Application Report
SLVA806–August 2016

Fast Charge Improvements Using the bq25120 Adjustable VBATREG, Charge Current, TS, and Status Indicators

Steve Schnier *Battery Management Solutions*

ABSTRACT

Most wearable devices are meant to be worn at all times, taking data when the user is awake and asleep. In order to do that, the time between charging must be maximized and the time spent charging must be minimized. The low Iq BQ25120 provides several features to extend the life of the product when in use. The device also has several features that can be used during charging to reduce the time spent charging. This paper describes how to use the BQ25120 features such as adjustable VBATREG, adjustable fast charge current, TS (NTC monitor), and status indicators to get the most charge in the smallest amount of time.

1 Basics of Charge (CC-CV)

Like most chargers, the bq25120 supports multiple battery chemistries for single-cell applications. Charging is done through the internal battery MOSFET, and there are several loops that influence the charge current: constant current loop (CC), constant voltage loop (CV), input current limit, VDPPM, and VIN(DPM). During the charging process, all loops are enabled and the one that is dominant takes control. The charge current is regulated to ICHARGE until the voltage between BAT and GND reaches the regulation voltage. The voltage between BAT and GND is regulated to VBATREG (DV Mode) while the charge current naturally tapers down. When termination is enabled, the device monitos the charging current during the CV mode, and once the charge current tapers down to the termination threshold, ITERM, and the battery voltage is above the recharge threshold, the device terminates charge, and turns off the battery charging FET. A standard charging cycle is show in Figure 4.

The bq5120 has several features that can reduce the time spent in the CC phase and get more energy into the battery in a shorter amount of time.

2 Improved Fast Charge using the bq25120

The bq25120 has an I2C interface that allows the host to change charging parameters and monitor status during charging. Using these features can reduce the time spent in the CC phase.

The device implements a simple voltage battery monitor which is normally used to determine the depth of discharge. However, it can also be used to monitor the battery voltage during charge. The VBMON function is equivalent to a 5-bit ADC, so it is not very accurate. However, for the improved fast charge implementation, it is good enough for the purpose.

Additionally, the device has the ability to adjust the battery regulation voltage with the VBATREG parameter in the customer registers. The VBATREG is adjustable from 3.6 V up to 4.65 V in 50-mV steps. This enables the ability to change the CV voltage dynamically during charging. When using a 4.35-V end charge voltage battery at a faster charge rate, to avoid degrading the battery, a lower battery voltage should be used for the faster charge rate, in this case 4.2 V could be used. Consult with your battery vendor to determine the right fast charge profile for the battery in your application.

The device also allows dynamically changing the fast charge current. To reduce the charge time, it is possible to increase the charge rate when in the CC stage, and then reduce the charge current for the final CC stage when the VBATREG is also adjusted to the recommended final voltage, in this example it is 4.35 V.

The improved fast charge flow chart is shown in Figure 1.

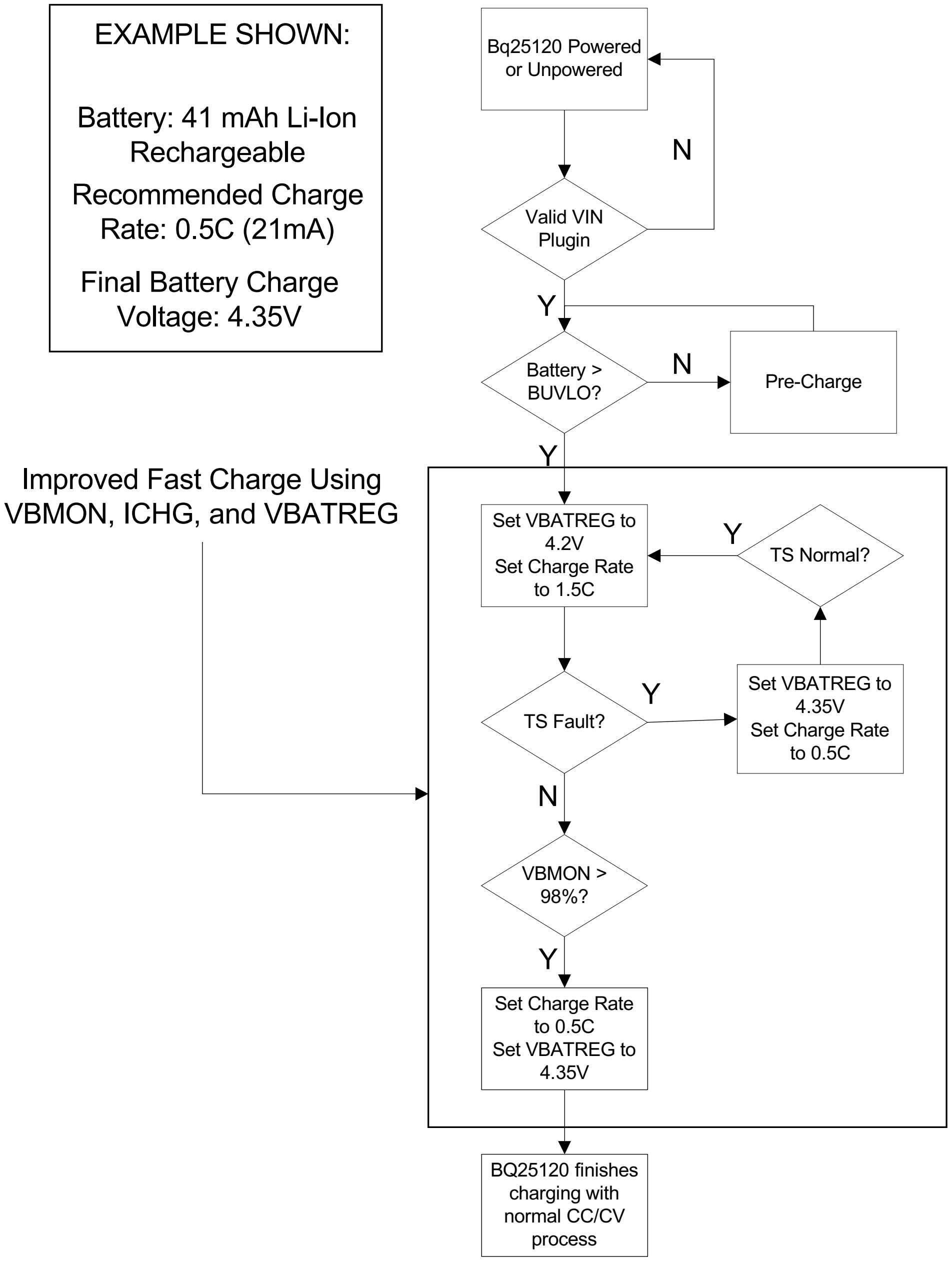

Figure 1. Improved Fast Charge Flow Chart Using the bq25120 Features

The flow chart in Figure 1 was implemented with a battery and a simple host, in this case an MSP430. The same battery was used with the recommended 0.5C charge rate for comparison.

Comparing the normal fast charge cycle with the improved fast charge cycle, one can see that the improved fast charge cycle reached termination at 150 minutes (2 ½ hours), where the normal fast charge reached termination at 190 minutes (over 3 hours).

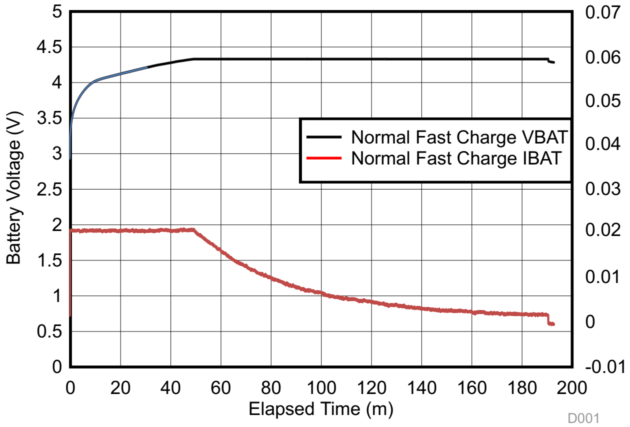

Figure 2. Normal Fast Charge Cycle

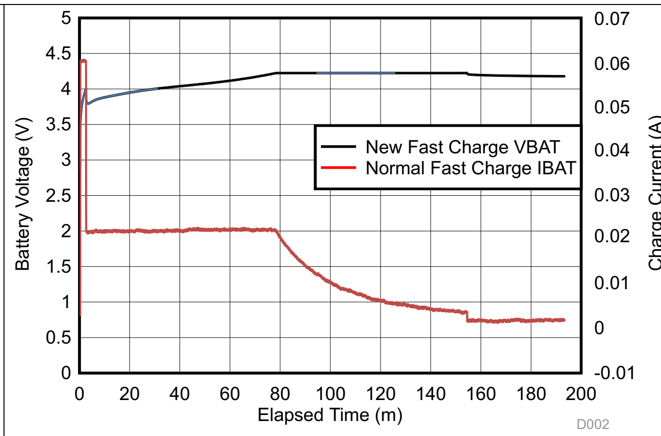

Figure 3. Improved Fast Charge Cycle

Additionally, by plotting the Coulombs entered into the battery during the same time, in this case 30 minutes, it is obvious that more energy was delivered to the battery when the improved fast charge method was used. This is a scenario where a user only charges the battery for a short amount of time each day, such as when they are in the shower. In 30 minutes, 46 Coulombs were delivered to the battery with the improved fast charge method, versus 37 Coulombs with the normal fast charge method. This is 20% more energy delivered to the battery in the same time.

The results show the potential to reduce the charging time for a full charge. Alternately, they show how to increase the amount of energy delivered to the battery in the same charging time. The bq25120 has additional features that can be used for other improved fast charge methods. Be sure to work with your battery vendor to determine a safe improved fast charge method for the battery in your system.

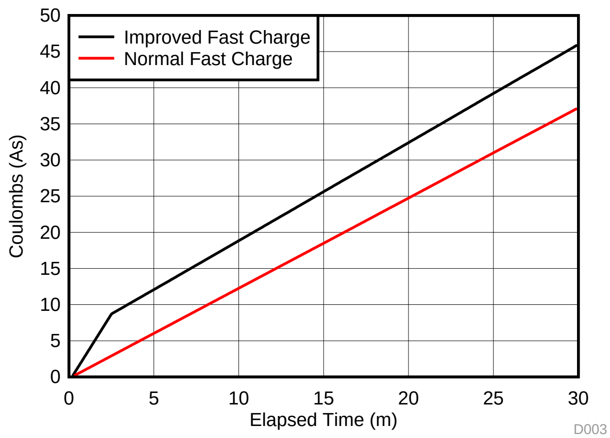

Figure 4. Comparison of Standard vs Improved Fast Charging

3 References

1. *bq25120 700-nA Low IQ Highly Integrated Battery Charge Management Solution*, SLUSBZ9
2. *Challenges and Solutions in Battery Fuel Gauging*, SLYP086

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265