

Simple MPPT-Based Lead Acid Charger Using bq2031

Lokesh Ghulyani and Ankur Verma

PMP - BMS Battery Charge

ABSTRACT

This application report is intended for users designing an MPPT-based lead acid battery charger with the bq2031 battery charger. This report contains a design for charging a 12-A-hr lead acid battery using MPPT (maximum power point tracking) for maximizing charging efficiency for solar applications.

Contents

1	Introduction	1
2	I-V Characteristics of Solar Panel	2
3	bq2031-Based MPPT Charger	3
4	Other Implementations	4

List of Figures

1	I-V Characteristics of Solar Panel	2
2	Variation of I-V Characteristics With Sunlight	2
3	Schematic of MPPT-Based Charger Using bq2031	3

List of Tables

1	Input Voltage Regulation by External Loop	3
---	---	---

Trademarks

All trademarks are the property of their respective owners.

1 Introduction

The simplest method of charging a battery from a solar panel is to connect the battery directly to the panel, but this is not the most efficient method. Suppose the panel has a rating of 75 W and produces a current of 4.65 A with a voltage of 16 V at standard test conditions of 25°C temperature and 1000 W/m² of insolation. The lead acid battery has a voltage of 12 V; directly connecting the panel to this battery reduces the panel voltage to 12 V and only 55.8 W (12 V and 4.65 A) can be extracted from the panel for charging. A DC-DC converter is required for efficient charging. This application report describes a design using the bq2031 for efficient charging.

2 I-V Characteristics of Solar Panel

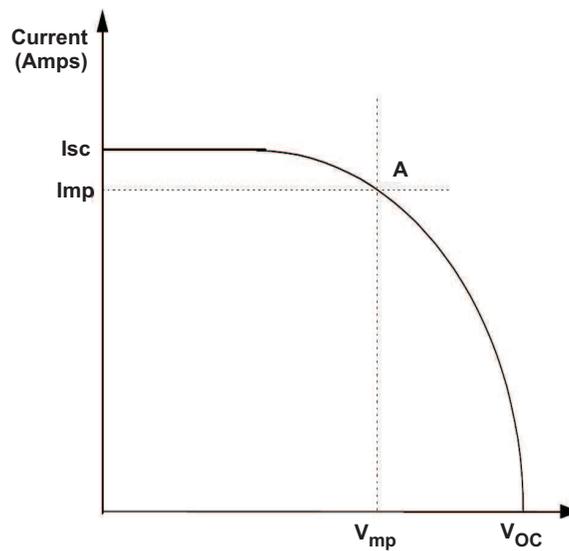


Figure 1. I-V Characteristics of Solar Panel

Figure 1 shows the typical characteristics of a solar panel. I_{sc} is a short-circuit current that flows through the panel when the panel is short circuited. It is the maximum current that can be obtained from the panel. V_{oc} is the open-circuit voltage at the terminals of the panel. V_{mp} and I_{mp} are the voltage and current values at which maximum power can be obtained from the panel. As the sunlight reduces the maximum current (I_{sc}) which can be obtained, the maximum current from the panel also reduces. Figure 2 shows variation of I-V characteristics with sunlight. The blue curve connects the points of the maximum power at different values of insolation.

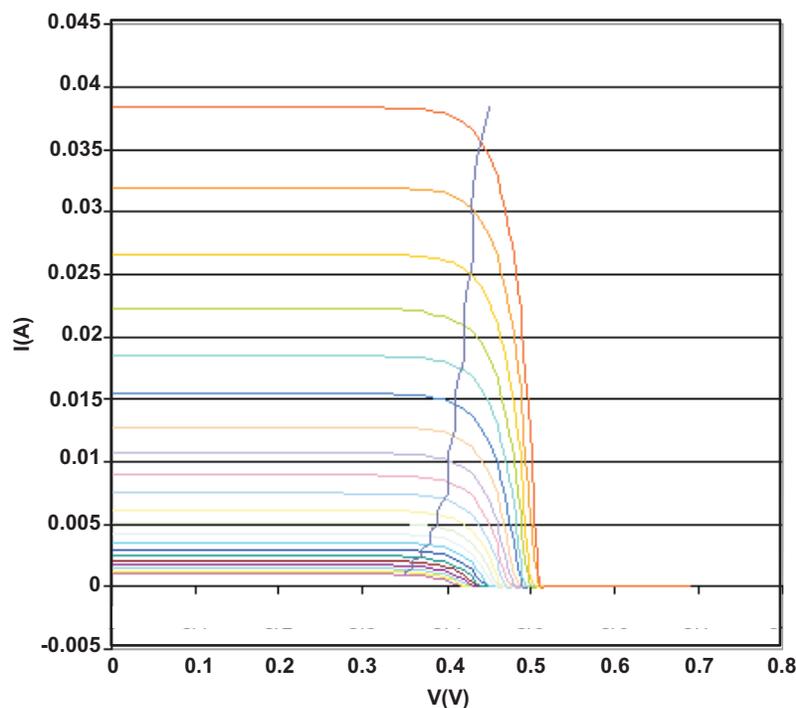


Figure 2. Variation of I-V Characteristics With Sunlight

The purpose of the MPPT circuit is to maintain the operating point of the panel at the maximum power point in different sunlight conditions. As seen from Figure 2, the voltage at which maximum power is transferred does not change very much with sunlight. The circuit designed with the bq2031 uses this property to implement MPPT. An extra current control loop is added to reduce the charge current as the sunlight reduces and to maintain panel voltage around the maximum power point voltage.

3 bq2031-Based MPPT Charger

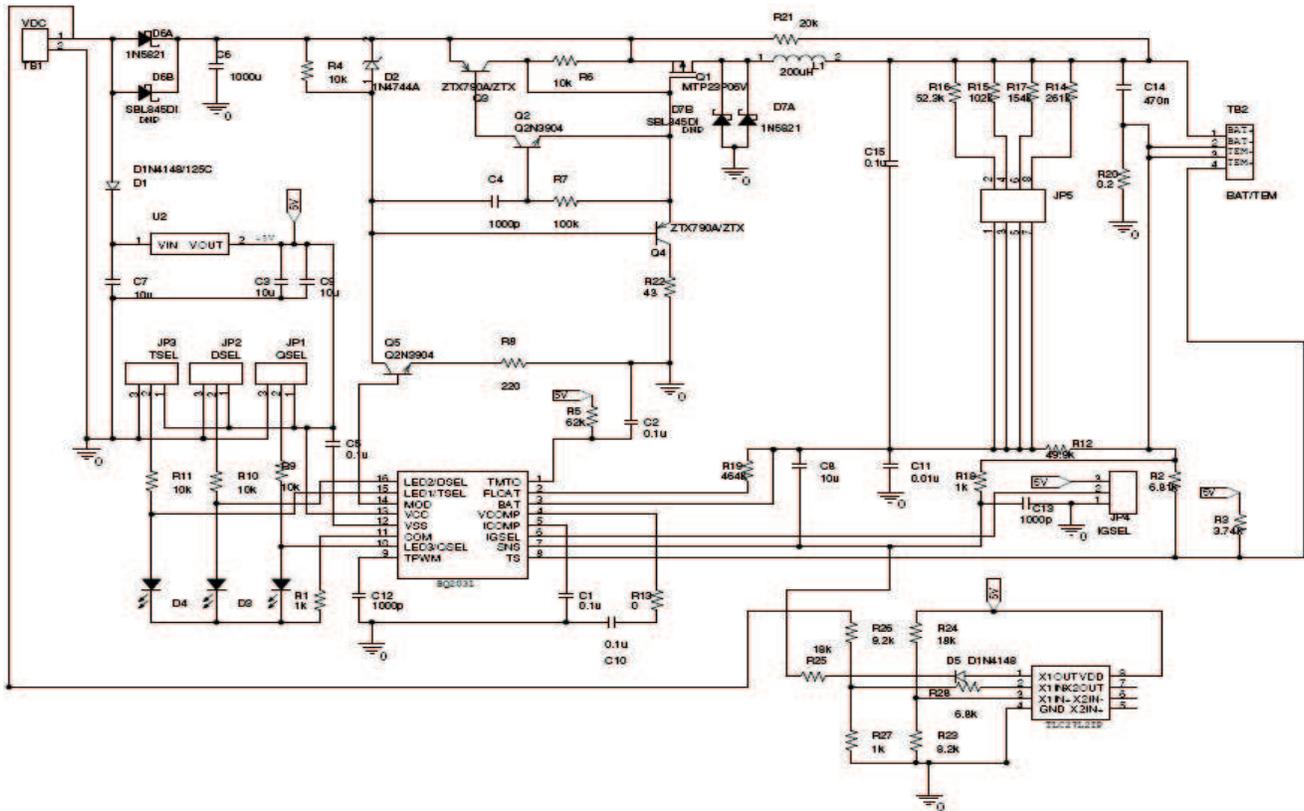


Figure 3. Schematic of MPPT-Based Charger Using bq2031

Figure 3 shows the schematic of a DV2031S2 board with an extra current control loop added to implement the MPPT using the operational amplifier TLC27L2. The bq2031 maintains the charging current by maintaining a voltage of 250 mV at sense resistance R₂₀. A reference voltage of 1.565 V is generated using 5 V from U2. The input voltage is compared with the reference voltage to generate an error voltage which is applied at the SNS pin of bq2031 to reduce the charge current. The voltage (V_{mp}) at which maximum power can be obtained from the panel is programmed using resistors R₂₆ and R₂₇. $V_{mp} = 1.565(R_{26}+R_{27})/R_{27}$. With R₂₇ = 1 kΩ and R₂₆ = 9.2 kΩ, V_{mp} = 16 V is obtained. TLC27L2 is internally compensated with a bandwidth of 6 kHz at V_{dd} = 5 V. Because the bandwidth of TLC27L2 is much less than the switching frequency of bq2031, the extra current control loop remains stable.

Table 1. Input Voltage Regulation by External Loop

S. NO.	V _{IN} - INPUT VOLTAGE (V)	INPUT CURRENT LIMIT IMPOSED BY SOLAR PANEL (A)	V _{OUT} - CHARGING VOLTAGE (V)	I _{OUT} - CHARGING CURRENT (A)
1	18.00	1.5	13.00	1.06
2	16.14	0.95	12.97	0.94
3	16.13	0.80	12.92	0.788
4	16.11	0.70	12.88	0.692
5	16.10	0.60	12.84	0.588

Table 1. Input Voltage Regulation by External Loop (continued)

S. NO.	V _{IN} - INPUT VOLTAGE (V)	INPUT CURRENT LIMIT IMPOSED BY SOLAR PANEL (A)	V _{OUT} - CHARGING VOLTAGE (V)	I _{OUT} - CHARGING CURRENT (A)
6	16.10	0.50	12.80	0.484
7	16.11	0.40	12.76	0.392

The bq2031 in the preceding circuit (see [Figure 3](#)) provides a maximum current of 1 A. If the solar panel can provide enough power to charge the battery at 1 A, the external control loop does not come into action. But if the insolation decreases and the solar panel is unable to provide enough power to charge the battery at 1 A, the external control loop reduces the charge current to maintain input voltage at V_{mp}. The results shown in [Table 1](#) verify the working of the circuit. The voltage readings in bold type represent the condition when the external control loop is reducing the charge current to maintain input at V_{mp}.

4 Other Implementations

Complexity of the Solar MPPT algorithm depends upon the algorithm used— popular ones are Perturb and Observe (P&O), and Incremental conductance. P&O modifies the operating voltage or current of the PV panel until maximum power is obtained. Easy to implement, the only disadvantage of the P&O method is that it oscillates around a maximum power value even under steady-state illumination. Another popular method- Incremental conductance- can determine the MPP/ without oscillating around this point. It can compute the MPP with higher accuracy than the P&O method under rapidly varying radiation condition. The only drawback is higher complexity and more time taken to compute the MPP. Besides the bq2031 mentioned in this application report, Texas Instruments also has dedicated programmable MPPT controllers for PV panels such as the [SM72442](#) and [BQ24650](#). For high-end applications, C2000-based MPPT kits can serve as excellent starting points.

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from A Revision (April 2014) to B Revision Page

- Added *Other Implementations* section 4
-

Changes from Original (December 2009) to A Revision Page

- Changed spelling of insulation..... 4
-

IMPORTANT NOTICE FOR TI DESIGN INFORMATION AND RESOURCES

Texas Instruments Incorporated ("TI") technical, application or other design advice, services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using any particular TI Resource in any way, you (individually or, if you are acting on behalf of a company, your company) agree to use it solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources.

You understand and agree that you remain responsible for using your independent analysis, evaluation and judgment in designing your applications and that you have full and exclusive responsibility to assure the safety of your applications and compliance of your applications (and of all TI products used in or for your applications) with all applicable regulations, laws and other applicable requirements. You represent that, with respect to your applications, you have all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. You agree that prior to using or distributing any applications that include TI products, you will thoroughly test such applications and the functionality of such TI products as used in such applications. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

You are authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources 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.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING TI RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY YOU AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

You agree to fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of your non-compliance with the terms and provisions of this Notice.

This Notice applies to TI Resources. Additional terms apply to the use and purchase of certain types of materials, TI products and services. These include; without limitation, TI's standard terms for semiconductor products (<http://www.ti.com/sc/docs/stdterms.htm>), [evaluation modules](#), and [samples](http://www.ti.com/sc/docs/sampterm.htm) (<http://www.ti.com/sc/docs/sampterm.htm>).

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2017, Texas Instruments Incorporated