Dawood University of Engineering & Technology, Karachi, Pakistan.

Abstract

Nowadays every person spends more time on a laptop and the problem which comes mostly when the person using the system is its charging life. This is a very annoying problem, and every person wants some helpful tips for his laptop's battery life. We are frequently ignorant of the health of the laptop battery, even though it is an important piece of equipment. Your windows laptop will likewise be insufficient in terms of information. It just features a little battery indicator on the surface that shows the remaining time and % Percentage. As time goes by, battery problems. It's the ability to keep a charge. The figures on the charge level display are changing. It's also not uncommon for discharge estimates to be incorrect. However, there are workarounds and solutions available. This laptop battery analysis tool indicates real-time readings of other essential parameters like voltage, capacity, and battery life. The main programming board is Arduino Uno for operating our Battery Management.

Index Terms: Battery Management System (BMS), Battery Electronics, and commercial off-the-shelf (COTS)

1) PROBLEM DESCRIPTION

Although the laptop battery is an important part of the equipment, unaware of its condition. Your windows laptop will likewise be insufficient in terms of information. It just features a little battery indicator on the surface that shows the remaining time. You will start to notice a few battery issues as time goes on. The battery no longer holds a charge.

Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN: 1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 02-2023
DOI 10.17605/OSF.IO/8NMTC

The charge level indicator displays erratic readings. It also typically has a faulty discharge estimation. There are, however, workarounds and solutions for enhancing the procedure of laptop battery analysis.

Battery failure & its decreased backup has always been a major problem in electronics, sometimes it is due to internal heating or resistance. As all the remote & wireless devices need good backup timing & health. Whenever the battery needs to be tested to find the fault and cause of failure, we must open it completely which is a difficult approach. If the battery's health, internal resistance, and other specifications can be monitored or analyzed during its charging and discharging time we can analyze the fault in advance and by doing this we will be able to increase its backup timing. For these enhancements, there were different approaches like voltage equalization of the series battery pack, zero voltage discharge capabilities, wireless battery analyzer, Intelligent Battery Analyzer, etc. But still, old tactics are used in our country because of costly analyzers, for this purpose, we decided to develop a cost-effective analysis tool that helps to detect the battery's fault not just the fault but also shows the battery's details like its voltage, capacity, health, life without opening it, like an analysis meter that helps in analyzing electronic devices. This project is considered, as a favor to cost-efficient measures for the detection of health and other specifications.

2) RELATED WORK

Automated Battery Charged Analyzer that explained this. The goal of the program is to minimize the cost and increase the efficacy of battery maintenance. This will necessitate the use of a complete battery support solution. This will be performed by inserting cutting-edge battery charger analyzer units at the appropriate times. When possible, commercial off-the-shelf components will be used in these units. System prototypes will be used to illustrate these novel concepts as proof of concept [1].

Rechargeable electric batteries are required for the functioning of nearly all automobiles and a wide range of electric power-dependent devices. Nickel-Cadmium, Lithium, and other battery technologies routinely outperform Lead-Acid in certain applications. Lead-acid batteries, on the other hand, virtually usually meet the whole needs of huge current capacity demands of automobiles and other electric power-dependent systems. [2]. The problem of eliminating battery failure elaborated that, Reliable electricity is essential in the backup power business. Hospitals, banks, and other vital facilities rely on huge and rising batteries. Mobile telecommunications facilities, utility reception, transmission stations, and a plethora of additional commercial and industrial installations are also examples. Despite the significance of keeping most customer testing does not correctly depict battery status, even though these mission-critical backup power systems are in good operating order. This is primarily because standard battery test equipment has only been used to assess the battery's electrical characteristics [3].

This paper describes the design and simulation of a laptop power bank based on a microcontroller. The concept utilizes a battery management system to monitor and control the status of charge/discharge and voltage levels of the battery bank. The simulations were conducted with the aid of PROTEUS and MATLAB software. It was determined that

Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN: 1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 02-2023
DOI 10.17605/OSF.IO/8NMTC

the BMS performed optimally under various operational conditions.[1].

This study presents a formula for calculating battery efficiency to control battery status. The proposed formula for calculating battery efficiency utilizes the charging time, charging current, and battery capacity. Using the proposed state of charge (SoC) and state of health (SoH) computations, an algorithm that can precisely determine the battery's status is proposed. To reduce the initial mistake of the Coulomb counting method (CCM), it is possible to precisely compute the SoC by adding the battery efficiency to the open circuit voltage (OCV). During the charging and discharging process, a battery's internal resistance and constant current (CC) charging time decrease. As proposed in this study, the SoH may be estimated from the CC charging time of the battery and the battery's efficiency.[2]

This study proposes a programmable logic controller (PLC)-based BMS to alleviate the disadvantages of micro-controller-based BMSs, including low dependability, low flexibility, and troubleshooting challenges. In addition, the accurate real-time estimation procedure for the state of charge (SOC) is accomplished by combining the Coulomb Counting (CC) and open-circuit voltage (VOC) techniques [3].

This study examines the concept and architecture of cloud-based smart BMSs, as well as their functionality, usability, and future battery application benefits. The potential separation of smart BMS local and cloud functionalities is also considered. It is anticipated that cloud-based smart BMSs will increase the dependability and overall performance of LIB systems, hence contributing to the widespread use of renewable energy [4].

The paper provides an overview of the battery management system utilized in contemporary electric vehicles. The system and its operations, including practical ways for balancing the battery and the types of batteries utilized in the automotive industry, are detailed [5]

In this study, a battery management system is presented that can prevent overcharging and passively balance the battery. The overcharging protection circuit is tested by simultaneously monitoring the voltage and current of each charged battery cell. While the passive balancing circuit operates solely by sensing the voltage of each battery cell, the active balancing circuit also includes a current source. Based on the measurements, the suggested circuit can prevent overcharging and balance each battery cell at 3.75 Volts and 0.2 Amps [6].

This study describes computationally efficient and accurate ensemble learning algorithms capable of identifying anomalies in Li-ion cell charging. In addition, it is demonstrated that by measuring charging cycle divergence, it is feasible to reliably and efficiently determine when a cell has encountered thermal and electrical stress due to overcharging.[7]

This paper begins with a summary of battery management systems and their primary functions. In order to assess the viability of balancing the capability of reconfigurable batteries as multifunctional battery electronics, a MATLAB simulation of two existing works on reconfigurable battery packs with inversion capability is performed to compare and contrast these two options and illustrate their application perspective [8].

Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN: 1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 02-2023
DOI 10.17605/OSF.IO/8NMTC

The review comprises both academic literature and industry-published reports and data. The objective is to provide practical guidance, metrics, and methods to improve the environmental performance of battery systems used in electronics (such as cellphones and laptops), vehicles, and cordless power tools in order to ultimately inform users, battery designers, suppliers, vehicle and device manufacturers, and material recovery and recycling organizations [9].

In this study, an effective lithium cell simulation model including thermal dependence is proposed. The proposed equivalent circuit model consists of one series resistor, one voltage source, and one RC block. The 1 RC and 2 RC Lithium-ion battery versions typically seen in the literature are contrasted and researched. MATLAB/Simulink software is utilized to simulate the Lithium-ion battery 1RC and 2RC models. The simulation results in his work indicate that the Lithium-ion battery 1 RC model has a higher maximum output error of 0.42% than the 2 RC Lithium-ion battery model under constant current conditions, and a higher maximum output error of 0.18% under UDDS Cycle conditions [10].

3) METHODOLOGY

Firstly, Connect the battery with an analyzer tool then the battery is analyzed. The controller read the parameters with the entered command after the battery is categorized for lithium ion & lithium polymer, when all parameter of the laptop battery is displayed afterward, we generate the report with battery parameters. Establishing charging and discharging setup (7V, 12V & 14V) respectively. An I2C LCD serial converter to link the LCD display to the Node MCU is used, which is going from the LCD's 8-pin to the adapter's 4-pin. As Arduino. cc began developing new MCU boards based on non-AVR processors, such as the ARM/SAM MCU used in the Arduino Due, they needed to modify the Arduino IDE to support alternate toolchains to enable Arduino C/C++ to be compiled for these new processors, with the introduction of the Board Manager and the SAM Core. A core is the set of software components necessary for the Board Manager and Arduino IDE to build an Arduino C/C++ source file for the machine language of the target MCU. Some ESP8266 enthusiasts created an Arduino core for the ESP8266 Wi-Fi SoC, which is commonly referred to as the "ESP8266 Core for the Arduino IDE."

Become the dominant software development platform for ESP8266-based modules and development boards, such as NodeMCUs. This is useful because the Node MCU is small, and we want to minimize the number of pins on the board. The NodeMCU pins that are being used are mentioned as D1, D2, VIN, and Ground. The LCD connection is in the form:

VIN = VCC, Ground = Ground, D1 = SDA, D2 = SCL

Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN: 1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 02-2023
DOI 10.17605/OSF.IO/8NMTC

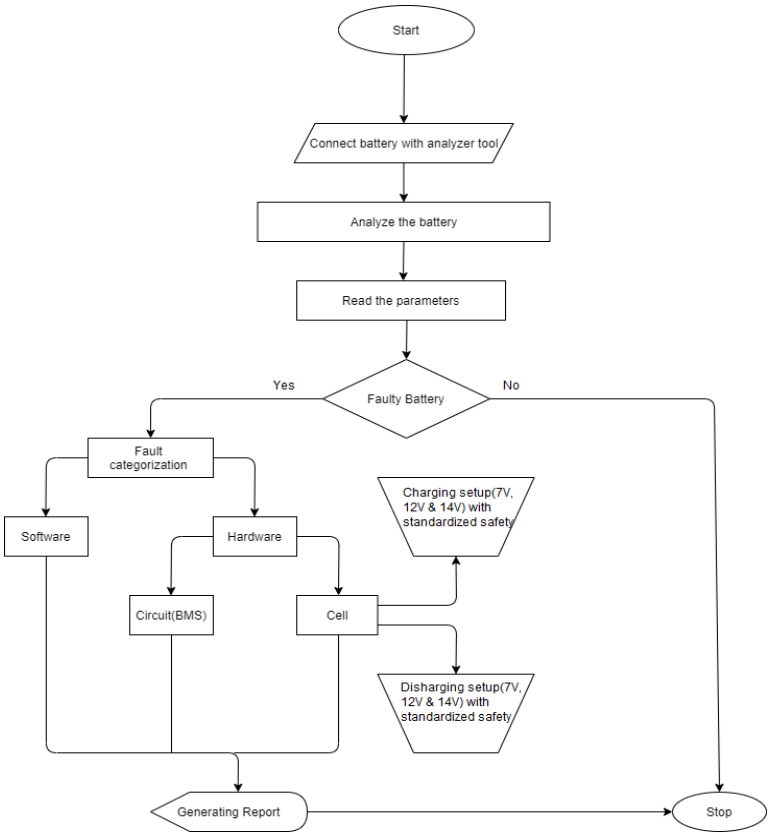

Fig 1: System Model

We got three different communications pins as known as serial data serial clock ground these are the three different communication pins, we got from the controller known as the laptop battery analysis tool which will collect the data from laptop battery circuit known as BMS which will get all the data from your laptop battery passes from this pin to analog controller**,** start from laptop battery analysis tool that will just communication pins serial data serial clock and ground from laptop battery circuit known as BMS battery management system which will connect to the analysis tool known as laptop battery analysis tool first we will connect the communication pin of a battery to this analysis tool then the analysis store will analyze the battery giving command it will read all the parameters of laptop battery then it will make a decision that yours battery laptop battery is in fault or your laptop battery is in perfect and in working condition if your laptop battery is in okay condition the loop and all the parameters which you need by the controller of laptop battery will come out from the loop and tells that your laptop battery is okay and stop the loop while in the other case that if your laptop battery is in fault now the whole loop will go into the decision condition what kind of fault your laptop battery occurs first it will categorize the fault the categorization of a fault is in two ways. It is in the form of hardware, otherwise, it is in the form of Hardware and Software. Now the controller take a decision if your laptop battery is in hardware fault and what kind of hardware fault will occur in your laptop battery The basic hardware is categorized into two types of circuits which are known as BMS battery management systems where it will manage all the

Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN: 1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 02-2023
DOI 10.17605/OSF.IO/8NMTC

charging and discharging concept of lithium-ion and lithium-polymer cells while the other the second world is about the cell fault what is cell a battery which maintains all the power through which your laptop run up. There are two sorts of hardware faults that can occur in basic hardware. Circuit BMS battery management system is the first. Cell battery is the second type. Now we are talking about the concept of cell there is not a single cell which is used in laptop battery which will give power to your laptop there are a combination of cell user laptop battery to making a power required power which your laptop wants the basically the seller categorizing to three types 7 volt two series in a combination of a cell when we are talking about 12 volt battery the 3 series in a combination of a cell when we are talking about 14 volt battery the 4 cell is used in a series combination to maintain a required power with how much power your laptop battery wants your laptop want, then the controller make a decision that its hardware fault for its software fault if it's hard ware it would categorize into two type circuit or a cell when it's offered it will make a decision that what kind of fold your battery occurs then it will generate an report and display in in the graphical LED display that it's of very fold or it's hardware for if it's hard ware and it will categorize it from BMS or it's from cell.

- **Procedure of NodeMCU Setup**

Arduino IDE Software Installation. After installation, a desktop icon for the Arduino IDE appears. To open the Arduino window, click on the icon. As seen in the illustration, open the File and select Preferences.

(1) Selection Preferences

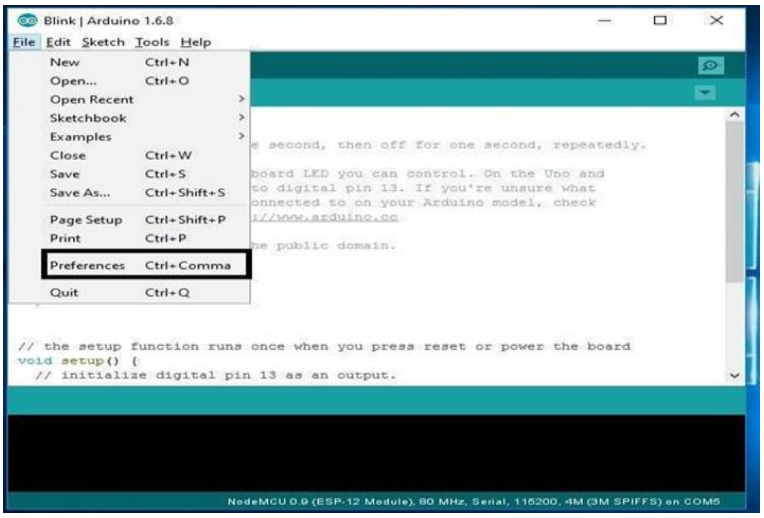

Fig 2: Selection Preferences

(2) Additional Board Manager

The Additional Boards Manager, enter the following URL: arduino.esp8266.com/stable/package esp8266com index and press OK.

Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN: 1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 02-2023
DOI 10.17605/OSF.IO/8NMTC

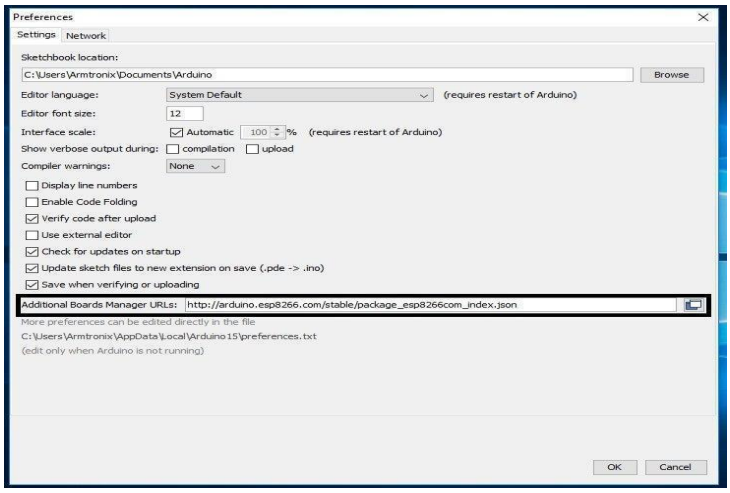

Fig 3: Additional Board Manager

(3) Board Selection

Select Board: Click on "Adriano/Genuine Uno" then "Boards Manager" as indicated in the diagram.

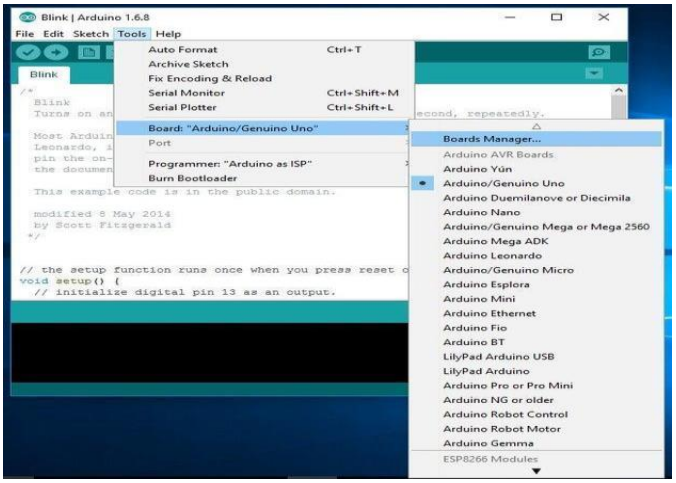

Fig 4: Board Selection

(4) Installation Process

When the Boards Manager window appears, scroll to the bottom of the page until you see the ESP8266 module. Once we have it, we need to choose that module, choose a version, and then click the Install option.

Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN: 1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 02-2023
DOI 10.17605/OSF.IO/8NMTC

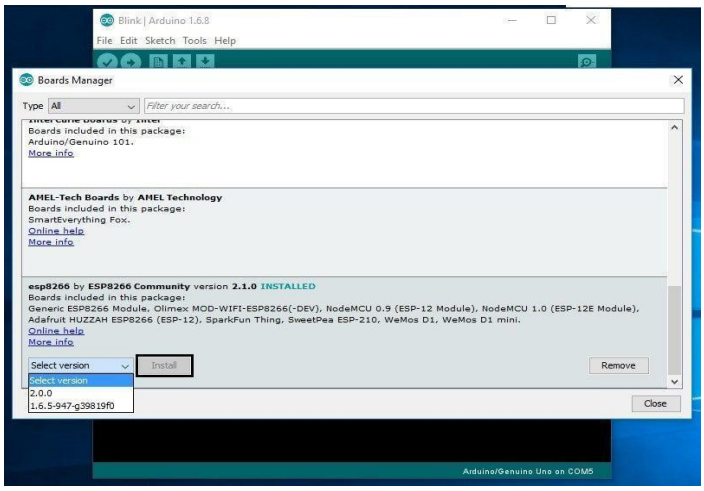

Fig 5: Installation Process

(5) Selection of Node MCU

Select the Board: “Arduino Genuino Uno,” followed by NodeMCU (ESP12E Module) or additional esp8266 modules, as needed. This may be accomplished by scrolling down, as seen in the picture.

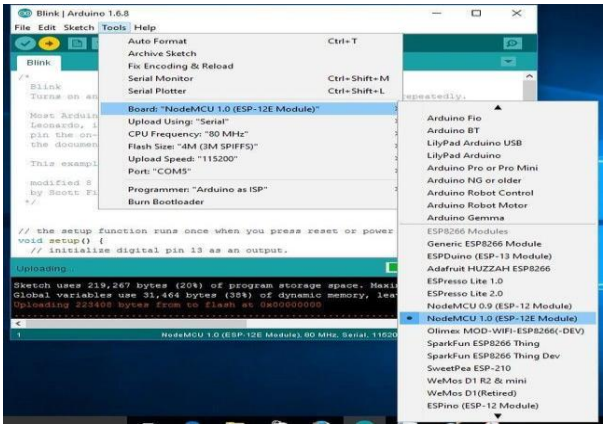

Fig 6: Selection of Node MCU

(6) Booting Constraints

Booting Connect the ESP8266 module to your PC. Using a USB connection cable, as indicated in the diagram. The circuit is attached to the UNIVERSAL SERIAL BUS, it detects the COM port, which in this case is COM5.

Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN: 1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 02-2023
DOI 10.17605/OSF.IO/8NMTC

Fig 7: Booting Constraints

(7) Blink Status

To open the window, navigate to the File tab, Examples, Built-in example, 01. Basics, and Blink.

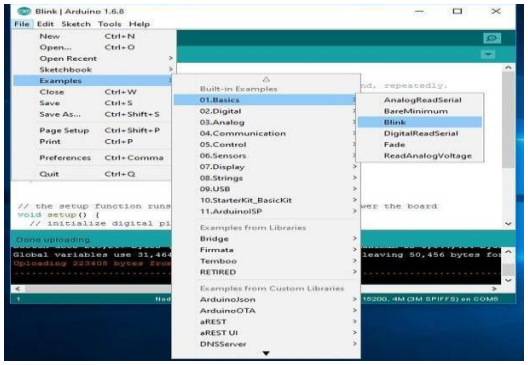

Fig 8: Blink Status

The example for the blink program will appear in a new window; choose the port using the tools menu: Depending on whatever esp8266 module is attached to your computer's COM port, “COM” will be shown. Refer to the preceding procedures to choose a COM port.

- **Example Code**

Change all the digits 13 to 16 in the blink example code, then submit the program to the module by pressing the right arrow in the image. It will cause the NodeMCU module on-board to blink.

```
void loop(){
pin Modes(15, OUTPUT);}
void loop(){
delays(10);
digitalWrite(15 HIGH);
delays(100);
```

Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN: 1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 02-2023
DOI 10.17605/OSF.IO/8NMTC

digitalWrite(15, LOW);

delays(100); //

}

Follow the procedures outlined in the figure. To paste the file, navigate to the libraries folder and paste it there, as shown in the example below.

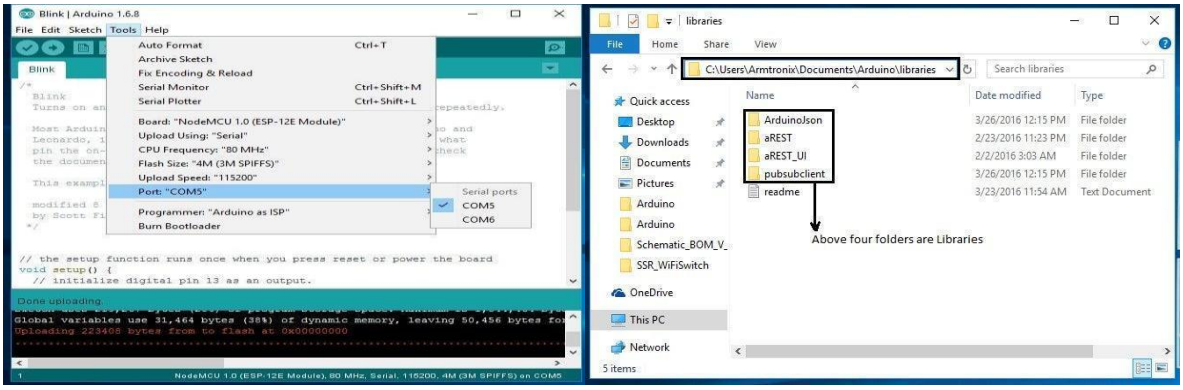

Fig 9: Example Code

4) RESULTS

Results and conclusion are given.

Fig 10: Hardware result (1)

Fig 11: Hardware result (2)

Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN: 1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 02-2023
DOI 10.17605/OSF.IO/8NMTC

(1) Simulation Results

Simulation Results are given below.

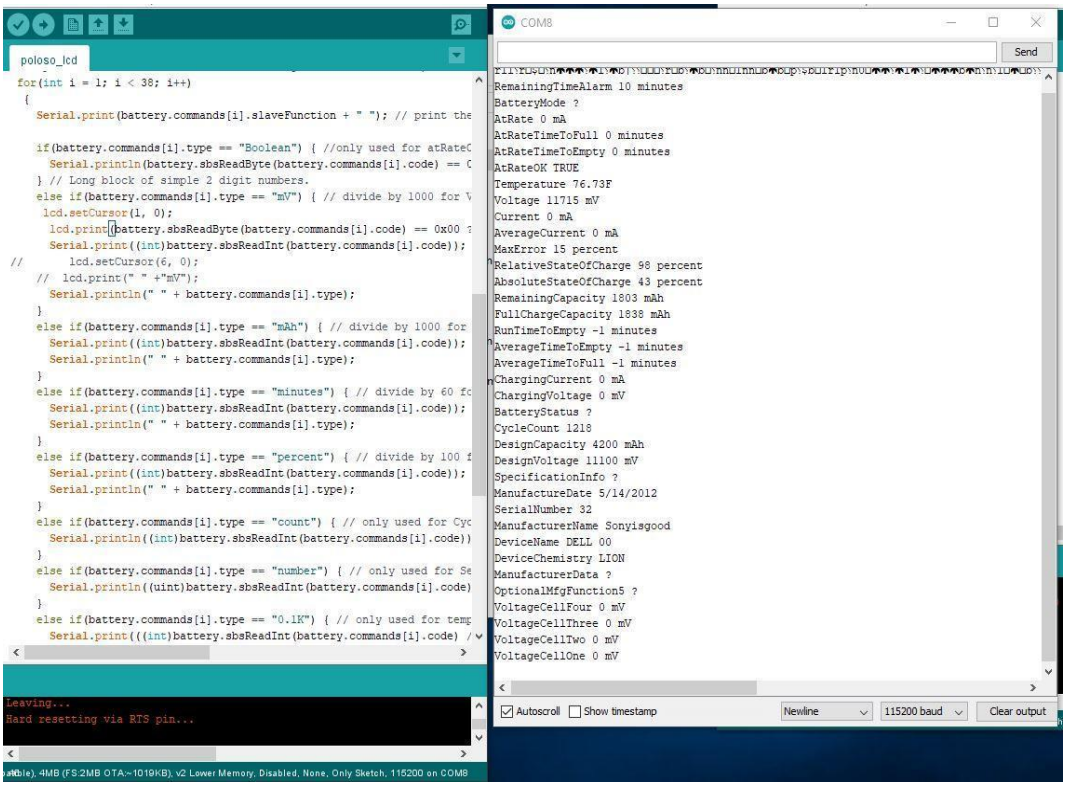

Fig 12: Simulation Result

(2) Sublime Results

Sublime Results are given below.

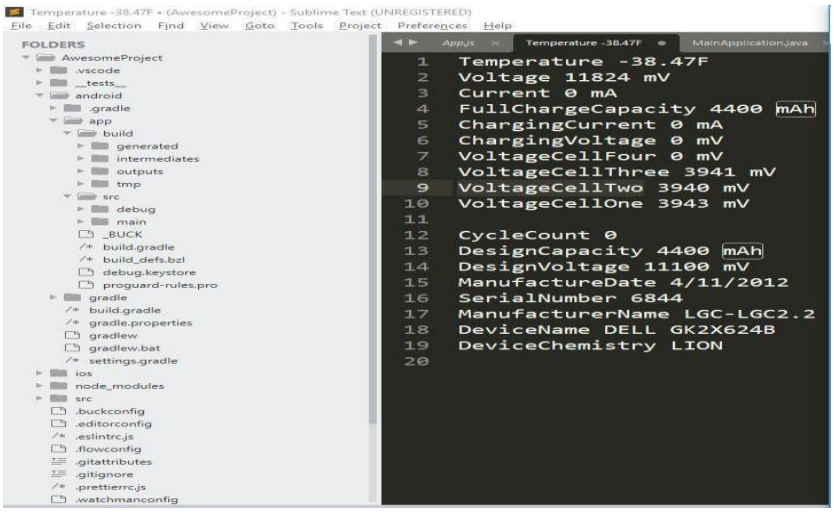

Fig 12: Sublime Results

Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN: 1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 02-2023
DOI 10.17605/OSF.IO/8NMTC

(3) Received Parameters

• Temperature	• Voltage	• Current
• Cycle Count	• Device Chemistry	• Per Cell Voltage
• Discharging Current	• Charging Current	• State of Charge

5) CONCLUSION

This project provides a solution to increase the ease and maintenance of laptop batteries. The cost-effective and user-friendly tool gives advanced time to troubleshoot battery faults and adds to the backup and overall battery life. This laptop battery analysis tool indicates real-time readings of other essential parameters like voltage, capacity, and battery life. The main programming board is Arduino Uno for operating our Battery Management.

6) FUTURE RECOMMENDATIONS

This Battery Management System has immense potential to incorporate with a mobile application that can also indicate the battery's health and life in the palm of your hand. The vitals of your battery, such as charging, and discharging can be easily shown on the mobile application. This tool can predict the life of the battery so predictions like when the battery needs to be replaced or repaired can be easily sent to mobile applications in the form of alerts and notifications. Other features like battery life cycle and remaining battery capacity can be easily displayed on your mobile phone. The mobile application will also help to relocate the closest troubleshooting DIY solutions and demonstrate to the user how to operate the simple emergency backup steps. We are planning to extend our work with other devices alongside laptops like medical equipment, which can help the operator to arrange alternatives before the battery failure.

References

1) B. C, “Design and Simulation of Microcontroller Based Laptop Power Bank,” IOSR Journal of Humanities and Social Science (IOSR-JHSS, vol. 25, no. 10, pp. 42–47, 2020, doi: 10.9790/0837-2501104247.

2) J. Lee, J.-M. Kim, J. Yi, and C.-Y. Won, “Battery Management System Algorithm for Energy Storage Systems Considering Battery Efficiency,” Electronics (Basel), vol. 10, no. 15, p. 1859, Aug. 2021, doi: 10.3390/electronics10151859.

3) N. Mohammed and A. M. Saif, “Programmable logic controller-based lithium-ion battery management system for accurate state of charge estimation,” Computers & Electrical Engineering, vol. 93, p. 107306, Jul. 2021, doi: 10.1016/j.compeleceng.2021.107306.

4) M.-K. Tran, S. Panchal, T. D. Khang, K. Panchal, R. Fraser, and M. Fowler, “Concept Review of a Cloud-Based Smart Battery Management System for Lithium-Ion Batteries: Feasibility, Logistics, and Functionality,” Batteries, vol. 8, no. 2, p. 19, Feb. 2022, doi: 10.3390/batteries8020019.

5) F. Issa, “Battery Management System for an Electric Vehicle,” The Scientific Bulletin of Electrical Engineering Faculty, vol. 21, no. 2, pp. 31–34, Dec. 2021, doi: 10.2478/beef-2021-0019.

6) Michael, R. P. Sujatmiko, T. Abuzairi, M. Rizkinia, and T. A. Kurniawan, “Design of Overcharging Protection and Passive Balancing Circuits Using Dioda for Lithium-Ion Battery Management System,”

ISSN: 1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 02-2023
DOI 10.17605/OSF.IO/8NMTC

in 2019 16th International Conference on Quality in Research (QIR): International Symposium on Electrical and Computer Engineering, Jul. 2019, pp. 1–4. doi: 10.1109/QIR.2019.8898267.

7) J. Obert, R. D. Trevizan, L. Torres-Castro, and Y. Preger, “Ensemble Learning, Prediction and Li-Ion Cell Charging Cycle Divergence,” IEEE Open Access Journal of Power and Energy, vol. 8, pp. 303–315, 2021, doi: 10.1109/OAJPE.2021.3100004.

8) R. Eskandari, P. Venugopal, and G. Rietveld, “Advanced Battery Management Systems with Integrated Battery Electronics,” in 2022 IEEE 20th International Power Electronics and Motion Control Conference (PEMC), Sep. 2022, pp. 55–61. doi: 10.1109/PEMC51159.2022.9962868.

9) M. Woody, M. Arbabzadeh, G. M. Lewis, G. A. Keoleian, and A. Stefanopoulou, “Strategies to limit degradation and maximize Li-ion battery service lifetime - Critical review and guidance for stakeholders,” J Energy Storage, vol. 28, p. 101231, Apr. 2020, doi: 10.1016/j.est.2020.101231.

10) B. v. Rajanna and M. Kiran Kumar, “Comparison of one- and two-time constant models for lithium-ion battery,” International Journal of Electrical and Computer Engineering (IJECE), vol. 10, no. 1, p. 670, Feb. 2020, doi: 10.11591/ijece.v10i1.pp670-680.