International Journal of Electrical and Electronics Research ISSN 2348-6988 (online)
Vol. 7, Issue 3, pp: (10-15), Month: July - September 2019, Available at: www.researchpublish.com

Lithium-İon battery charging and discharging monitoring system (BMS) based on Stm32

[1]VALA MÜANDIS, [2]Dr.Öğr.Üyesi .BAYRAM AKDEMIR

[1,2]Konya Teknik University,Electric and Electronic Engineering,Konya,Turkey

Abstract: **A simple microcontroller (MCU) firmware code will be implemented via Nucleo Stm32f103Rb can provide low-cost, intelligent real-time monitoring battery charging system.Linear battery charger and an 8-bit integrated Analogue-to-Digital Converter (ADC), can accurately measure voltage as well as tracking the battery's remaining and used charge. The inherent flexibility of the scheme allows users to make trade-offs which can adapt the methods used for measurement, and the components, to suit different battery technologies and system configurations.**

Keywords: **Battery Charging, Nucleo, Charging Performance.**

I. INTRODUCTION

This paper presents a battery charging controller based stm32 microcontroller which contains a supportive platform communication to take the continues reading for the value of the charging voltage. The Li-İon battery is been chosen for charging and discharging of series, shunt charge controller due to its features. An ADC can be used for measuring battery voltage. This approach provides flexible solutions and enables battery charger to be managed more intelligently, with high accuracy. Some simple applications only need to track the voltage change, which requires the least budget and resources. On the contrary, some applications need more sophisticated fuel-gauging functions. This paper discusses a battery charge management using a stand-alone integrated ADC using Stm32 Nucleo board and its software paltforms.

2. REVIEW OF BATTERY CHARGING AND DISCHARGING CHARACTERISTICS

Battery discharging behavior varies with parameters such as battery chemistry, load current, temperature and aging. Figure 1 shows the battery discharging curves of various battery chemistries. The battery discharging curve for typical batteries is almost flat until it reaches about 80% of its full range. After this point, the curve falls sharply [1]

The battery's internal chemical reaction is mostly governed by voltage and temperature. The low temperature limit is determined by the freezing temperate of the electrolyte. Most batteries do not work below -40°C. Batteries perform better at higher temperatures because the chemical reaction processing is accelerated at higher temperatures. However, the rate of unwanted chemical reactions increases and results in acceleration of battery life. At extremely high temperatures, the active chemicals can break down and destroy the battery [1]

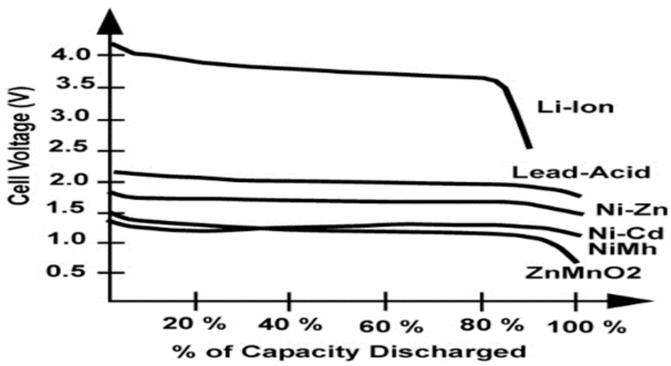


Figure 1: Battery Discharge Characteristics [1]

Figure 2 shows the battery discharging curve over temperature. As shown in Figures 1 and 2, true battery charge management requires the monitoring of current, voltage and temperature. However, for simplicity, temperature is not monitored in this paper.

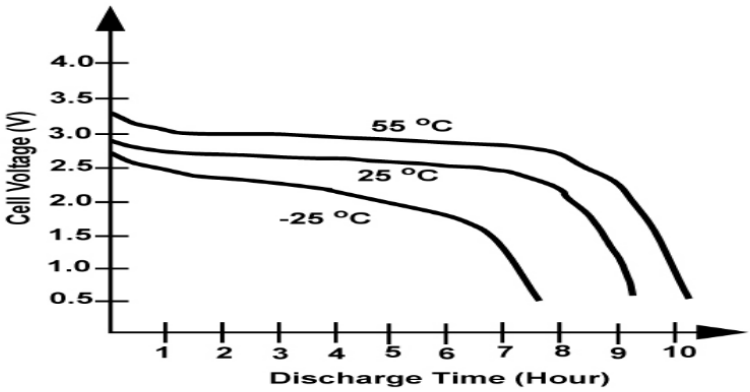


Figure 2: Li-Ion Battery Discharge Characteristics vs. Temperature [1]

3. MATERIAL AND METHOD

In this work, we mainly focused to implement series, and combined series and shunt controller. To develop this charge controller we considered that using the Stm32-Nucleo board will be used as a data acquisition system to implement the exact reading for the battery voltage during charging and discharging operations. Measuring voltage of the charging source, ups and other daily use batteries consumes a lot of time. Grabbing multimeter, opening the battery boxes and touching both the multimeter leads to terminals of battery takes some effort. That's Stm32 Nucleo board will be represent a system through which we can see the status of the battery on PC directly. The STM32 Nucleo board is a low-cost and easy-to-use development platform used to quickly evaluate and start a development with an STM32 microcontroller in LQFP64 package. The Nucleo Stm32f103Rb boards provide an affordable and flexible way for users to try out new concepts and build prototypes by choosing from the various combinations of performance and power consumption features, provided by the STM32 microcontroller. The following (Figure 3) pins map belong to the used board.

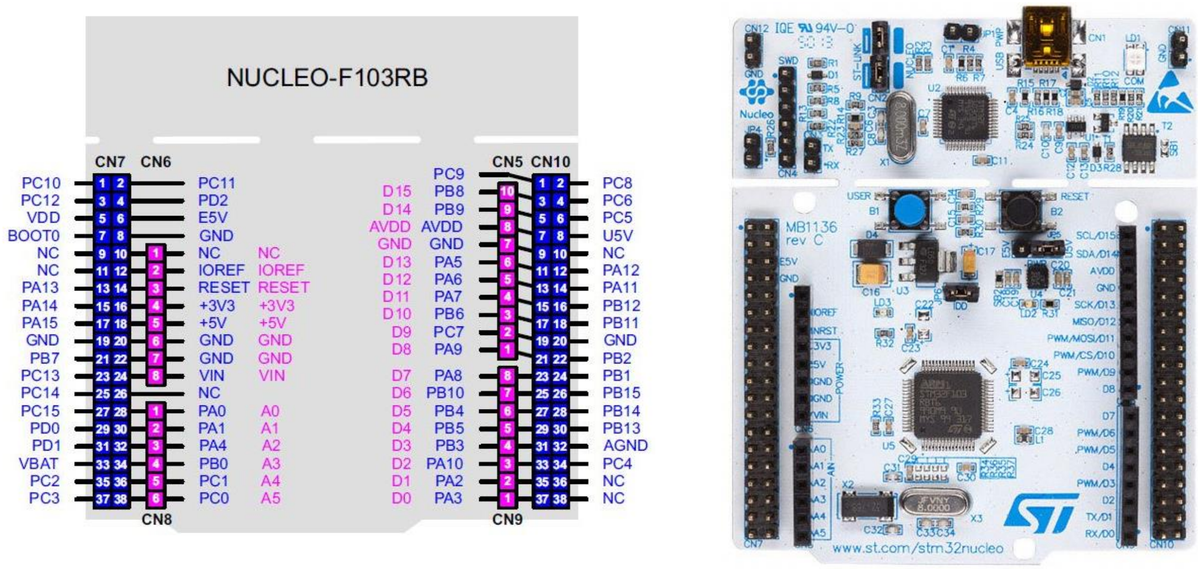


Figure 3: Nucleo Stm32F103Rb Pins map

Since we are going to develop a system which can monitor battery status and update us on our browser. We need some circuit/device/controller which can effectively measure voltage. A serial interface device which can connect to PC, takes voltage reading from controller and updates the end user about the current battery level. Battery monitoring circuit is a traditional voltage divider circuit. 12 volt batteries will be measured. Circuit can be modified to measure 24 volt batteries and even more 48 volts parallel battery cluster.

4. BATTERY VOLTAGE MANAGEMENT USING ADC

Figure 4 shows examples of battery voltage measurement using an ADC. A single ended input is connected to the battery voltage. In Figure 4(a), R1 and R2 are used as voltage dividers to limit the input voltage to less than the ADC's reference voltage [1]. The voltage divider modifies the ADC input voltage as follows:

$$V_{IN} = \text{Battery Voltage} \bullet \frac{R2}{(R1+R2)}$$

The total series resistance (R1 + R2) of the voltage divider is chosen at about 1 Mega Ohm (MΩ), so that the current leakage due to the voltage divider is negligible. Since the input is artificially scaled down by the voltage divider, the measured battery voltage must be calculated by multiplying the inverse factor of the voltage divider ratio to the ADC output codes.

$$V_{Measured} = \text{ADC Output Codes} \bullet LSB \bullet \frac{(R1+R2)}{R2} \bullet \frac{1}{PGA}$$

$$LSB = \frac{\text{Reference Voltage}}{2^{N-1}}$$

Figure 4(b) can be used if the battery voltage range is less than the ADC's reference voltage. The battery voltage can be directly connected to the ADC input pin without the voltage divider.

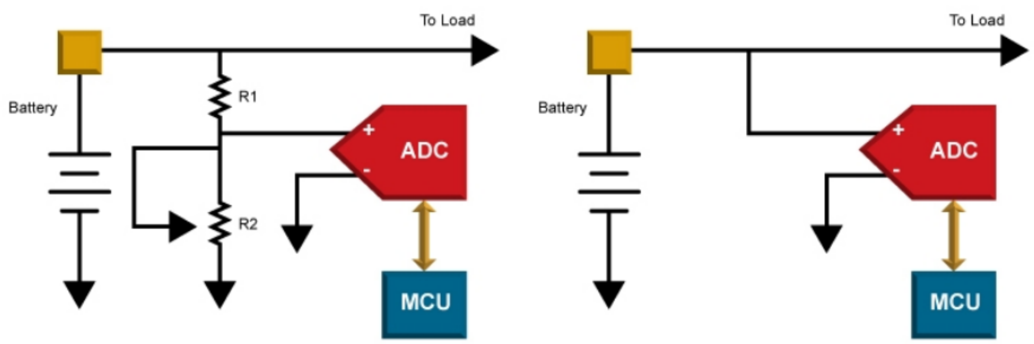


Figure 4: Circuit Diagrams for Measuring Battery Voltage Using an ADC [2]

4.1. Voltage divider working and calculations

Nucleo is a tiny device, it works on 3.3 volts. Since it is working on 3.3 volts its pins can source and sunk 3.3 volts only. Voltage greater than 5 volt may blow the pin or fry the nucleo. In our case we want to measure 12 volt battery and nucleo adc(analog to digital channel) can only accept 3.3 volts. What we will do is divide the voltage between two resistors and measure only voltage across one resistor and remaining resistor voltage will be calculated mathematically. Typical voltage divider circuit and formula is given below.

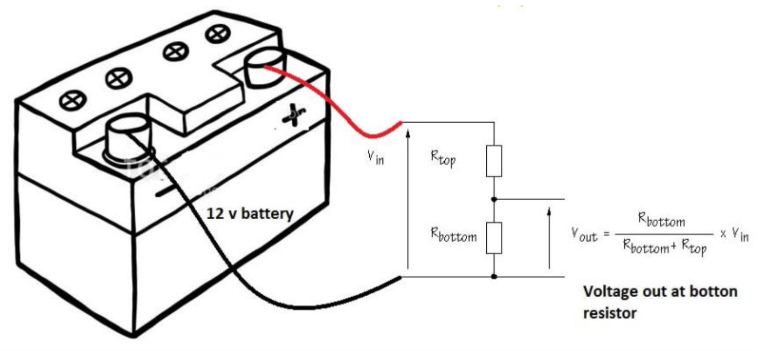


Figure 5: Simple Voltage Divider

Low ohm resistors can sunk much current and wires could be heated instantly. Consequently wires can melt down in seconds. So always use sufficient amount of resistors for bigger ampere hour batteries. I selected one resistor Rbottom to be 10k ohm. During charging battery voltage can increase to 18 volts. Charge controller also output voltage approximately equal to 15 volts to charge the batteries.

4.2. Formula Calculation

To measure voltage across Rbottom, we gave its value randomly to be 10k ohm. We know Vout can be up to maximum 3.3 volts since nucleo works and accepts maximum 3.3 volts at its I/O pins. Vin is 18 volts when the battery is charging. Now we can find Rtop.

$$Vout = Vin\frac{Rbottom}{Rbottom + Rtop}$$

$$3.3v = 18v\frac{10k}{10k + Rtop}$$

$$10k + Rtop = \frac{180k}{3.3v}$$

$$Rtop = 54.54 - 10k$$

$$Rtop = 44.54k$$

If 18 volts are at battery side it will be divided across resistors, 3.3 volts drops at 10k resistor and remaining 14.7 volts drops at 44.54 k resistor. 44.54 k ohm resistor is not available in market therefore we will use the one above this rating which is 47 k ohm resistor.

$$Vrbottom = Vin\frac{Rbottom}{Rbottom + Rtop}$$

$$Vrbottom = 12v\frac{10k}{47k + 10k}$$

$$Vrbottom = \frac{120k}{57k}$$

$$Vrbottom = 2.1 \text{ volts drops at Rbottom}$$

$$Vrtop = 12 - 2.1 = 9.9 \text{ volts drops at Rtop}$$

Two cases are given above when source is at 18 volt and when source is at 12 volt in both the cases the ratio comes out to be constant value. This ratio is utilized in code for predicting the actual source/battery voltage. Ratio is multiplied with voltage at Rbottom for actual voltage value. Project circuit diagram is given below. ADC0 channel have been used of nucleo board to measure the battery voltage. Both the battery and nucleo power must be grounded together in order to complete the circuit. Its a most common mistake will measuring the voltage that both grounds are not grounded together. If the nodemcu ground is not taped with the battery ground the adc0 pin will become a floating pin and it starts reading floating values.

The range of voltages obtainedat Vout will be between 0V and whatever logic high is for the microcontroller.Then all that is needed is to connect the Vout portion of the voltage divider circuit to the ADC pin on the microcontroller, and to do some calculations.

Now its a hard task to accomplish. But still their are some cleaver ways to do so. In this post i am going to enlist some of the ways through which we can measure individual battery voltage which is a part of series or parallel connected string/array of batteries.

ADC will convert the input voltage to a value between 0 and 1023, a fully charged 12V battery should be near the 1024 value, and this value will decrease as the battery discharges.If a 5V reference is used, then the lowest value that the ADC should see would be 847, because that would be 10.5V, which is the lowest the battery should go before serious damage could occur.Mapping this 847 to 1023 rangeto a percent scale results in a charge scale that can be used to determine the life left in a battery.

4.3. Why Voltage divider ?

Microcontrollers work on 5 or 3.3 volts. So their pins are also working on 5 volt TTL logic. Voltage higher than 5 volts could potentially harm the pin or may fry the microcontroller. Solar panel, car, ups, generator and back up batteries normally are at 12 volts. Microcontroller can not measure 12 volts directly. So voltage divider is used here to divide the voltage in two half while ensuring that the one half voltage can not increase 5 volts in any scenario(charging etc). This half voltage is feed to microcontroller to measure the voltage.

4.4. Batteries connected in series

Batteries are connected in series to increase the voltage output. For example two 12 volt batteries are connected in series to build up 24 volts. Now how to measure voltage of individual batteries connected in series. See the circuit below. Four 12 volt batteries are connected in series to output 48 volts.

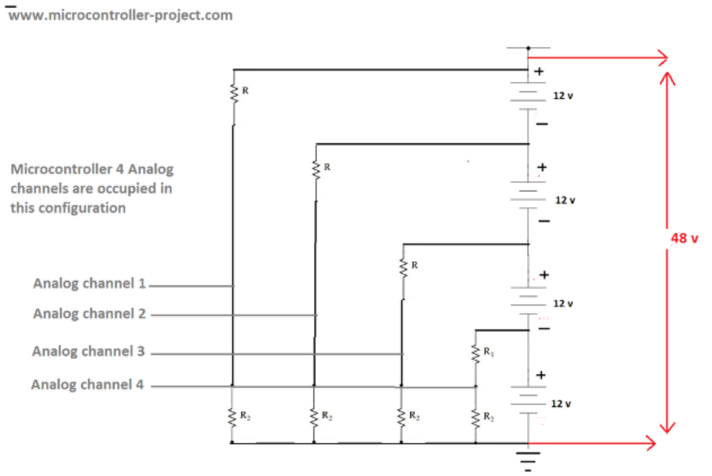
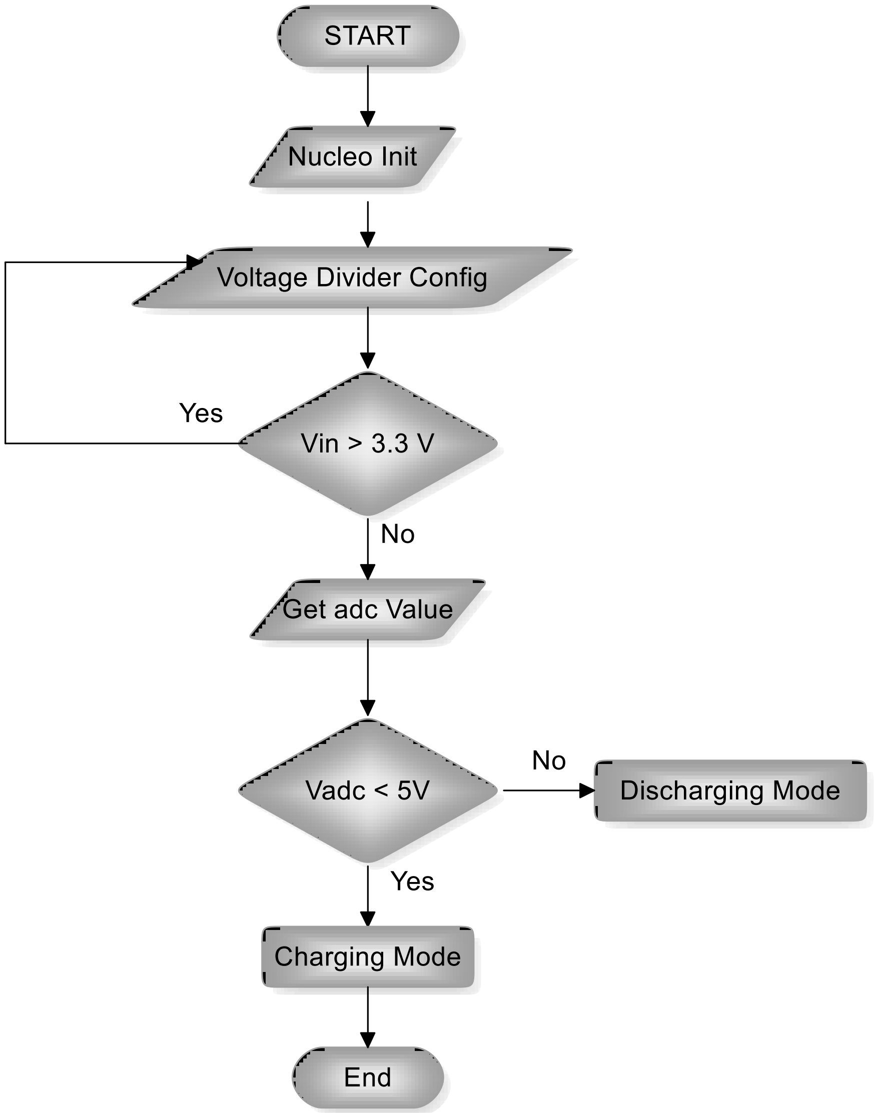


Figure 6: Simple Voltage Divider

In the above circuit four voltage divider circuits are used to measure voltage across each battery. The technique is to measure the voltage across high potential battery first, than against the lower ones and negating the subsequent batteries voltage from the one at higher potential. Other batteries voltages can be calculated with same method. In the above scenario for each battery their must be a dedicated analog channel. For higher string of batteries more analog channels are required and microcontrollers usually have 8 analog channels at max. So this method is feasible only when batteries in series combination are not greater than 4.

5. CONCLUSION

The Nucleo Stm32f103Rb board is a good fit for a Li-ion battery charger solution, because of integrated peripherals like the high-resolution ADC and watch dog timer. The implemented application for this paper has been tested using STMStudio in the real time (charge-discharge) tracking for real Li-ion battery acoording to the following simple algorithm:



REFERENCES

[1] MCP3421 Data Sheet, “18-bit ADC with I2CTM Interface and On-Board Reference,” DS22003, Microchip Technology Inc., 2007.

[2] MCP3422/3/4 Data Sheet, “18-bit, Multi-Channel ((Analog-to-Digital Converter with I2CTM Interface and On-Board Reference,” DS22088, Microchip Technology Inc., 2008.

[3] MCP73831/2 Data Sheet, “Miniature Single-Cell, Fully Integrated Li-Ion, Li-Polymer Charger Management Controllers,” DS21984, Microchip Technology Inc., 2008.

[4] Microchip Application Note # AN1156, “Battery Fuel Measurement Using Delta-Sigma ADC Devices,” by Youbok Lee, DS01156A, 2008.