Smart Charge control of batteries in Electric vehicle using LabVIEW with IoT platform

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Abstract

With the depleting rate of global petroleum product there is a need in the replacing of all the engine vehicles with emerging electric vehicles (EVs). But the replacing faces a major challenge in terms of limited availability of charging facilities, unacceptably long charging period and heating of battery due to uncontrolled charging circuits. EVs are predicted to be the next disruptive market force for transportation and technology. Hence, many researches have been done on battery charging for EVs. Till now, the Constant Current Constant Voltage (CCCV) strategy is mostly preferable because of its proper balance between charging time and charging capacity but it takes more charging time. Hence, this paper tends to explore EV world with great attention of time by the help of Multi-step Constant Current (MCC) strategy. In this paper, a smart charging technique is proposed for electric vehicles by controlling the charging circuit through LabVIEW and IoT platform which selects the charging current of the batteries on the basis of battery temperature. Simulation has been performed for both existing Constant Current & Constant Voltage Strategy and the proposed Multistage Constant Current Strategy. The comparison has been done and found that MCC is more efficient than CCCV in terms of charging time as well as temperature control of the battery. EV user can check the battery available capacity, charging time, temperature of the battery in a webpage or a mobile application through IoT platform

Keywords: ***Li-ion battery, multi stage constant current, charging time, temperature control***.

I. Introduction

As all-electric cars emit no direct pollutants, they help to improve air quality [1]. The Battery Electric Vehicle (BEV), which is entirely powered by batteries and recharged by plugging the vehicle [2], is a one-stop solution for this. Because of its advantages, such as high energy density, minimal maintenance, and extended service life [3,] Li-ion batteries are the best suited for EV applications among the many types of batteries on the market. Despite its benefits, the Li-ion battery is extremely susceptible to overcharging and deep discharge, which can shorten its lifespan and potentially result in a fire or explosion. As a result, the battery should only be used in a secure location. Battery charging is important since it affects battery protection and accessibility [4]. A well-designed charging method protects the battery, reduces temperature fluctuations, and improves energy conversion efficiency [5]. Fig 1 depicts the limits for developing a smart charging method for a battery.

To increase the deployment of the Electric Vehicle sales, the smart charging strategy is required to charge a battery with less time and high safety. So, there is a need to find the effective way of charging with the smart approach to charge the battery quickly within safe operating area [6]. One such a way is multi-step constant current charging strategy with the consideration of charging period and temperature upsurge. Charging current control and charging time calculation have been done through Graphical Programming Language (LabVIEW). Another contribution of the paper is reducing the manual work and handle smart approach in the Electric Vehicle charging station [7]. The user can turn ON and OFF the battery charging process using mobile app with the IoT platform.

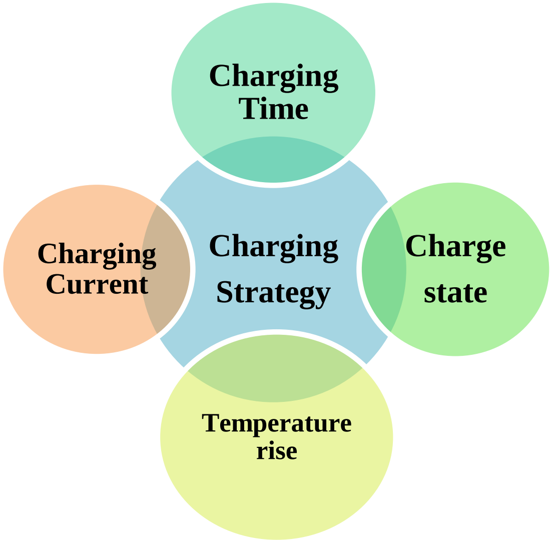

Fig. 1 Constraints to develop smart charging strategy

First, the battery's voltage, current and temperature have been collected using a data acquisition system. After obtaining the behavior of a battery, an appropriate charging pattern has been given to the battery. Finally, the LabVIEW controller regularly monitor the battery's temperature with the safe operating temperature. When temperature rises above the limit, the controller reduces the charging current of the battery to control the temperature rise. Furthermore, when a malfunction develops in the battery's operation, use a mobile app to switch off the charging process and safeguard the battery from harm. A user interface between the battery and the controller is provided via an effective communication network [8-9].

II. Related works Proposed Smart Charging

In this paper, DC fast charging is employed. By increasing the charging current, the time required to charge the battery become reduced. For example, if AC charging required 5 hours, then the DC fast charging require 2 hours because the current rate has been increased in this technique.

In this paper, three lithium-ion batteries connected in series to get higher voltage. While charging the batteries temperature will increase. If temperature goes beyond a certain level battery will burst out. So, the temperature level is monitored with the help of temperature sensor and the temperature level is given to the LabVIEW via Arduino. The level of checking temperature is programed in LabVIEW. The block diagram of the suggested work is illustrated in Fig 2.

When the temperature goes beyond certain level, the battery charging current has been reduced to control the temperature rise in the batteries. When the abnormal conditions occur, the Relay Circuit will trip the charging process by the user control via mobile app. The charging time and cost can be calculated using the LabVIEW. The results are sent to the cloud with the help of Arduino. MIT app inventor is used to see the all the details in mobile phone. The battery management system can regulate the voltage levels while charging the batteries. The flowchart of the battery charging process control is explained in Fig 3.

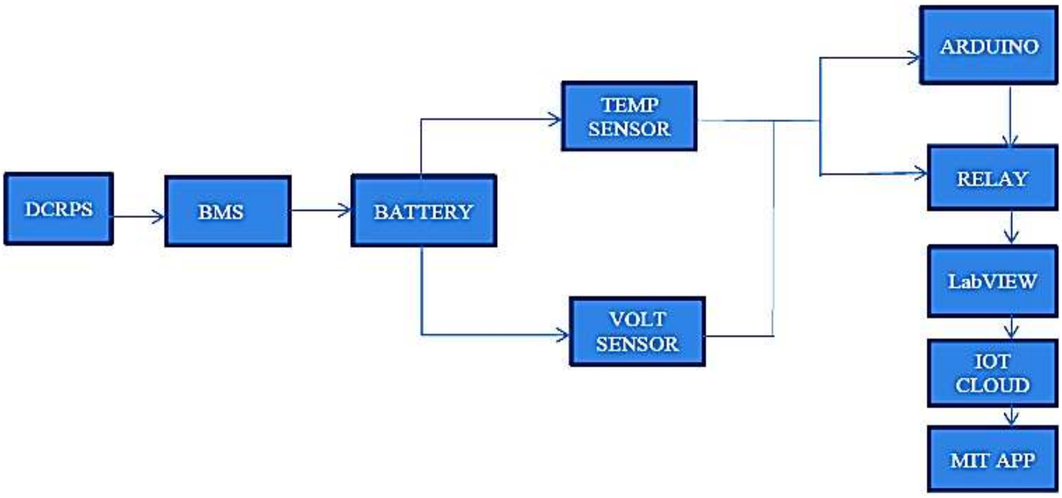

Fig. 2 Block diagram of the suggested charging process control

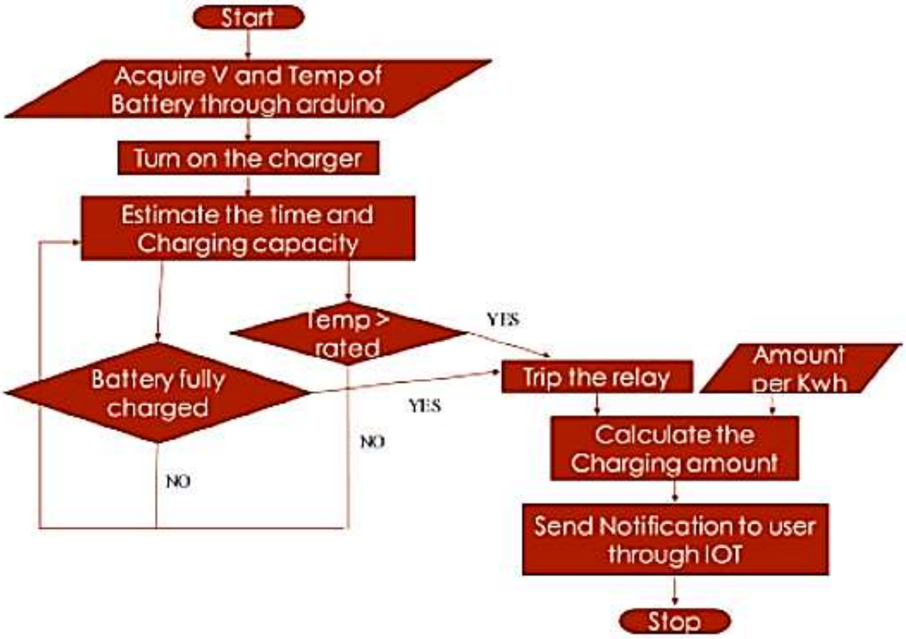

Fig. 3 Flowchart of Fast Charging for EV

III. Simulation Results and Discussion

Acquire the Battery voltage and temperature through the Arduino and the data are send to the LabVIEW. When the temperature is within the limit, the charger circuit turned on and estimate the required time and current to charge the battery. If the temperature is going beyond a certain limit, then trip the relay otherwise battery continuously charging. Meanwhile, when the battery has been fully charged, the control signal goes to the trip circuit. Both the temperature monitoring and charging capacity calculation are parallel processing and the charging time is calculated to send the notification to the user through IoT.

A. **Constant Current and Constant Voltage (CCCV) Strategy:**

The Li-ion battery module has been charged using the CCCV charging approach. In the case of rapid chargers for Li-ion batteries, the CCCV technique is the most extensively used and acknowledged charging method. The CCCV technique has two modes: the first (CC mode) is ON, which means the battery is charged with constant current until the terminal voltage reaches the nominal value, and the second (CV mode) is ON, which means the battery is charged with constant voltage until the battery current hits its lower limit. Despite this, the CV mode takes nearly three times as long as the CC mode to charge. As a result, the total charging time for the battery is extended. The implementation of constant current loop and constant voltage loop of this method using LabVIEW is shown in Fig 4.

- When SOC reaches the maximum state, it switches over from constant current loop to constant voltage loop.
- If State of Charge (SOC) reaches 100%, it will terminate constant voltage loop.

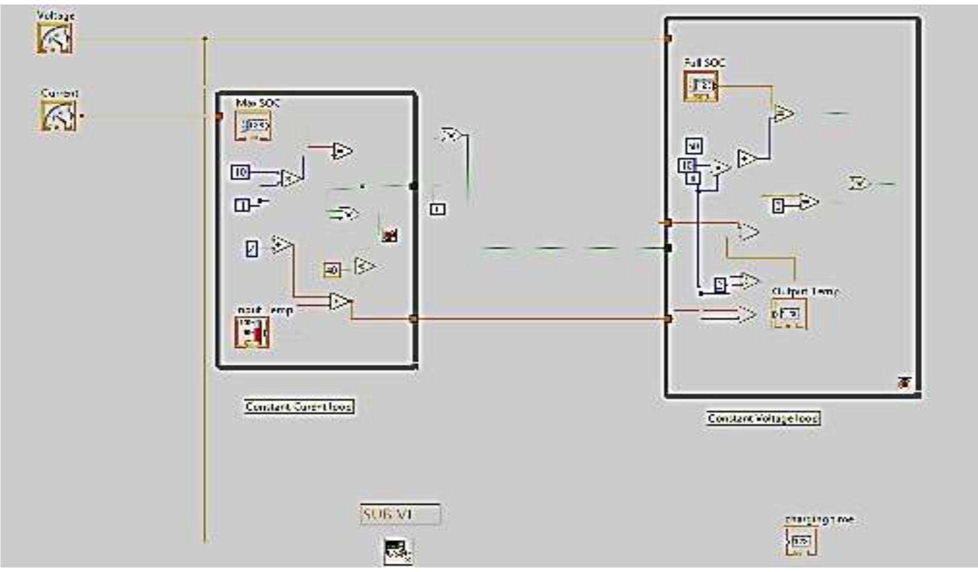

Fig. 4 CCCV charging using LabVIEW platform

The current and voltage act as inputs. Optimized values of maximum and full state of charge by existing algorithms have been calculated. From VI, battery temperature has been estimated and time to charge the battery is calculated. The front panel for CCCV is depicted in Fig 5.

The mathematical formulation for time to charge the battery has been created. It is done by the application of Sub VI, as shown in Fig 6. From the inference of datasheet of Panasonic Li UF383551F, the simulation has been verified with the real time values, as depicted in Fig 7.

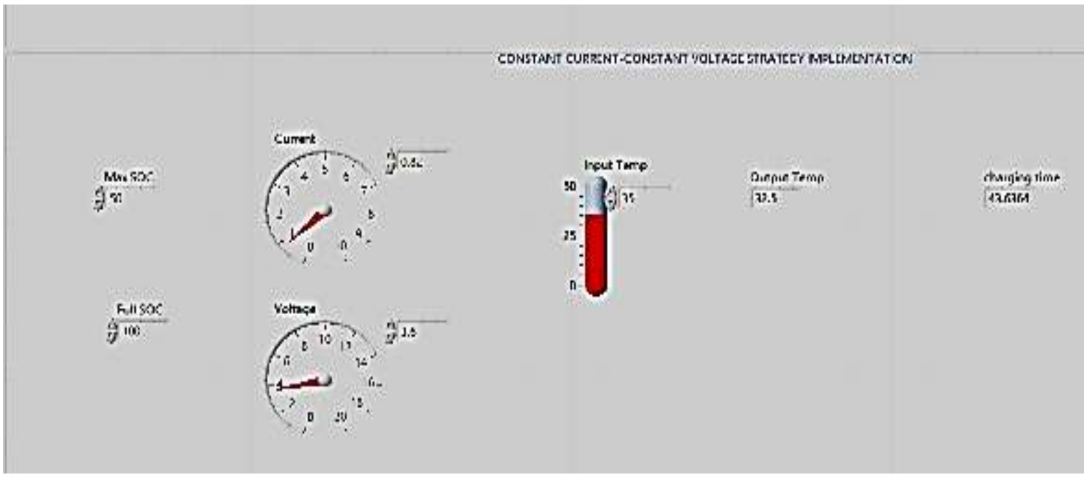

Fig. 5 Front Panel for CCCV

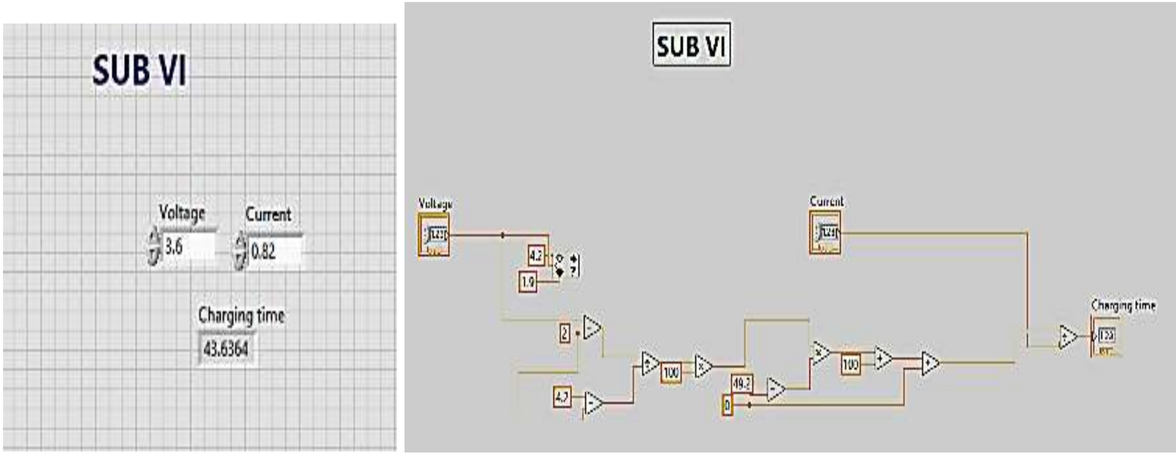

Fig. 6 Front panel and Block Diagram of SUB VI

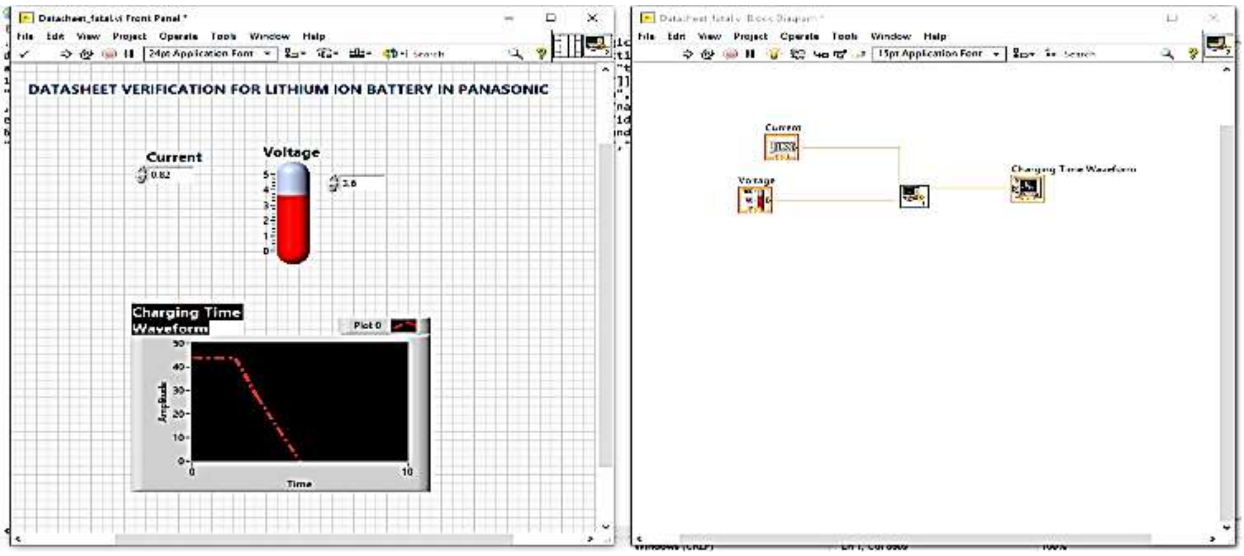

Fig. 7 Verification of results with Real time datasheet

B. Multi stage Constant Current (MCC) Strategy:

The MCC saves charging time and regulates temperature increase, however it becomes difficult when the constant current value for each charging phase needs to be fixed. In this paper, the smart charging is presented as a solution to the problem, as shown in Fig 8-10.

- At first, the charging current rate is chosen above the rated current until the SOC reaches 70%.
- After it reaches SOC of 70%, the charging current is reduced at each step until it reaches 100%.
- Consequently, the temperature and voltage of the battery has been monitored.
- By this method, time to charge the battery gets halved than CCCV method.

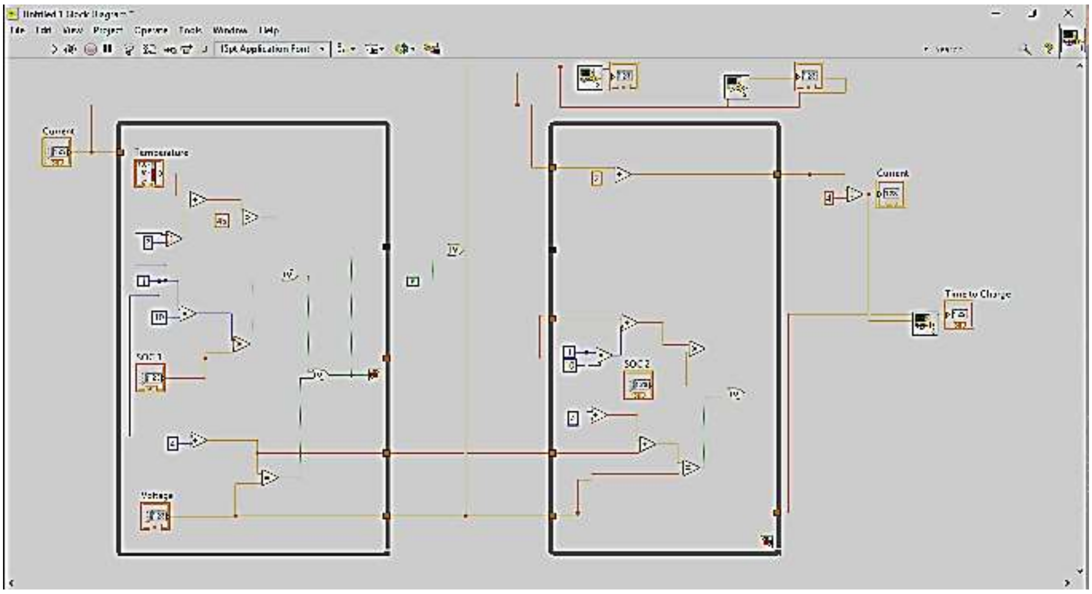

Fig. 8 Block Diagram of MCC charging strategy using LabVIEW

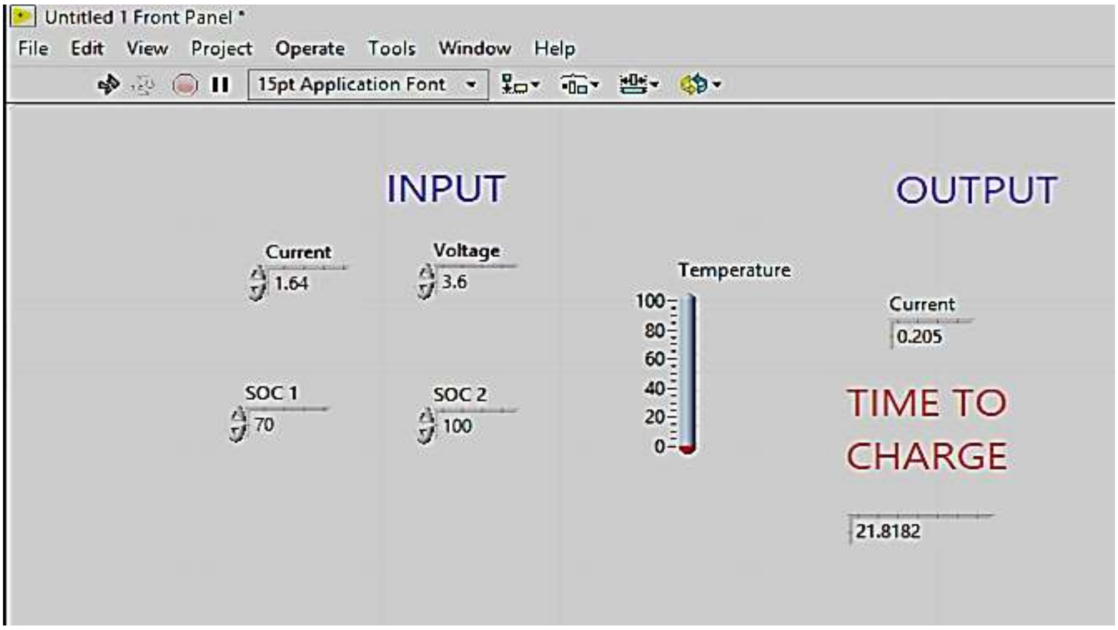

Fig. 9 Front Panel of MCC method in LabVIEW

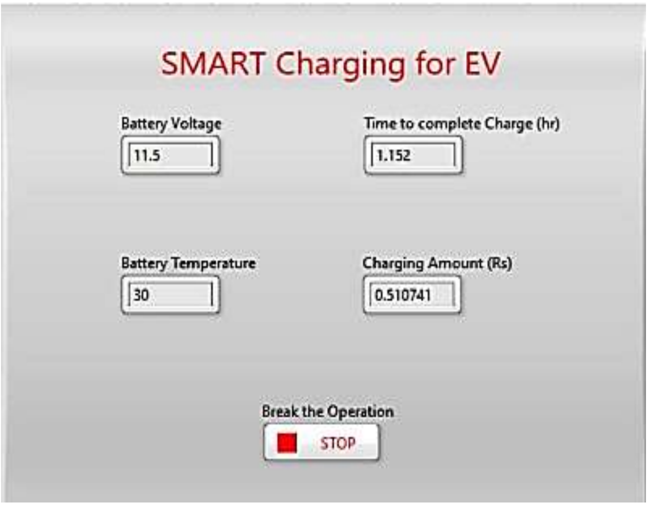

Fig. 10 Front Panel of LabVIEW window

As seen from Fig 11 and 12, the cost estimation and the battery temperature monitoring have been successfully completed.

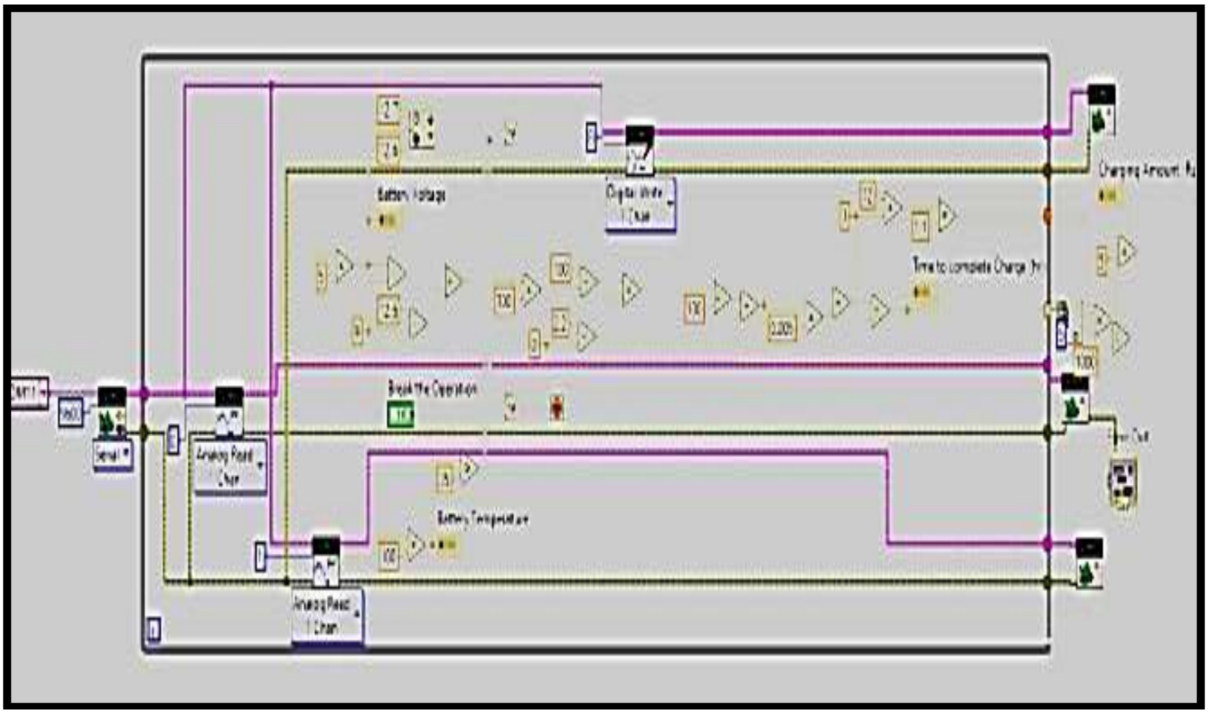

Fig. 11 Arduino with LabVIEW

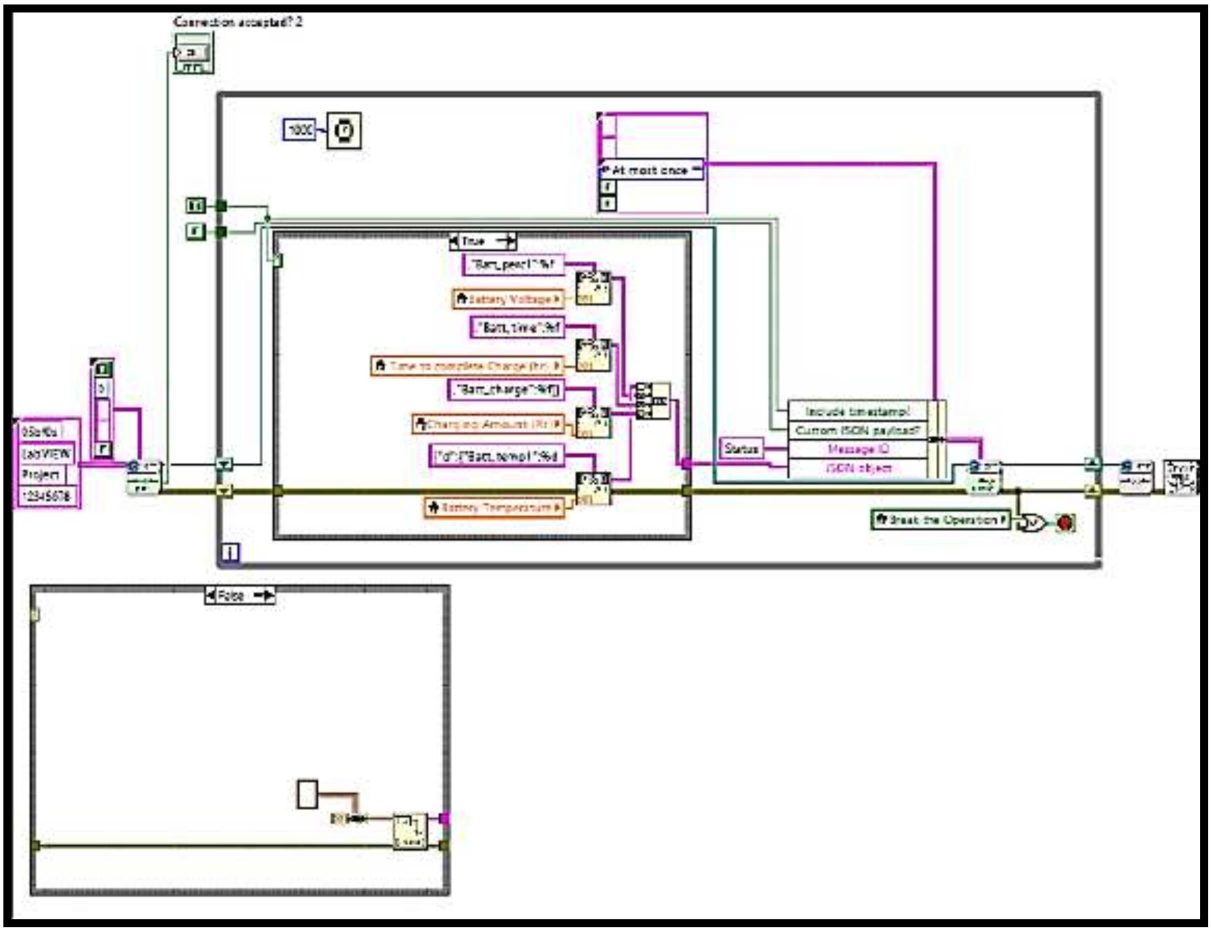

Fig. 12 IoT with LabVIEW

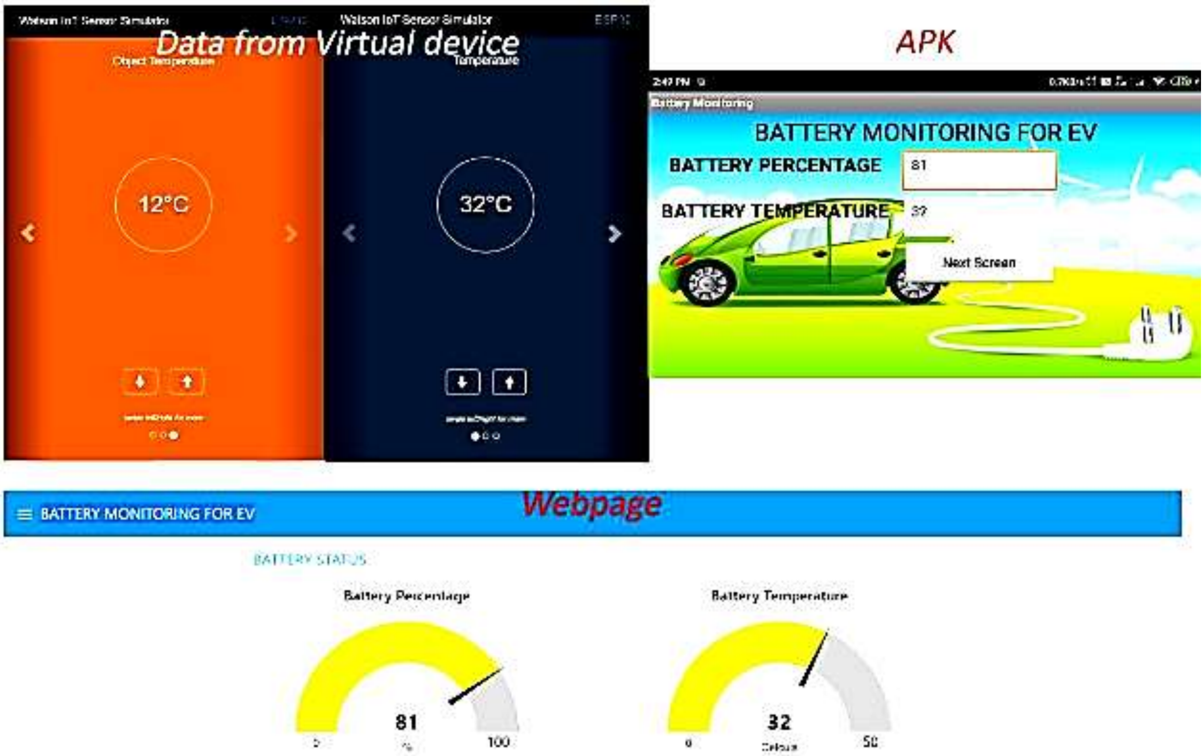

Fig. 13 Status of Battery in discharging mode in EV

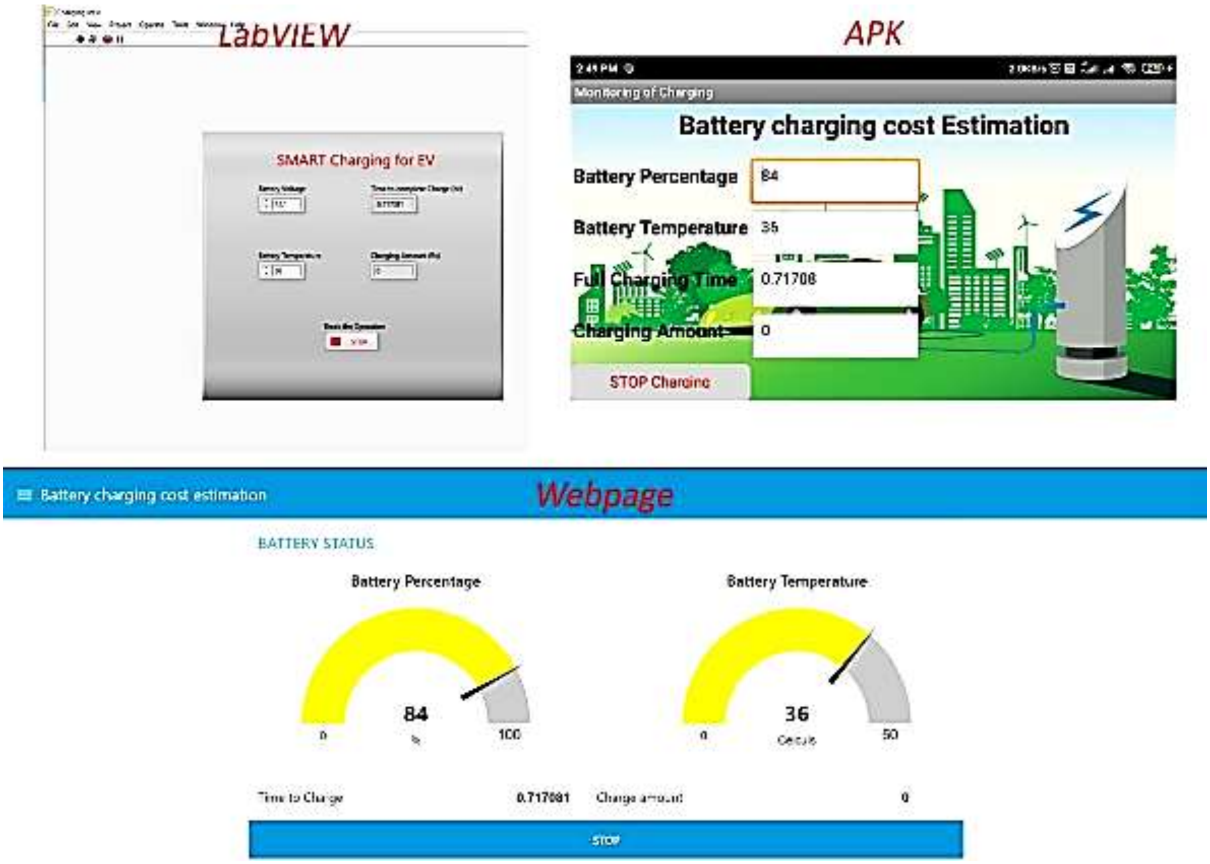

Fig. 14 Status of battery during charging

During the discharging mode of the battery in EV, the battery remining charge percentage and temperature has been noted and send to the user mobile through APK and webpage. The data from virtual device and received data in customer mobile both are verified successfully, as shown in Fig 13.

At the time of charger is connected to the battery, the battery charging time and cost estimation have been calculated using LabVIEW and the data has sent to the webpage and APK successfully. During the charging of a battery, the status of the battery like battery charging percentage, battery temperature, charging time and charging cost are displayed in Figure 14. The front panel window shows the battery voltage, temperature and these data are sent to the customer mobile app.

IV. Conclusion

Quick charging of Li-ion batteries is a difficult problem for EV producers in order to deploy the expansion of EVs. Fast charging causes the temperature within the cell to rapidly rise, reducing the battery's life. As a result, smart Li-ion battery charging has become a critical way for resolving issues in EV applications. This paper proposes to handle temperature rise control while charging the EV batteries using smart and fast charging approach i.e., multi stage constant current charging method. When temperature exceeds certain limit, the charging current has been reduced to control the temperature rise in the battery. Smart charging approach can be done with the help of IoT platform. Simulation have been implemented using the LabVIEW and Arduino. The battery status has been displayed to the user through the mobile app.

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