International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

# Microcontroller Based Li-Ion Battery Charger

**Maheysh Sharrma**

Department of Electronics, St. Francis De Sales College, Nagpur – 440006, India

**Abstract:**
Lithium-ion (Li-ion) batteries have emerged as a primary secondary power source for portable systems. Their notable advantage lies in their ability to be recharged numerous times before disposal, offering a clean energy source devoid of toxic elements. However, charging these batteries requires careful consideration. Fast charging or overcharging can elevate battery temperature, potentially leading to explosions and accidents. Various charging methods exist, but the Constant Current-Constant Voltage (CC-CV) approach stands out as particularly suitable for Li-ion batteries due to its ability to prevent critical overcharging. This paper introduces a Li-ion battery charger circuit leveraging an 89S52 microcontroller. The charger employs the CC-CV method to achieve a full charge for the battery.

**Keywords**: Battery Charger, CC-CV Charging, Li-ion Battery.

## Introduction

Three primary chemistries dominate the landscape of secondary batteries: Nickel Cadmium (NiCd), Nickel Metal Hydride (NiMH), and lithium-ion (Li-ion) batteries. However, NiCd and NiMH batteries fall short in meeting certain criteria due to their limited energy capacity, larger size, and environmental concerns. In contrast, Li-ion batteries boast high operating voltage, impressive energy and power density, minimal self-discharge, and the absence of memory effects [1].

This superiority has led to Li-ion batteries becoming the preferred choice for a vast array of portable electronics and, more recently, in the realm of electric and hybrid-electric vehicles [1-4]. Yet, charging Li-ion batteries demands a distinct approach to ensure that prescribed limits for current, voltage, temperature, power, and energy are never breached. Continuous monitoring during charging becomes essential to uphold safe boundaries for voltage and current levels.

## Li-Ion Battery Charging Methods

Numerous battery charging approaches have been suggested, including constant trickle (CTC), constant current (CC), constant voltage (CV), and constant-current constant-voltage (CC-CV) strategies. Given that the lifespan of Li-ion batteries can be significantly impacted by both undercharging and overcharging, the conventional choice for charging these batteries is the CC-CV method [2]. Another widely employed charging technique is the TPC charging method.

## Constant Current-Constant Voltage Charging Method

The CC-CV method stands out as the most prevalent and widely adopted approach for battery chemistries, especially those with an upper voltage limit, such as Li-Ion batteries. This method involves two distinct phases in the charging logic: an initial phase of constant current followed by a subsequent phase of constant voltage.

The charging process commences with a consistent current, typically set between 0.25C to 1.0C or below the limits specified by the battery manufacturer. During this phase, the cell voltage steadily increases over time. When the cell voltage reaches a specific threshold (usually around 4.2V for Li-Ion batteries), the second phase initiates—the voltage-controlled stage. Here, the charging current gradually decreases as the battery reaches its capacity [3, 4].

In the graphical representation below (Fig. 1), (a) illustrates the current profile, while (b) demonstrates the anticipated rise in cell voltage over time. Charging ceases when the current decreases to a predefined level, typically set between 3% to 10% of the current level used during the constant current charging phase [4, 5].

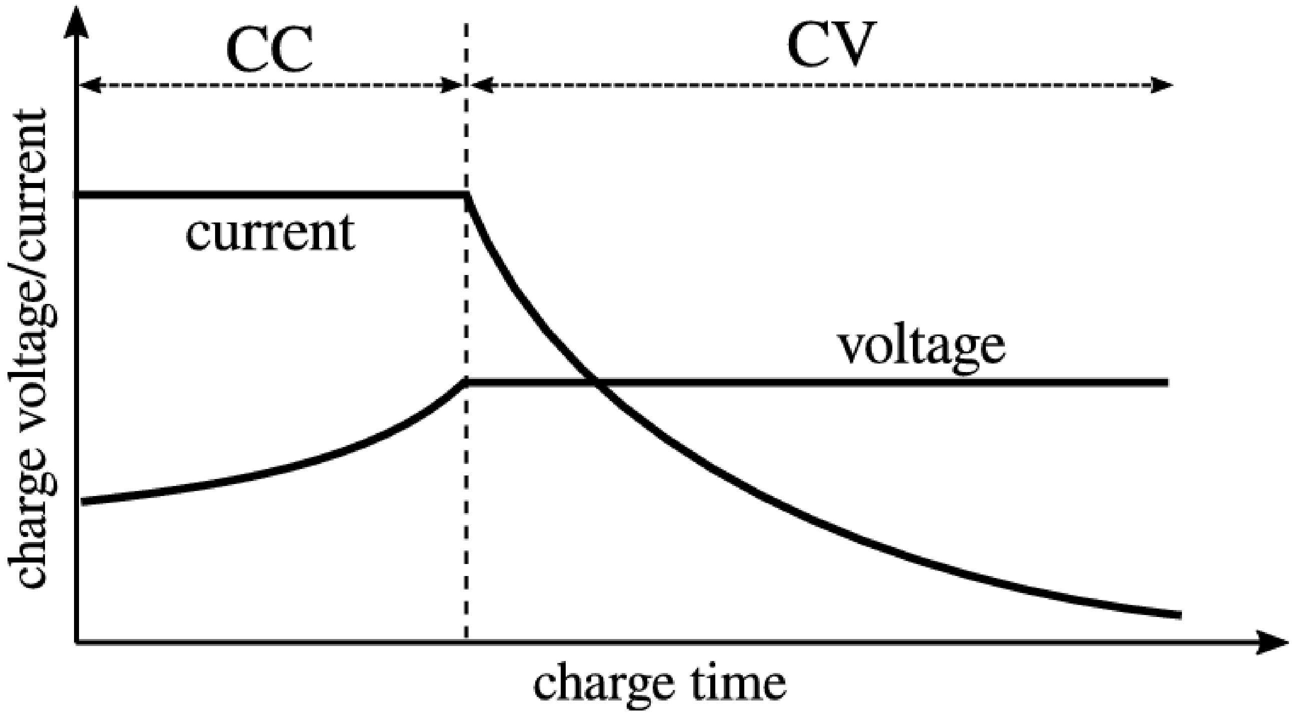


**Fig. 1 Current profile and cell voltage of CC – CV Charging**

**Time Pulsed Charging Method**

The Time Pulsed Charging (TPC) method is employed in various portable electronics within the industry, such as cell phones and music players. In this method, the current is delivered in pulses, interspersed with short intervals of zero current sent to the battery. This approach allows the battery cells to relax intermittently, extending the charging capacity by delaying the rapid rise in cell voltage compared to the CC-CV method.

Moreover, during the periods of zero current supplied to the battery, the readings of the battery cell voltage tend to be more precise. Consequently, the TPC method offers improved accuracy in monitoring cell voltage during the charging process.

Beyond these benefits, the TPC method also presents advantages at the cell's chemical level, contributing to its efficacy as a charging strategy.

**Hardware Setup**

**Block diagram**

Figure 2 illustrates a generalized block diagram of a battery charger unit [6], comprising key components: the user interface and controller, data acquisition unit, load, charger, and battery temperature measurement.

The user interface and controller serve as the interface for operators to input test specifications, manage test controls, and store test data. On the other hand, the data acquisition unit is responsible for gathering pertinent data and relaying it back to the user interface.

Monitoring battery temperature during charging becomes crucial, hence the inclusion of temperature measurement. This element aids in tracking and preventing excessive battery temperatures during the charging process.

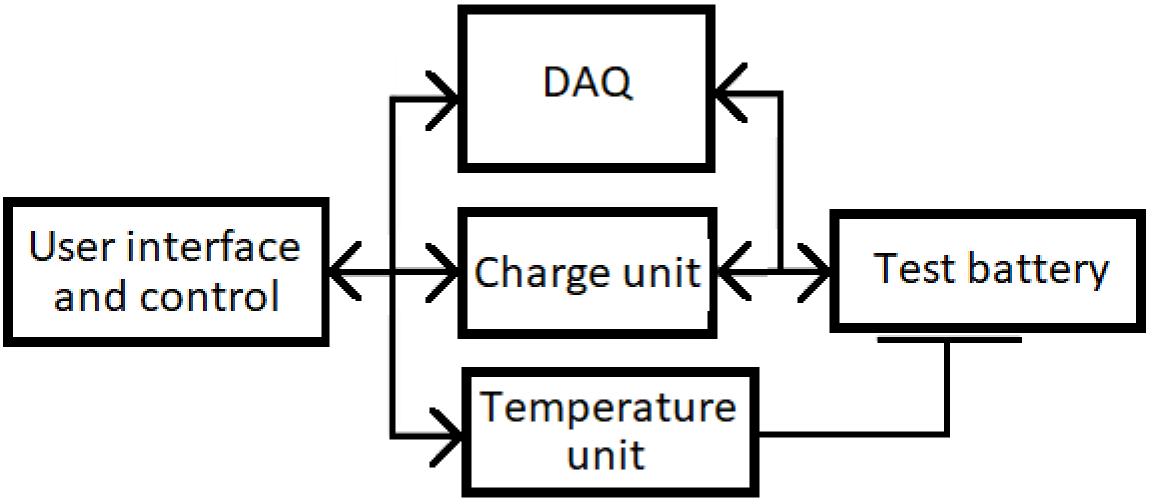


**Fig. 2 Block diagram of battery charge unit.**

**Microcontroller circuit**

The 89S52 microcontroller, known for its low power consumption and high 8-bit performance, includes four 8-bit ports, 16-bit timers, and a full-duplex UART. It plays a pivotal role in controlling the functions of the test system, managing components such as the ADC, DAC, charging circuit, battery temperature measurement circuit, and USB-to-serial interfacing circuit.

Tasked with executing commands received from the computer, the microcontroller oversees the entire test process and transmits the sampled data back to the computer. The software on the computer then analyses the battery's performance based on the data received.

The microcontroller communicates the ADC binary data, representing battery voltage and charging current measurements, while receiving instructions governing the charging process. This includes commands to start or stop the process, perform Open Circuit Voltage (OCV) measurements, set measurement ranges, and receive binary equivalents for charging current magnitudes, subsequently applied to the DAC.

Programming for the microcontroller is carried out in assembly language, given its role primarily in controlling peripheral devices.

Figure 3 displays the connection layout of the system devices to the microcontroller. Port 0 manages logic bits, facilitating control over various operations such as charging channel selection and range determination. The ADC and DAC are linked to the microcontroller through ports P1 and P3 respectively, while the connection to the computer occurs via the microcontroller's UART port.

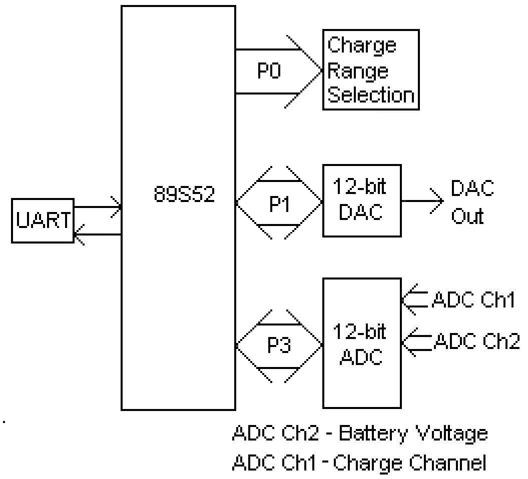


**Fig 3 Connection of system devices to microcontroller 89S52**

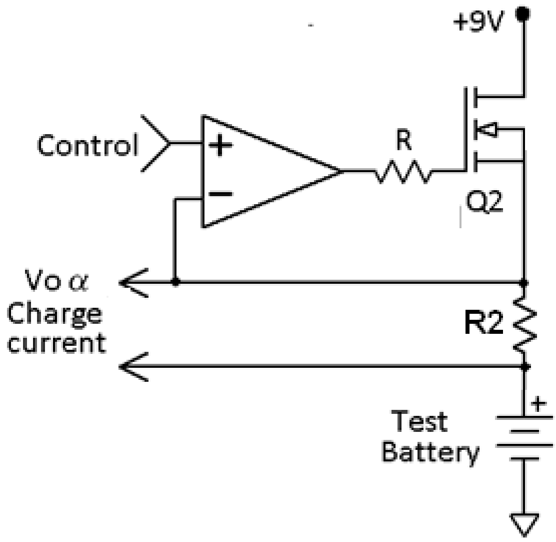


**Fig. 4 Schematic diagram of charging circuit**

**Software**

The test system's adaptability relies heavily on the control and data acquisition software. Developing a dedicated program tailored for test programming, equipment control, and efficient data storage and processing significantly simplifies the testing procedures [7].

The test system software is crafted using the Visual Basic (VB) programming language. Leveraging the Visual Basic programming environment not only facilitates the construction and modification of programs but also ensures robust support for user interfaces. Additionally, the software is designed to enable real-time graphical representation of battery data, providing visual displays for current and voltage measurements..

**System Implementation and Results**

Figure 5 displays the algorithm implemented for the CC-CV charging method applied to Li-Ion cells utilized in mobile phones. Initially, the battery undergoes charging at a consistent current of 500mA. Once the cell voltage reaches 4.15V, the constant current charging phase concludes, and the constant voltage charging phase commences. Charging persists until the current diminishes below 50mA, signalling the completion of the charging process. Figure 6 illustrates the graphical representation of the charging current and battery voltage evolution throughout the charging procedure.

## Conclusion

This paper introduces a system designed for charging Li-Ion batteries utilizing the CV-CC method. The software, developed in Visual Basic, includes graphical representations illustrating the dynamic changes in current and voltage over time throughout the charging procedure.

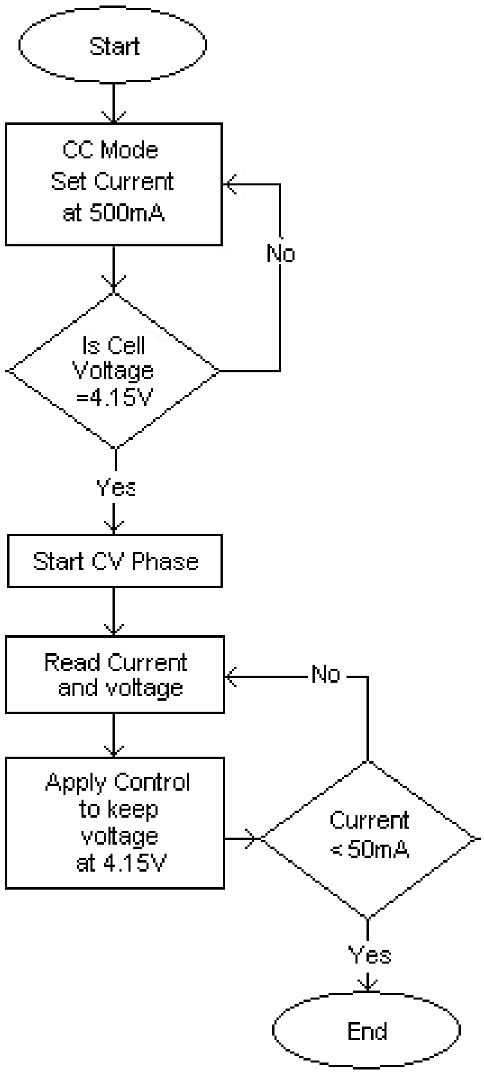


**Fig. 5 Flow diagram for CC-CV charging**

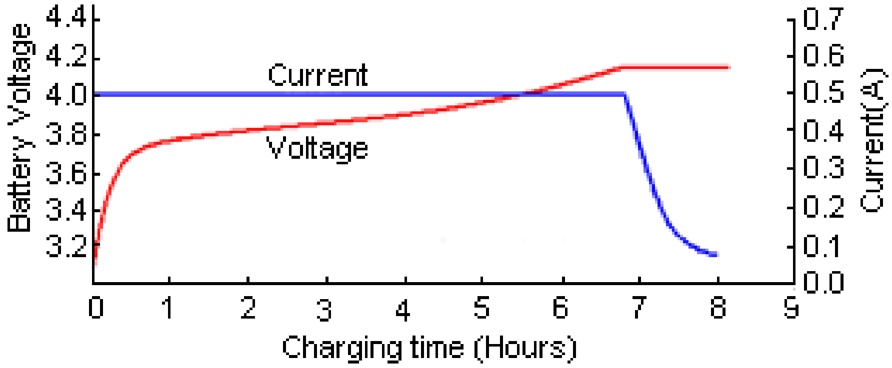


**Fig. 6 Charging current and battery voltage of Li-ion cell using CC-CV process**

## References


1. G Nagasubramanian, R.G Jungst, Energy and power characteristics of lithium-ion cells, Journal of Power Sources, Volume 72, Issue 2, 21 April 1998, Pages 189-193.
2. Carcone, J.A.;, "Performance of lithium-ion battery systems," WESCON/94. 'Idea/Microelectronics'. Conference Record vol., no., pp.242-248, 27-29 Sep 1994
3. Min Chen; Rincon-Mora, G.A.; , "Accurate, Compact, and Power-Efficient Li-Ion Battery Charger Circuit," Circuits and Systems II: Express Briefs, IEEE Transactions on , vol.53, no.11, pp.1180- 1184, Nov. 2006
4. P. David and D. Stefano, “Survey of lithium-ionbattery performance for potential use in NASA mission,” in Proc. the 32nd Intersociety Energy Conversion Eng. Conf, Honolulu, Hawaii, July 1997, pp. 39-41.
5. Guan-Chyun Hsieh; Liang-Rui Chen; Kuo- Shun Huang; , "Fuzzy-controlled active state-of-charge controller for fasting the charging behavior of Li-ion battery," Industrial Electronics Society, 1999. IECON '99 Proceedings. The 25th Annual Conference of the IEEE , vol.1, no., pp.400- 405 vol.1, 1999
6. P.E. Pascoe, A.H. Anbuky / Measurement 34 (2003) 325–345]
7. Niu Xiamu, Sun Shenghe “Research on General Software Architecture of Automatic Measurement System”. ZEEE International Workshop on Emerging Technologies EMTECH 99.]