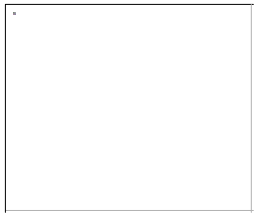

GET THE PICTURE?: A Simple Solar Charger

By Bruce Grubbs, N7CEE
The ARS Sojourner

The cover photo on the Sojourner for several months this summer shows the author operating a solar powered K2 on the rim of the Grand Canyon. I've gotten a number of questions about the power setup, and specifically on the charge controller being used. In a nutshell, I'm using a homebrew charge controller with a 5 watt flexible solar panel and a 7 amp hour SLA battery. The charge controller sits on top of the battery in this photo. (photo 501682.jpg)

The solar charge controller is based on an article by N1BBH in June 1987 QST. This article describes a smart battery charger for lead-acid batteries using the Unitrode UC3906N integrated circuit. A number of years ago, I bought A&A Engineering's Smart Battery Charger kit, which is derived from N1BBH's design. The A&A unit is an AC charger, but I soon modified it to accept solar input so that I could run my home station from solar panels, but still have the option to charge my home SLA battery pack from the AC mains during long periods of cloudy weather.

The A&A charger is too heavy to carry into a backcountry operating site, so I decided to build a charge controller purely for solar use. The resulting unit weighs just 3.5 ounces and is 2x2x3.5 inches. It fits nicely on top of the 7 amp-hour SLA that I normally use with the Elecraft K2.

Those who want the full theory behind the operation of the 3906 should refer to the QST article, and to the data sheet available from digikey.com. I'll just describe the basics. SLA batteries are low cost, reliable power sources for QRP operations. Though they are heavier than NiMH batteries, SLA's are widely available, sometimes as surplus from old computer uninterruptible power supplies. SLA batteries last a long time if cared for properly. Mainly, this

means charging the batteries correctly and avoiding deep discharges.

The UC3906 provides knows the temperature and voltage characteristics of lead acid batteries and intelligently manages a three mode charging cycle. When a discharged battery is first connected, the charge controller detects if the battery terminal voltage is too low, which could indicate one or more dead cells. This threshold is 0.8 volts per cell, or 4.6 volts for a six cell, 12 volt battery. The UC3906 also detects reverse polarity, and in both cases refuses to supply charging current. If the battery passes both tests, the charger goes into bulk mode and applies a high current for the initial charge. This rate is calculated by dividing the amp hour capacity, C, by 10, which is 700 milliamps for my 7 Ah battery.

As the battery voltage approaches full charge at 2.30 volts per cell (13.8 volts for a 12 volt battery), the charger goes into final charge mode, and tapers the charging current. The final charge LED on pin 9 goes on during this mode. When the cell voltage reaches 2.40 (14.4 volts for a 12 volt battery), the battery is in “overcharge”. The charge controller then goes into float mode and reduces the current as necessary to maintain the battery at 2.30 volts per cell. The final charge LED is out during float mode. Float mode will keep the battery charged indefinitely, and the charger can be left connected. If the input voltage drops below 4.5 volts (a frequent occurrence with solar power), the power LED on pin 7 goes out.

If a load is applied to the battery while the charge controller is connected, it will contribute up to the bulk rate to the load, while still keeping a beady eye on the battery. If the battery drops below 2.30 volts per cell, the charger goes back into bulk mode. The UC3906 also tracks the ambient temperature with an internal reference that knows the temperature characterics of lead acid batteries, and modifies the charging current appropriately. As long as the charger is in the same environment as the battery, you don't have to worry about overheating the battery.

The Unitrode UC3906 smart charger chip does all this with just a few external components. You can design a circuit to handle batteries of 6 to 24 volts and a wide range of amp-hour capacities. My version of the circuit is designed for the smaller 12 volt SLA's that I'd be willing to carry. Its bulk charging rating is set to 500 mA, just above the maximum output of my 5 watt panel. (photo 501683.jpg)

Layout is not critical, and I built my solar charger on a small general purpose circuit board. I used a small plastic enclosure with an aluminum cover. A pushbutton activates the two status LED's on demand, to avoid wasting precious solar power. The input and output are protected with automotive type 3 amp blade fuses, which are mounted in holders on the circuit board. In addition, the battery connection is protected with a solid-state self-resetting fuse for extra safety. Be extremely careful not to short the battery terminals, because even small SLA's can put out large amounts of current.

In this photo of the left side of the charger (501680.jpg), the solar panel input jack is on the left, and the battery jack on the right. The solid state self-resetting fuse is under the shrink tubing on the battery cable.

The top of the charger (photo 501682.jpg) has four output jacks for the load. I used photo jacks throughout. The final charge (green) and power (red) LED's are also visible, as well as the pushbutton, momentary SPST switch used to check the state of the LED's.

You can design the charger for different bulk rates (up to the 1 amp capacity of the pass transistor, Q1), by changing the value of Rs using the formula:

Rs = .25v / Ibulk

The UC3906N can be used with batteries of 6 to 24 volts (3 to 12 cells) by

changing the values of the resistors according to the following formulas, where N = number of cells:

RA = any value between 47 and 180 k ohms
RB = RA(1 / N-1)
RC = 3.86 x RA
R2 = 2.3 x R1 / VL (1 – 2.3 / VL), where VL is the low voltage fault level, normally 4.6 volts, and R1 can be any value between 47 and 100 k ohms.

Parts list (not including case, jacks, or switches):

Reference	Quantity	Description
R1	2	2 100K 1/4w 5%
R3	4	2 2.2k _w 5%
R5	1	10 1/4w 5%
R6	Not used	
RA	1	100k 1/4w 1%
RB	1	10k 1/4w 1%
RC	1	392k 1/4w 1%
RS	1	_ohm 1w 5%
C1	Not used	
C2	1	0.47uf 35 or 50v
C3	1	0.1uf 35 or 50v
Q1	1	TIP42 & mounting hardware kit
U1	1	Unitrode UC3906N
F1, F2	2	Fuse holder & fuse 3A
DS1, DS2	2	LED indicators

The UC3906N and a spec sheet is available from Digi-Key, www.digikey.com, part number 296-11621ND. Be sure to get the 16 pin dip version- the 3906 also comes in surface mount packaging. There is also a mil-spec version, the UC2906.

Schematic (SolarCharger.jpg)

* * * * * * * * * *

Bruce Grubbs, N7CEE, is an expert outdoorsman, QRPer, builder and contributing editor to The ARS Sojourner. He lives in Flagstaff, AZ.