



Boost converter with MPPT drives isolated solar panel loads

Designs from our labs describe tested circuit designs from ST labs which provide optimized solutions for specific applications. For more information or support, visit www.st.com

By Edward Friedman

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 V_{panel} to V_{out1} . To power L6924 #1, V_{out} 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. V_1 is the voltage at the converter side of the transformer primary. V_{panel} is the voltage at the panel side of the transformer primary. This is the same as V_{mp} and relatively constant, mostly changing as the Perturb and Observe algorithm hunts around to maintain the V_{mp} value. Ignoring the very small voltage drop across the SPV1040 internal MOSFETs when they are switched on, the V_1 will switch from zero to 4.5V. In continuous conduction mode, the duty cycle will be,

$$d_u = 1 - (V_{mp}/V_{out1})$$

If $V_{mp} = 3V$ and $V_{out1} = 4.5V$, 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 V_{mp} . 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

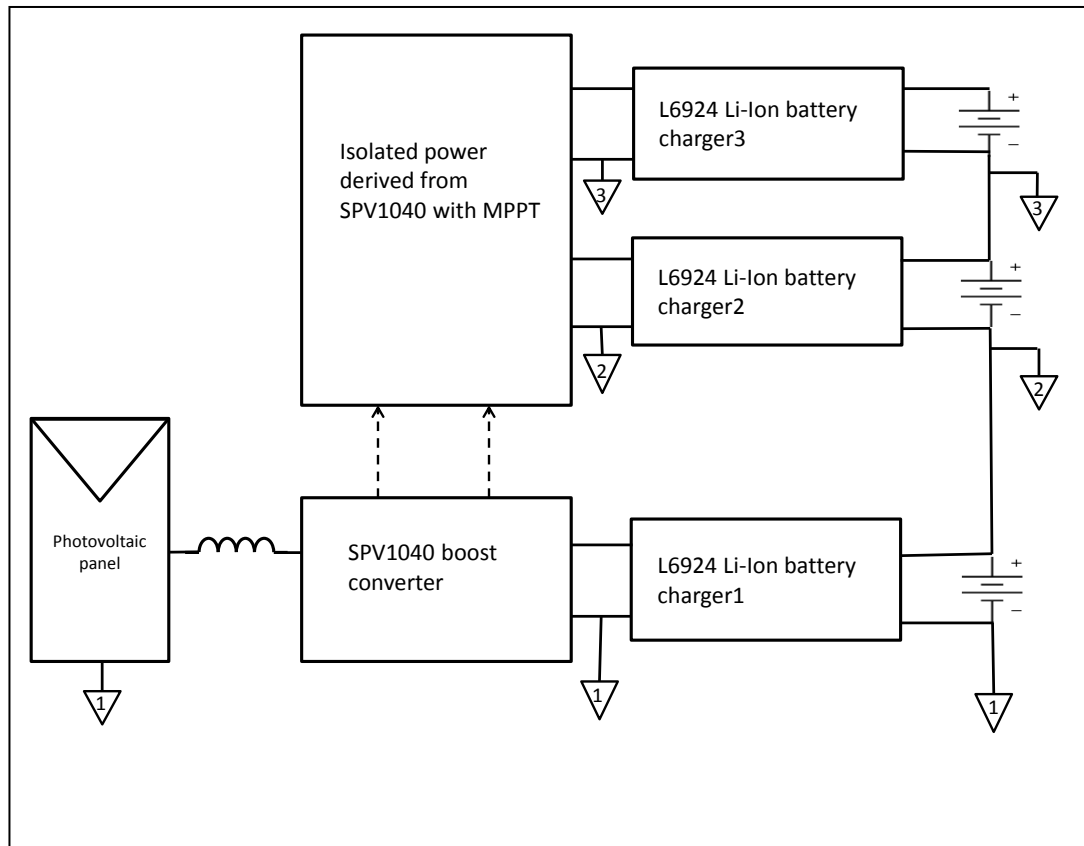
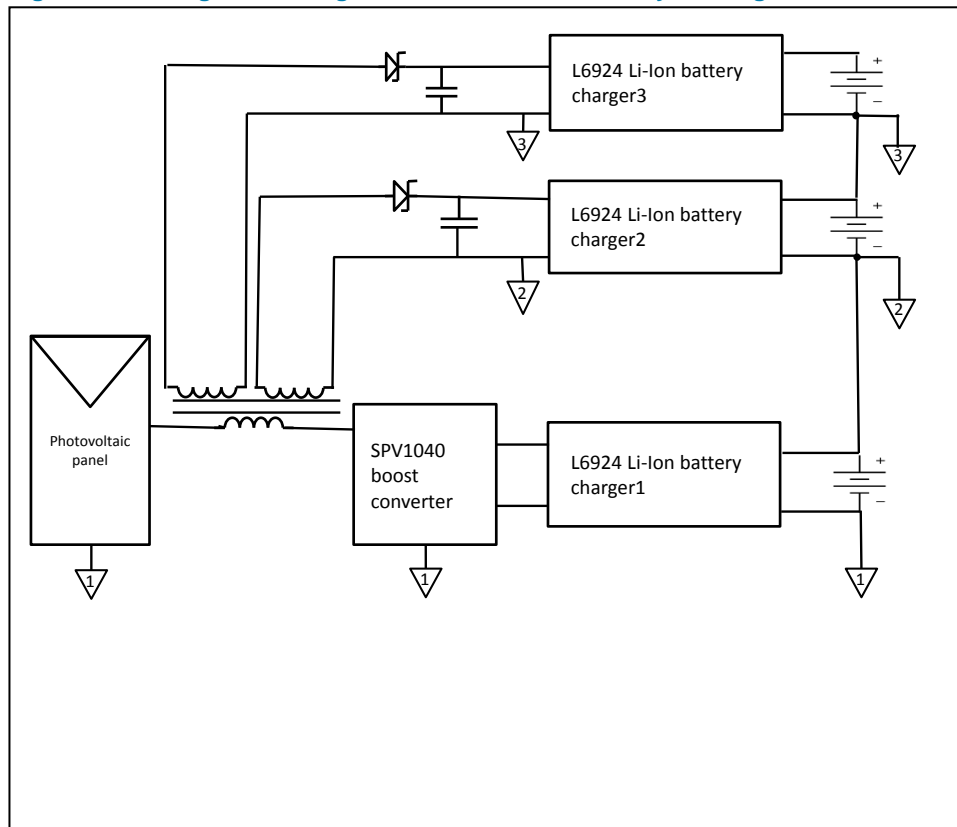


Figure 2. Driving three chargers from isolated secondary windings



Measurement results

A circuit was built using a 4V power supply representing V_{oc} 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 $V_{oc} = 4V$, V_{mp} 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, V_{panel} was stable at 2V. V_1 (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

Please Read Carefully

Information in this document is provided solely in connection with ST products. STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, modifications or improvements, to this document, and the products and services described herein at anytime, without notice.

All ST products are sold pursuant to ST's terms and conditions of sale.

Purchasers are solely responsible for the choice, selection and use of the ST products and services described herein, and ST assumes no liability whatsoever relating to the choice, selection or use of the ST products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by ST for the use of such third party products or services, or any intellectual property contained therein or considered as a warranty covering the use in any manner whatsoever of such third party products or services or any intellectual property contained therein.

UNLESS OTHERWISE SET FORTH IN ST'S TERMS AND CONDITIONS OF SALE ST DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY WITH RESPECT TO THE USE AND/OR SALE OF ST PRODUCTS INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION), OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

UNLESS EXPRESSLY APPROVED IN WRITING BY TWO AUTHORIZED ST REPRESENTATIVES, ST PRODUCTS ARE NOT RECOMMENDED, AUTHORIZED OR WARRANTED FOR USE IN MILITARY, AIR CRAFT, SPACE, LIFE SAVING, OR LIFE SUSTAINING APPLICATIONS, NOR IN PRODUCTS OR SYSTEMS WHERE FAILURE OR MALFUNCTION MAY RESULT IN PERSONAL INJURY, DEATH, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE. ST PRODUCTS WHICH ARE NOT SPECIFIED AS "AUTOMOTIVE GRADE" MAY ONLY BE USED IN AUTOMOTIVE APPLICATIONS AT USER'S OWN RISK.

Resale of ST products with provisions different from the statements and/or technical features set forth in this document shall immediately void any warranty granted by ST for the ST product or service described herein and shall not create or extend in any manner whatsoever, any liability of ST.

ST and the ST logo are trademarks or registered trademarks of ST in various countries.

Information in this document supersedes and replaces all information previously supplied.

The ST logo is a registered trademark of STMicroelectronics. All other names are the property of their respective owners.

© 2013 STMicroelectronics - All rights reserved

STMicroelectronics group of companies

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Philippines - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

www.st.com