MALIBU "Sun-Powered Solar Accent Light" Model LZ3W - by Intermatic

LZ3 uses an "amber" LED and LZ3W is the white LED version depicted here.

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Claimed Patents

I did a patent search on Intermatic. There are 67 patents issued to them, but none related to this circuit. Most of their patents are "design" patents. A "design" patent is for the utility of a product as a function of its shape. Think "fan blades", or a novelty flashlight!

The following patent numbers were stamped onto the solar panel housing:

5,041,952
5,086,267
5,221,891

The above patents show housings and circuits for a solar powered light which uses an incandescent lamp. Talk about yesterday's news!

Component Part Notes

The RB100A diode was made by Rohm and is now obsolete. It is a Schottky diode in a DO-41 case, rated at 40V and 1A. Fairchild's SB140 is an inexpensive substitute (Mouser).

Q1 is the most critical in that it should be fast and turn on hard. A 2N4401 or 2N2222 would probably substitute nicely. Q2 could probably be any moderate gain NPN. Q3 might be a 2N4403.

L1 had the color markings of a 100 uH inductor and looks to be a ferrite-core device. I measured the inductance and confirmed the value. (L1 measured 91.9 uH which is within the 10% tolerance indicated by the silver tolerance band.) The DC resistance was 0.650 ohms. That matches up well with a J.W. Miller 5300 series inductor. Mouser #542-5300-25 is a 100 uH part that will work.

Build Your Own???

For under twelve bucks for the whole light, why would anyone build this circuit? Actually, I might. The utility of this circuit is not as a solar light. The utility to me is as an emergency light that uses a single AA battery to power a 3.6V white LED. Burning my Maglite flashlights during a power outage is expensive. Candles suck. But a tiny light source that will run for days on a thirty-cent AA cell is pretty cool. Lose SP1, D1, R3, and Q2. Add a cheap switch in series with the battery, and you have a four dollar emergency light that is bright enough to read by.

But there are charge pump ICs that do this without an inductor. You are nuts! Yeah, but do those chips run at 1.0V? This will. To get the most life out of a battery the circuit needs to operate reliably at 1.0V. No charge pump IC will do that. A boost supply for LED backlights will do that but cost a lot more. And, they also require an external transistor, inductor, and rectifier.

Stick one of these circuits inside those dome lights they sell at the dollar stores. They will put out about as much light, need only 1 battery instead of 2, 3, or 4, and will last a lot longer. If you drop the LED light you won't break it or bang the filament. Incandescent lights only last about 50 hours, in case that is news to you. Yup, this is pretty cool, me thinks.

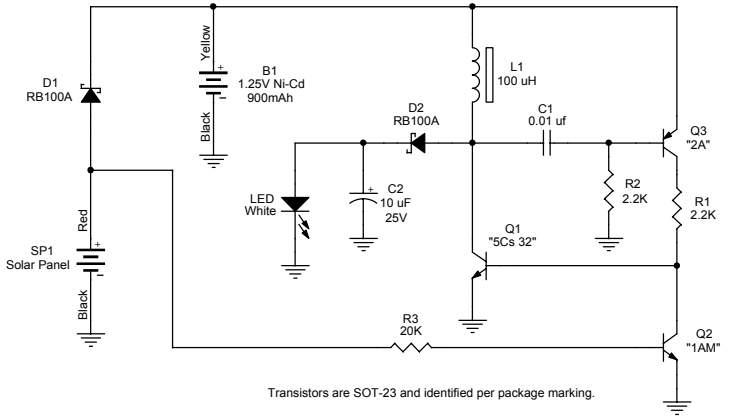
Solar Array Performance Notes

The solar cell array is marked "PCB-60608B" and measures about 2.38" x 2.38".
The solar cell array consists of 4, rectangular photovoltaic cells wired in series and encapsulated in resin.
The data below was gathered at about 2:30PM CST on 09-17-2005 in northeastern Illinois:

The open circuit voltage in full, direct sunlight is 2.230V and has a short-circuit current of 112mA.
The open circuit voltage in cloudy, direct sunlight is 2.046V and has a short-circuit current of 21.6mA.
The open circuit voltage in full sunlight but facing upward is 2.175V and has a short-circuit current of 72.0mA.
The open circuit voltage in cloudy sunlight but facing upward is 2.038V and has a short-circuit current of 17.7mA.

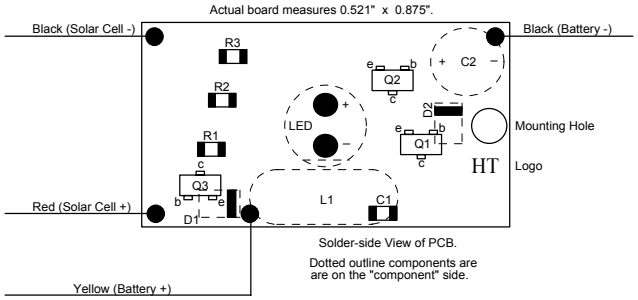
Normally, one would charge a Ni-Cd battery at 1/10C. For the 900 mAh battery, a 90 mA charge would be ideal.

Schematic Diagram of Light



Transistors are SOT-23 and identified per package marking.

Layout Diagram of Physical PC Board



Solder-side View of PCB.

Dotted outline components are are on the "component" side.

Circuit Description & Theory of Operation

The solar panel charges the battery directly without current limiting. (There is no charge control.) D1 is in series with the solar panel voltage to prevent battery discharge in absence of sunlight. The solar panel, without sunlight illuminating it, represents a discharge path for the battery! D1 is a Shottky diode. Shottkys have a lower forward voltage drop which is used to great effect in solar power applications. Components Q1, Q3, R1, R2, C1, and L1 form a relaxation oscillator. Q1 effectively shorts out the battery through inductor L1. The inductive kick is what permits higher voltages to be generated. The AC voltage at the bottom of L1 is rectified by D2. C2 smooths out the ripple and the voltage is applied to the LED. Current is limited by the resistance of L1.

Solar voltage is sampled by R3. When sufficient sunlight is present to charge the battery, R3 sources enough current into the base of Q2 to turn it on. When Q2 is turned on, the oscillator is prevented from running, thereby keeping the LED turned off. When the solar panel voltage drops to due low light, Q2 turns off and the oscillator starts which generates the LED voltage.

Circuit Performance Notes

When operated from a 1.5V source, the current consumption was 48-50mA - about 75 milliwatts. The white LED voltage measured 3.160V. I made no attempt to measure LED current. If the LED current was close to 20mA, the power supply efficiency was about 84%. While not great, it is more than acceptable.

If the solar panel voltage is kept at 0V, this circuit will start with an input of 0.8V. The LED will be dim in the extreme (VLED = 2.45V) but it will light. Pretty amazing, actually.

With Vin = 1.25V the VLED = 3.023V. And with Vin = 1.50V, VLED = 3.180V. VLED is 2.81V with an input voltage of 1.00V.

The oscillator was essentially a squarewave an operated at a frequency that was more or less, voltage dependant. The frequency varied between 67 and 75 kHz. Higher voltages corresponded higher frequencies.

These lights are manufactured in China (gosh, what a surprise!).
I bought this one at Walmart on 09-16-2005 for $11.43 + tax.

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Designed by Tom Farrand

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Title		
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