Simple MPPT-Based Lead Acid Charger Using bq2031

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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.

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Trademarks

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

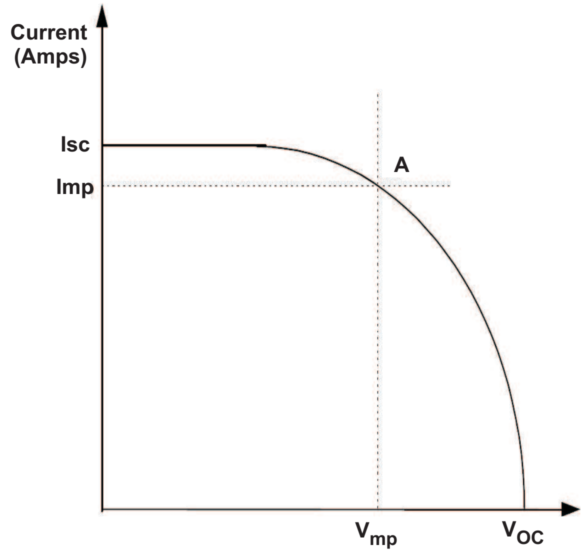

Figure 1. I-V Characteristics of Solar Panel

Figure 1 shows the typical characteristics of a solar panel. Isc 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. Voc is the open-circuit voltage at the terminals of the panel. Vmp and Imp are the voltage and current values at which maximum power can be obtained from the panel. As the sunlight reduces the maximum current (Isc) 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.

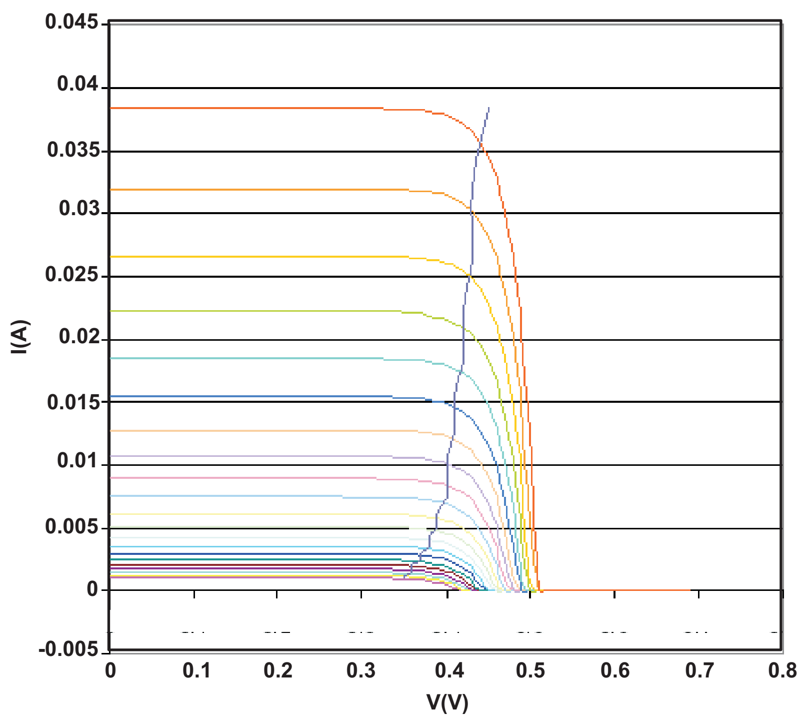

Figure 2. Variation of I-V Characteristics With Sunlight

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

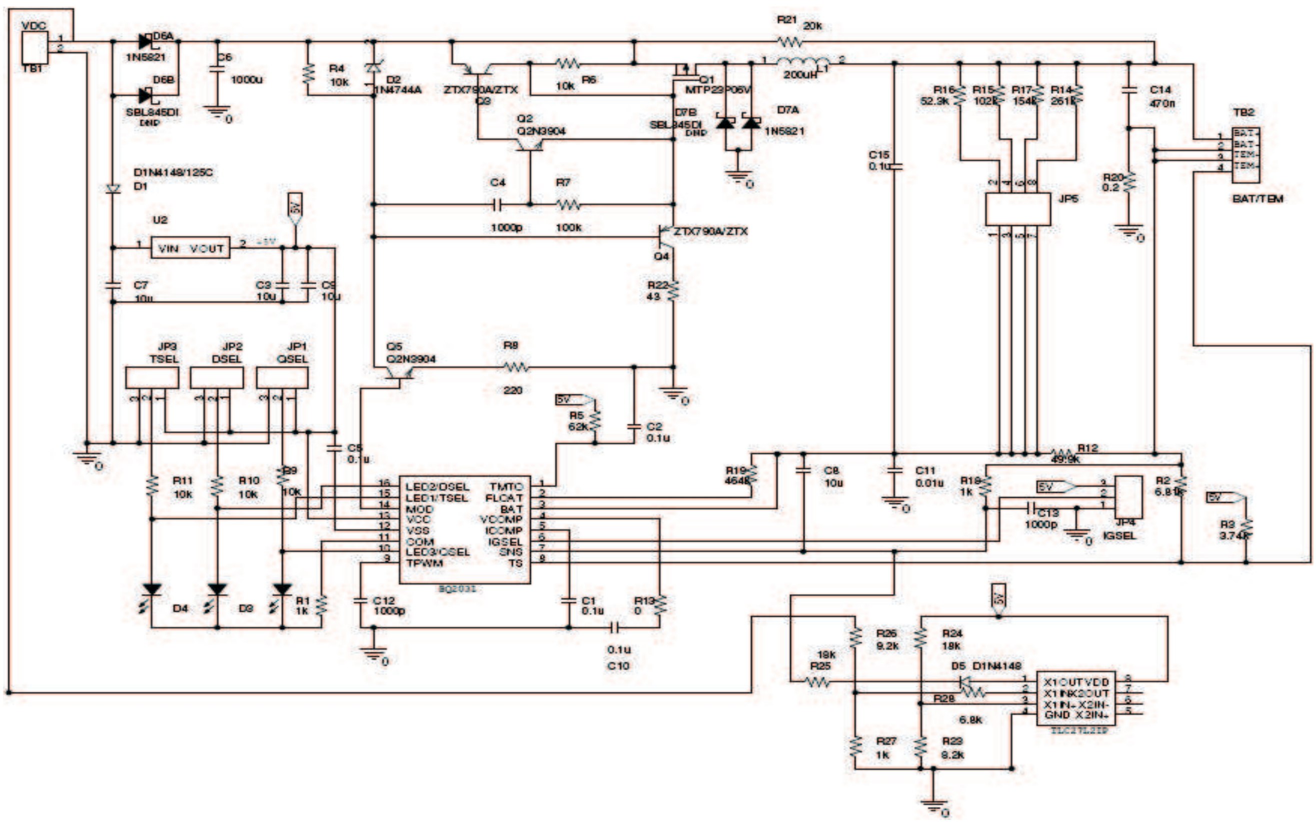

Figure 3. Schematic of MPPT-Based Charger Using bq2031

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 R_{20}. 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 R_{27} = 1 kΩ and R_{26} = 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 insolation.	4

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