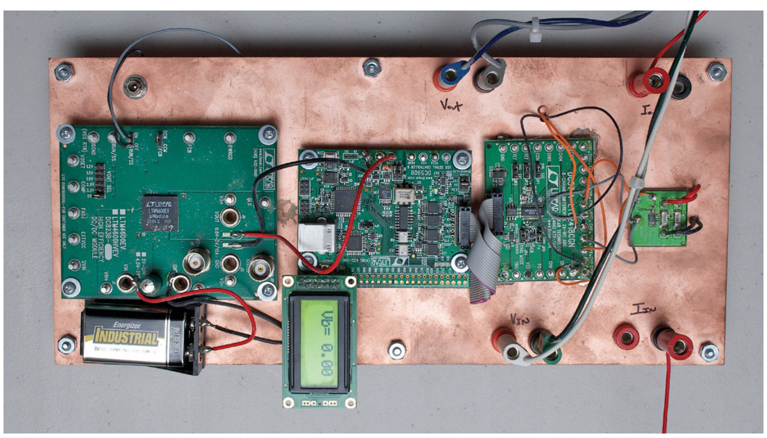
Solar energy passes the desert test

Alan Chern describes the challenges of testing a solar-powered battery charge circuit in the Nevada desert

Shade structure and shower stall using 12V water pump built using rechargeable power tools



Solar panel efficiency meter with real time display on LCD screen; from left to right: DC823B Demo board (LTM4600 buck regulator) ; DC590B Demo board PIC microcontroller; DC571A Demo board (LTC2418 24-bit, 8-channel ADC); DC1116A Demo board (LTC6103 current sense amplifier)

The task was the survival and operation of a solar powered battery charge circuit on a 12V lead-acid car battery that sourced power to peripherals such as LED lights, an audio system, and a water pump for a camp shower plus mist system.

The test environment was the hot Nevada desert, with no water, no shade, no electricity, nothing.

The repercussions of failure would yield a miserable experience for a field test like this. It was widely agreed that the charge system must be monitored to prevent the battery from draining entirely. Thus proper measurements must be taken and collected in real time in order to preserve and restore battery life.

Survival kit

The apparatus included a demo board which used a solar battery charge controller (LT3652) connected to a 70W solar panel (Solec SQ-70) which had a maximum voltage of 17V and current of 4.45A.

The charge controller optimised power from the solar panel by tracking the power curve and optimising it to charge the battery at 14V and 2A maximum current.

The question was, if we started with a fully charged battery and maintained charge throughout the day, would the solar panel provide enough power to keep the battery charged for all night LED light usage, a 12V water pump shower, a few hours of iPod playback of a 12V audio car amplifier, and other recharging peripherals?

We had to test the efficiency of the charge circuit. While it is not difficult to measure efficiency power-out/power-in x 100, it became impractical to take readings with four multimeters.

So we designed an "efficiency meter" using two demo boards containing a microcontroller and an analogue-to-digital converter (ADC), which measured and calculated efficiency in real time and displayed the results.

No meters, no calculator, and importantly, no computer is required.

The system operates on its own with just a 9V battery and internal embedded programming.

The real-time efficiency data was used to optimise the solar panel charge system, such as removing the guesswork in positioning the solar panel, determining time of day for most efficient charging, and proper budget of battery usage.

One demo board (DC590B) has a PIC microcontroller that interfaces with the other demo board (DC571A), an 8-channel differential 24-bit ADC (LTC2418). Only four channels are used. Two channels on the ADC measure V-in and V-out. The other two channels measure I-in and I-out in voltages as a ratio of current, using a current sense amplifier on the other board. The board was slightly modified with resistor changes for a 0.1V/1A ratio.

I wrote code that would flip through four differential channels on the ADC, take a snapshot of the measured voltages, convert, calculate efficiency, and display on the LCD. The result is a simple system that displays V-s (solar panel voltage), I-in (input current to the battery charger), V-b (battery voltage), I-out (output current from the battery charger to the 12V lead-acid battery), and calculated efficiency (V-b x I-out)/(V-s- x I-in) x 100.

Having each channel operate as a differential voltage measurement meant that the ground channels for V-in and V-out needed to be tied together. In my design, channels three, five, seven and nine are tied to ground. Channels two and six are V-s and V-b. Channels four and eight are I-in and I-out.

The ADC has an internal reference voltage limit of 2.5V that forced me to use a voltage divider on the V-s and V-b channels in order to stay within the input range of 20V maximum.

The resistor divider on the channel maximises resolution and internal code recalculates the true voltage value, with a negligible amount of error correction.

The final step was to make the unit run off a 9V alkaline battery to carry around with me, but also able to use with the 12V lead-acid battery. Another board (DC823B) used a buck regulator to regulate 5V to the entire solar panel battery charger system. I connected the 9V alkaline battery to the V-in terminals of the demo board with the 5V output selection jumper.

Living in the desert for a few days was not easy, but having battery power provided some creature comforts. We were able to combat the hot weather with a shower and mist system by using a 12V water pump.

The campsite was lit up with a string of LED lights. We even played our iPods through an amplifier and speakers.

Having a real-time efficiency meter helped us to budget our power consumption throughout the day, positioning solar panel orientation and determining how long we could use equipment before the battery drained.

It was still challenging, with dust storms blocking the sun, preventing solar panels from charging the battery and limiting power. But the system worked as designed, the battery never drained, and we survived the field test. ■

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