Simple Solar Cell Charger

Avoids overcharging of NiCad-batteries

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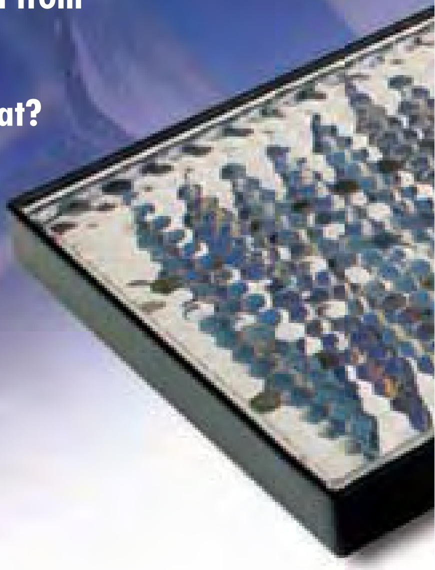
Small solar cells can be obtained very cheaply these days — or you could remove them from an old solar powered garden light. It would be nice to use them, but for what? With a handful of parts you could use such a solar panel to safely charge a set of batteries.



In In theory you could just connect a solar panel via a Schottky diode to several batteries connected in series. The internal resistance of a small solar panel is sufficiently large to limit the charging current to a safe value. But with such a simple circuit it would still be possible to overcharge the batteries. That's why we've put together a little charging circuit that avoids this (**Figure 1**).

OPERATION

There's not much to the circuit: it consists of just two transistors and a few passive components. The way it works is very straightforward. The voltage across the batteries is continuously monitored. When this voltage rises above a certain level (meaning that the batteries are fully charged), a power resistor is switched in parallel with the solar panel, which causes output voltage of the panel to drop and stops the batteries from being charged any further.

The voltage is monitored by the circuit around T2. Zener diode D2 puts the emitter of T2 at an offset of about 1.4 V. Potential divider R3, P1 and R6 supplies the base voltage to T2. When this rises above roughly 2 V (1.4 V plus the base-emitter drop of T2) the transistor starts conducting. This pulls the base of T1 lower via R5, which also causes T1 to conduct. The current from the solar panel is then diverted through power resistor R7 (10 Ω, a 1 W type is usually sufficient). This causes the voltage of the panel to drop, stopping the charging process of the batteries.

Depending on the tolerance of the components in the potential divider, T2 and D2, you'll have to experiment a bit with the setting of preset P1 to obtain the correct final voltage for the NiCad batteries. The accepted value for a fully charged battery is usually taken to be 1.44 V. In this case (for two batteries connected in series) the circuit has to be adjusted such that T2 starts conducting when the voltage across K2 reaches 2.88 V. If you want to charge more than two batteries at a time you only need to modify the potential divider. Simply increasing the value of R3 will make the circuit work with three or four batteries connected in series.

CONSTRUCTION

Since the circuit consists of relatively few components it can easily be built on a piece of experimenter's board (as the photo of our prototype shows). If you use screw terminals for the input and output connectors it will be easier to connect the leads from the solar panel and the batteries to the board.
The nominal voltage of the solar module is determined by the number of cells to be charged. Because of the typical voltage drop of 0.3 to 0.4 V across Schottky diode D1, the nominal module voltage should exceed the charge voltage set on P1 by about 0.3–0.4 V. A typical (inexpensive) solar module (array) to charge two cells consists of eight series connected solar cells. With a sufficient amount of sunshine such a module will supply about 140 mA at 8 times 0.45 V = 3.6 V. Of course, you can use larger modules with a higher nominal current capacity in order to reduce the charger time — this will be a matter of cost. With the 140-mA module, for example, a totally flat 1400-mAh battery (pack) will require 12 to 14 hours worth of uninterrupted sunshine (rare in the UK).
There is one thing you may have to watch out for during the construction: a zener diode of 1.4 V often consists of two normal diodes connected in series. This pseudo-zener should be connected in forward bias, not reverse biased like a true zener. The cathode (the connection with the ring) has to be connected to ground in this case!

The setting of the final charging voltage is best done by temporarily replacing the batteries with an adjustable DC power supply. Its output should be set to exactly 2.88 V. Connect a voltmeter across power resistor R7. Then place the solar panel in bright sunlight. Set the preset to the maximum resistance. Now slowly turn the preset back until the voltmeter suddenly shows a voltage of a few volts, indicating that T1 is conducting. The adjustment is now complete and you can disconnect the power supply and replace it with the batteries again

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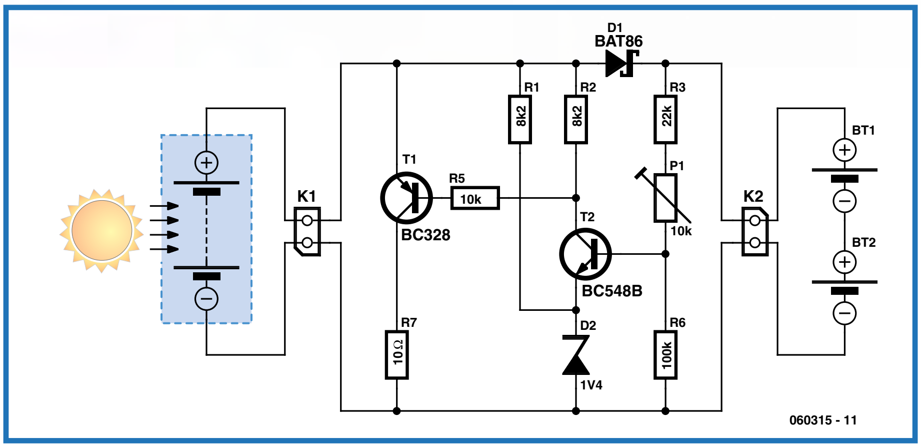

Figure 1. The circuit consists of only two transistors, two diodes, a preset and six resistors.