LINEAR TECHNOLOGY
DESIGN NOTES

Shrink Solar Panel Size by Increasing Performance

Design Note 1012

John Shannon

Introduction

Solar panels are gaining acceptance as a practical means of electricity generation in remote locations, but despite improvements in the technology, solar panels remain expensive. Much of the expense is the panel itself, where the size, and thus cost, of the panel rises with required power output. Maximizing panel performance is important in order to realize the smallest, most cost effective solution.

This Design Note presents two simple circuits that increase the energy harvested by a solar panel. In both of these cases, the panel charges a battery, which in turn, supports operation of the application circuit when the sun isn't shining.

Design Requirements

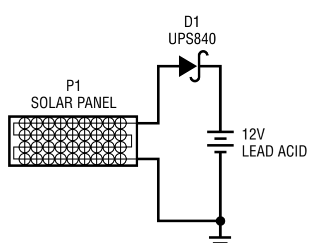
Optimum design of a solar battery charger requires some understanding of the characteristics of the panel. First, solar panels are leaky due to the large junction area, so the battery can discharge through the panel during dark periods. Also, every solar panel has a characteristic VI curve with a maximum power point, so to the extent that the load characteristics and the panel characteristics don't match, energy extraction is reduced. Ideally the panel would be constantly loaded at the maximum power point in order to fully utilize the available solar energy and thereby minimize the panel cost.

Solar Diode and the LTC4412

The panel leakage problem is typically solved with a diode in series with the panel. Reverse leakage is reduced to a low value, but some energy is still lost in the diode forward drop. A better solution uses the LTC®4412 ideal diode controller. This device, when combined in a simple circuit with a small external PFET, functions as an ideal diode—it has only 20mV of forward drop and low reverse leakage. This means the LTC4412 combines better charge performance and better discharge performance than a simple diode—you get more charging energy and you get to keep more of it. The low voltage drop of the LTC4412 ideal diode also allows the solution to scale to several amps of panel current without the heat generation problems of a conventional diode.

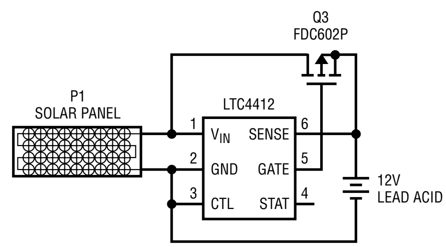
Two problems remain, namely the control of the float voltage into a fully charged battery and the loading of the panel at the optimal point for power generation. These problems can be solved by a switch mode charger using an efficient buck regulator.

Solar Panel with Diode



DISCHARGE (NIGHT CURRENT) = –162µA
CHARGE CURRENT TO BATTERY = 266mA

Solar Panel with LTC4412-Based Ideal



DISCHARGE (NIGHT CURRENT) = –17.6µA
CHARGE CURRENT TO BATTERY = 274mA

Figure 1. A Solar Panel Leaks Current When Not in Use (Dark or Night Discharge Current), a Potential Drain on the Battery. A Simple Diode Solution Lowers the Discharge Current, But it Also Introduces a Voltage Drop That Cuts Into the Battery Charge Current. A Better Solution is to Use an LTC4412-Based Ideal Diode That Reduces Reverse Leakage Currents by an Order of Magnitude over a Diode and Has Minimal Forward Voltage Drop, Thus Increasing the Charge Current

Using a Buck Regulator as the Battery Charger Controller

Conventional wisdom holds that the circuit shown in Figure 2 would not offer much benefit, but conventional wisdom is based on conventional parts. This circuit is a switch mode charger based on the unconventionally efficient LTC1625 No R_{SENSE}™ synchronous buck controller. The circuit is placed between the solar panel and the battery and serves to regulate battery float voltage. The additional, LTC1541-based control loop forces the charger to operate at the point of maximum panel power. This increase in efficiency shrinks the required panel size and thus reduces the cost of the overall solution.

Figure 3 shows charge performance of a conventional solar panel charger vs the LTC1625-based peak power tracking charger as a function of battery voltage. The data shows that higher charge current is available to the battery than with the simple diode or ideal diode based solution. The amount of extra current available vs the diode solutions depends on the battery voltage and is as high as 22% extra into a deeply discharged (10V) battery. The results were based on a 5W panel, at about 2:00 pm on a sunny September day and fails to show the LTC1625 in its best light. The LTC1625 is equally capable of higher power and can be used for a 10A solar-based charger with similarly high efficiency.

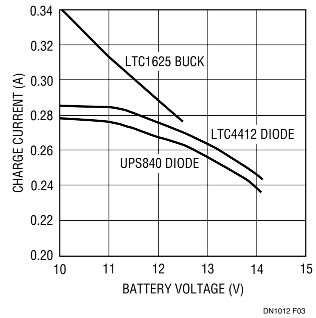


Figure 3. A Peak Power Tracking Circuit Provides More Current to the Battery Than Solutions Without a Tracking Circuit

Conclusion

The two circuits shown here improve solar energy extraction from a solar panel over a conventional diode-based reference circuit. The LTC4412-based circuit provides a simple upgrade from the traditional solar diode, gives higher charge current and lower discharge current and reduces heating problems. Adding an LTC1625-based buck regulator creates a complete charger with float voltage regulation and panel peak power regulation to maximize solar energy extraction. The benefit to this circuit is particularly noticeable in the event of a mismatch between the panel peak power voltage and the battery voltage.

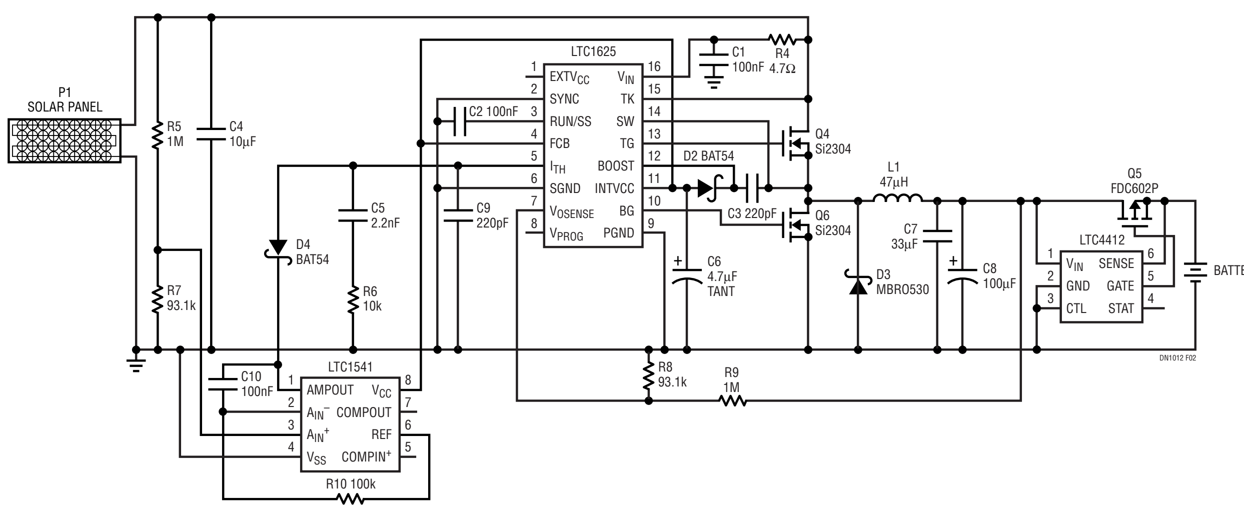


Figure 2. Peak Power Tracking Buck Charger Maximizes Efficiency

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Linear Technology Corporation
1630 McCarthy Blvd., Milpitas, CA 95035-7417
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