DN0012
Design note

DESIGNS from our LABS

Boost converter with MPPT drives isolated solar panel loads

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Main components	
SPV1040	High efficiency solar battery charger with embedded MPPT
L6924D L6924U	Battery charger system with integrated power switch for Li-Ion/Li-Polymer

Specification

How to power multiple isolated LI-Ion battery chargers connected in series from a single solar panel and one SPV1040 with 5V and 1A output capability.

Circuit description

Solar powered battery chargers for portable electronics can easily be accomplished with the SPV1040 boost converter with MPPT and L6924 Li-Ion battery charger. This is demonstrated with application note AN4050 and evaluation board STEVAL-ISV012V1. In this case, the solar panel drives the SPV1040 which powers one L6924 that charges one battery.

There are applications where two or more Li-Ion batteries need to be charged from one panel. An example of this is when Li-Ion batteries are connected in series to supply a higher output voltage. In other cases, a solar panel may need to supply separate loads that are isolated from one another. Since the L6924 is dedicated to only one battery, a design is needed where one panel feeding one SPV1040 can drive multiple L6924 chargers, each connected to its own battery and isolated from one another. Figure 1 shows the SPV1040 driving three battery chargers connected in series, isolated from one another.

It is important that the power sources for L6924 #2 and L6924 #3 also be derived from the SPV1040 so that the MPPT function is accomplished not only for L6924 #1, but also for L6924 #2 and L6924 #3.

For the battery charger load to extract maximum power from the panel, the SPV1040 with MPPT must match the equivalent load resistance of the battery charger to the output resistance of the panel. For multiple battery chargers the SPV1040 must match the equivalent load resistances of all three battery chargers to that of the panel, yet maintain voltage isolation among the three chargers.

This can be accomplished by changing the SPV1040 input inductor to a primary transformer and by coupling power for L6924 #2 and L6924 #3 from isolated secondaries. Figure 2 shows a block diagram that includes the panel and the transformer with its secondary windings driving floating AC-DC power supplies powering battery chargers.

The SPV1040 boost converter boosts the panel output voltage Vpanel to Vout1. To power L6924 #1, Vout will be set to 4.5V to be within the SPV1040 Absolute Maximum Ratings. Since the L6924 handles a wide input voltage range, this setting is not critical. V1 is the voltage at the converter side of the transformer primary. Vpanel is the voltage at the panel side of the transformer primary. This is the same as Vmp and relatively constant, mostly changing as the Perturb and Observe algorithm hunts around to maintain the Vmp value. Ignoring the very small voltage drop across the SPV1040 internal MOSFETs when they are switched on, the V1 will switch from zero to 4.5V. In continuous conduction mode, the duty cycle will be,

$$du = 1 - (Vmp/Vout1)$$

If Vmp = 3V and Vout1 = 4.5V, the duty cycle will be 0.33.

In discontinuous mode when the average output current is very small, the duty cycle will be less and the waveform will not be rectangular. In any case, there will be a 0 to 4.5V change across the transformer primary. This waveform is coupled to the secondary for rectification to power the additional battery chargers. Choices for the AC-DC power supply block could include a flyback, forward converter or half wave rectifier circuit. A flyback topology would result in the secondary voltage reflected back to the primary overstressing the SPV1040. In a forward converter, the output voltage is proportional to the duty cycle and the duty cycle will vary, though slightly, with Vmp. The best and simplest choice in this application is a half wave rectifier shown in Figure 2.

The SPV1040 Perturb and Observe algorithm depends upon measuring the input power to perform MPPT. This is accomplished in part by measuring the input current through the inductor (transformer primary) and input MOSFET. Since the power consumed by the loads on the transformer secondaries is reflected to the primary, this power is included when the SPV1040 performs its Perturb and Observe function.

In designing the transformer, the core must not saturate with the value of the DC current flowing through the primary.

Figure 1. SPV1040 driving three isolated battery chargers

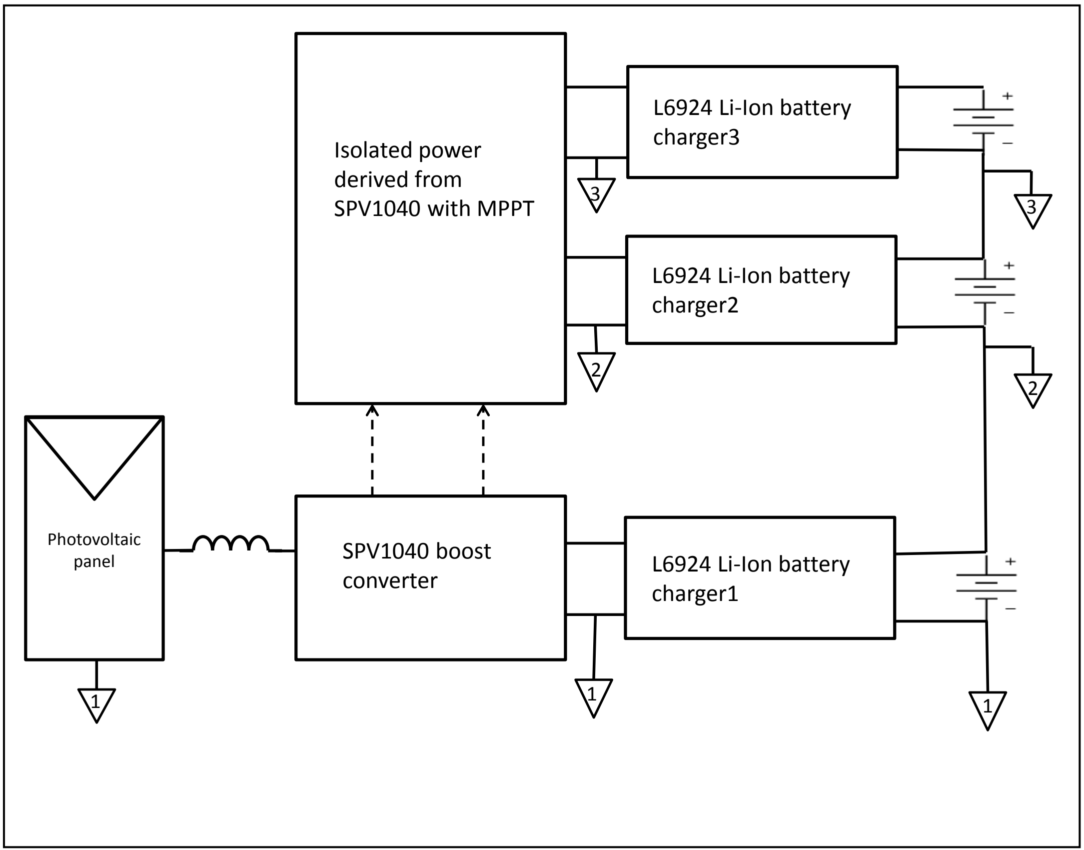
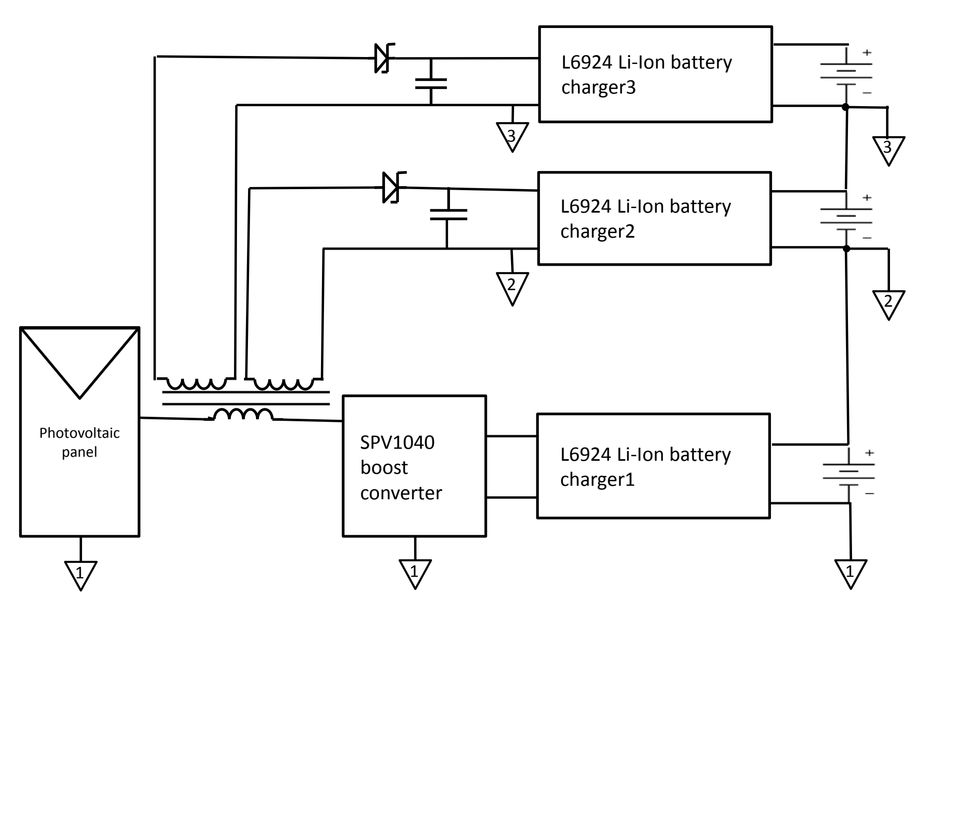


Figure 2. Driving three chargers from isolated secondary windings



Measurement results

A circuit was built using a 4V power supply representing Voc with 3.3 ohm series resistance to simulate a solar panel. The transformer was a Cramer Coil CSM16VT custom designed with a 7:1 turns ratio originally to be used as a forward converter. Subsequently, a half wave rectifier circuit would be used in the final design. The principle remains the same.

The load directly on the SPV1040 simulating the Battery Charger1 was a 100 ohm resistor. The SPV1040 output voltage was set for 4VDC, drawing 160mW from the simulated panel. With a Voc = 4V, Vmp would be 2V. The SPV1040 boosted 2V to 4V resulting in a 50% duty cycle.

To test the concept, a 6.25 ohm resistor was placed in parallel with the transformer primary. Referring to Figure 2, Vpanel was stable at 2V. V1 (at the input to the SPV1040) was a square wave from -2V to +2V. Power dissipated in the 6.25 ohm resistor was 640mW. The SPV1040 remained in regulation. The maximum power available from the 4V source was 1.21W. Total power consumed by the loads was 160mW + 640mW or 800mW.

Similar tests were run with resistive loads connected to the transformer secondaries. In each case when the isolated power consumed by the isolated loads plus the power consumed by the direct load on the SPV1040 was less than the maximum power available from the source, the SPV1040 performed its MPPT function.

Support material

Main components	
SPV1040	High efficiency solar battery charger with embedded MPPT
L6924D	Battery charger system with integrated power switch for Li-Ion/Li-Polymer
L6924U	Battery charger system with integrated power switch for Li-Ion/Li-Polymer

Related design support material
STEVAL-ISV006V2
STEVAL-ISV012V1
STEVAL-ISV015V1
Documentation
SPV1040 High efficiency solar battery charger with embedded MPPT
L6924 Battery charger system with integrated power switch for Li-Io/Li-Polymer
AN3319 - STEVAL-ISV006V2: solar battery charger using the SPV1040
AN4050 - STEVAL-ISV012V1: lithium-ion solar battery charger
AN4123 - STEVAL-ISV015V1 up to 2.5 W solar USB charger

Revision history

Date	Version	Changes
30-Apr-2013	1	Initial release