DESIGN NOTES

Tiny 2-Cell Solar Panel Charges Batteries in Compact, Off-Grid Devices

Design Note 491

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Introduction

Advances in low power electronics now allow placement of battery-powered sensors and other devices in locations far from the power grid. Ideally, for true grid independence, the batteries should not need replacement, but instead be recharged using locally available renewable energy, such as solar power. This Design Note shows how to produce a compact battery charger that operates from a small 2-cell solar panel. A unique feature of this design is that the DC/DC converter uses power point control to extract maximum power from the solar panel.

The Importance of Maximum Power Point Control

Although solar cells or solar panels are rated by power output, a panel's available power is hardly constant. Its output power depends heavily on illumination, temperature and on the load current drawn from the panel. To illustrate this, Figure 1 shows the V-I characteristic of a 2-cell solar panel at a constant illumination. The I-vs-V curve features a relatively constant-current characteristic from short-circuit (at the far left) to around 550mA load current, at which point it bends to a constant-voltage characteristic at lower currents, approaching maximum voltage at open circuit (far right). The panel's power output curve shows a clear peak in power output around 750mV/530mA, at the knee of the I-vs-V curve. If the load current increases beyond the power peak, the power curve quickly drops to zero (far left). Likewise, light loads push power toward zero (far right), but this tends to be less of an issue.

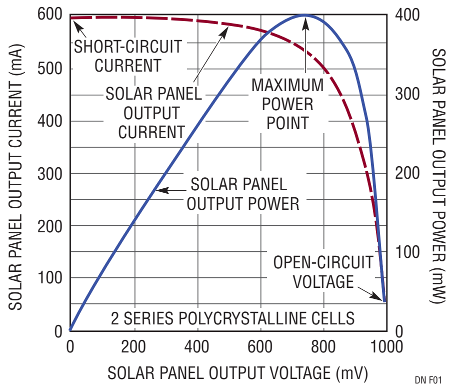

Figure 1. Solar Panel Output Voltage, Current and Power

Of course, panel illumination affects available power—less light means lower power output; more light, more power. Although illumination directly affects the *value* of peak power output, it does not do much to affect the peak's *location* on the voltage scale. That is, regardless of illumination, the panel output voltage at which peak power occurs remains relatively constant. Thus, it makes sense to moderate the output current so that the solar panel voltage remains at or above this peak power voltage, in this case 750mV. Doing so is called maximum power point control (MPPC).

Figure 2 shows the effects of varying sunlight on the charge current, with maximum power point control and without. The simulated sunlight is varied from 100% down to approximately 20%, then back up to 100%. Note that as the sunlight intensity drops about 20%, the solar panel's output voltage and current also drop, but the LTC3105 maximum power point control prevents the panel's output voltage from dropping below the programmed 750mV. It accomplishes this by reducing the LTC3105 output charge current to prevent the solar panel from collapsing to near zero volts, as is shown in the plot on the right side of Figure 2. Without power point control, a small reduction in sunlight can completely stop charge current from flowing.

LTC3105 Boost Converter with Input Power Control

The LTC3105 is a synchronous step-up DC/DC converter designed primarily to convert power from ambient energy sources, such as low voltage solar cells and thermoelectric generators, to battery charging power. The LTC3105 uses MPPC to deliver maximum available power from the source. It accomplishes this by reducing the LTC3105 output current to prevent the solar panel from collapsing to near zero

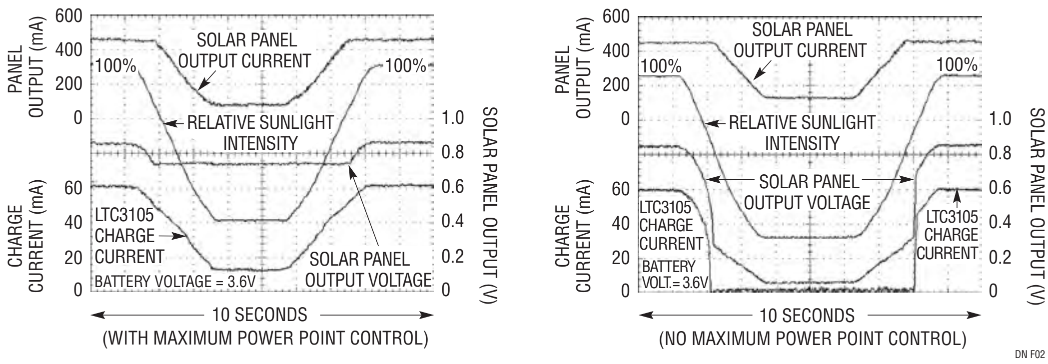

Figure 2. Changing Sunlight Intensity Effects on Charge Current

volts. The LTC3105 is capable of starting up with an input as low as 250mV, allowing it to be powered by a single solar cell or up to nine or ten series-connected cells.

Output disconnect eliminates the isolation diode often required with other solar powered DC/DC converters and allows the output voltage to be above or below the input voltage. The 400mA switch current limit is reduced during start-up to allow operation from relatively high impedance power sources, but still provides sufficient power for many low power solar applications once the converter is in normal operation. Also included are a 6mA adjustable output low dropout linear regulator, open-drain power good output, shutdown input and Burst Mode® operation to improve efficiency in low power applications.

Solar-Powered Li-Ion Battery Charger

Figure 3 shows a compact solar-powered battery charger using a LTC3105 as a boost converter and a LTC4071 as a Li-Ion shunt charger. A 2-cell 400mW solar panel provides the input power to the LTC3105 to produce over 60mA of charge current in full sunlight. Maximum power point control prevents the solar panel voltage from dropping below the 750mV maximum power point, as shown in Figure 1. The converter's output voltage is programmed for 4.35V, slightly above the 4.2V float voltage of the Li-Ion battery. The LTC4071 shunt charger limits the voltage across the battery to 4.2V. Grounding the FBLDO pin programs the low dropout regulator to 2.2V, which powers the "charging" LED. This LED is on when charging and off when the battery voltage is within 40mV of the float voltage, indicating near full charge. An NTC thermistor senses battery temperature and lowers the LTC4071 float voltage at high ambient temperatures for increased battery safety. To prevent battery damage from over-discharge, the low battery disconnect feature disconnects the battery from the load if the battery drops below 2.7V.

Conclusion

Although the circuit described here produces only a few hundred milliwatts, it can provide enough power to keep a 400mAhr Li-Ion battery fully charged under most weather conditions. The low input voltage, combined with input power control, makes the LTC3105 ideal for low power solar applications. In addition, the LTC4071 shunt charging system complements the LTC3105 by providing the precision float voltage, charge status and temperature safety features to assure long battery life in outdoor environments.

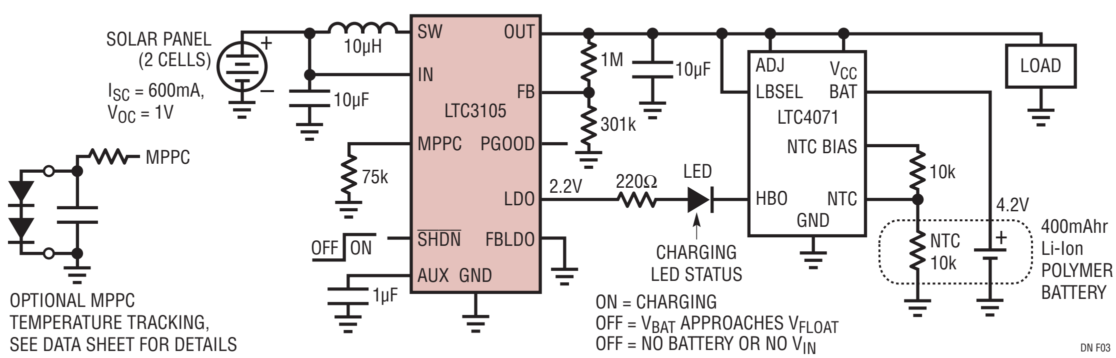

Figure 3. 2-Cell Solar Panel Li-Ion Battery Charger

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