

Assembly Manual

Solar Generator

(Shortform - PCB & components only)

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K-3129



With advances in solar cell technology, falls in price and higher efficiency, solar cells have finally begun to be practical sources of power. This is a cheap, no fuss way to trickle charge a battery.

The ETI-569 Solar Charger is designed to charge any standard 12V lead acid car battery in any area where mains power is unavailable. It is ideal for remote data acquisition stations, caravans and boat.

Of course, there are solar chargers around, but these are extremely expensive. With the ETI-569 the emphasis is on simplicity and cheapness.

Design Problems

The major difficulty in using solar cells for charging is the fact that their output voltage and current vary immensely with the intensity of the sun's rays. Another problem is that discharge from the lead acid battery into the solar charger must be avoided during night time. Furthermore, overcharging the lead acid battery must be automatically prevented.

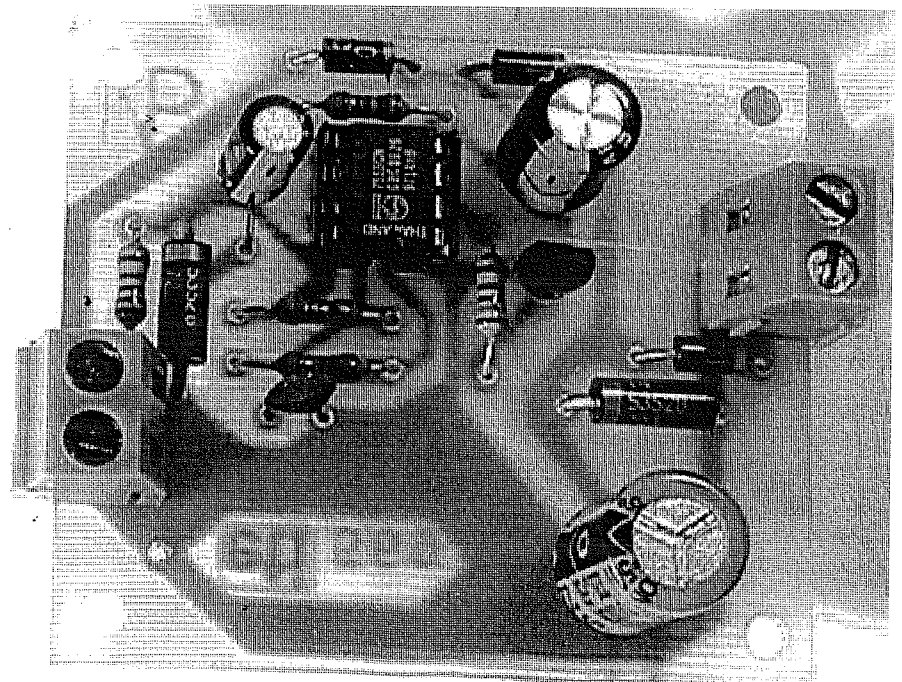
The simplest way to re-charge a lead acid battery is to maintain a 15 volt current across the terminals with a series resistor to program the charging current. The problem here as regards to solar charging is obvious, for how is this current to be maintained constantly with varying weather conditions. For any given light intensity, maximum power can only be obtained if the charger draws the right amount of current taking too much current from the solar charger will lead to a drop in terminal voltage and it will thus take a very long time to charge the lead acid battery. As explained in Figure 1, the circuit input impedance has

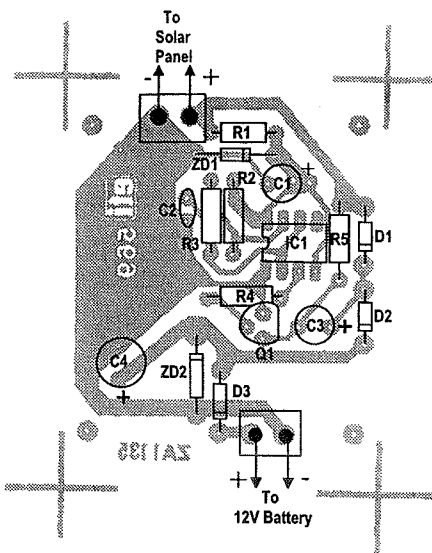
to be continually re-adjusted to ensure that maximum power is drawn from the solar battery.

Ideally, the charging circuit has to have the ability to detect the right amount of current and at the same time, keep 14V across the lead acid battery regardless of the fluctuations on the solar battery. Sound easy?? It would be easier if we had a stable power supply for the circuitry. However the whole idea be-

hind the ETI-569 is to build a maintenance free system without using any manmade source of power. It seems vaguely ludicrous for a solar charging circuit to be powered by something else like a dry cell battery.

Clearly the design task is not easy if the solar circuit has to tackle the above problems and yet be simple enough to be constructed by the hobbyist. In fact it is well nigh impossible but a compromised





circuit is quite feasible.

Design Solutions

Most modestly cheap solar panels are made up of a chain of solar cells. During cloudy day-time hours, the solar battery output voltage is low (less than 12V), so one of the first things we need is a voltage doubler to increase the voltage from the solar battery. This device raises the problem of overcharging the lead acid battery.

The answer to this problem is some kind of artificial load which automatically switches in to take up the charging current when the battery is full and switches itself off when the battery is being charged. An excellent artificial load can be constructed with a constant 15V voltage zener diode and a 1N4002 rectifying diode connected across the lead acid battery. As the battery approaches full capacity, its terminal voltage gradually rises and starts to turn on the zener. From then on, any more current will be absorbed by the zener diode.

Referring back to Figure 1 again, you will see that a different amount of current at a different intensity of light will have to be drawn in order to maximize the output energy from the solar battery. The zener diode automatically ensures this. Consider the case when the sunlight in-

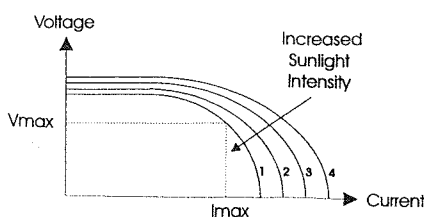


Fig.1: Voltage and current output at various light intensities.

creases, the voltage from the solar cell rises, resulting in more volts across the lead acid battery will soak up more current as a consequence. This extra burden on the solar battery will lower its output voltage as indicated by the curve shown in Figure 1. Consequently, voltage across the lead acid battery drops as well, resulting in a smaller current flow. Automatically, this process comes to rest on a point where the products of voltage and current give a maximum value. The settling point is constantly re-adjusted according to the changing sunlight intensity.

When there is little sunlight around, the voltage output of the solar battery is very low. Even with the help of the voltage doubler, the output voltage may not be enough to charge the lead acid battery. At night everything stops except the diode in series with the lead acid battery which prevents the battery from discharging. The charging process will resume automatically on the next sunny day providing a maintenance free charging operation.

The voltage doubler itself is made up of an oscillator. We decided to use a CMOS 555 timer, since it draws minimal current allowing every drop of juice from the solar panel to be used for charging the battery.

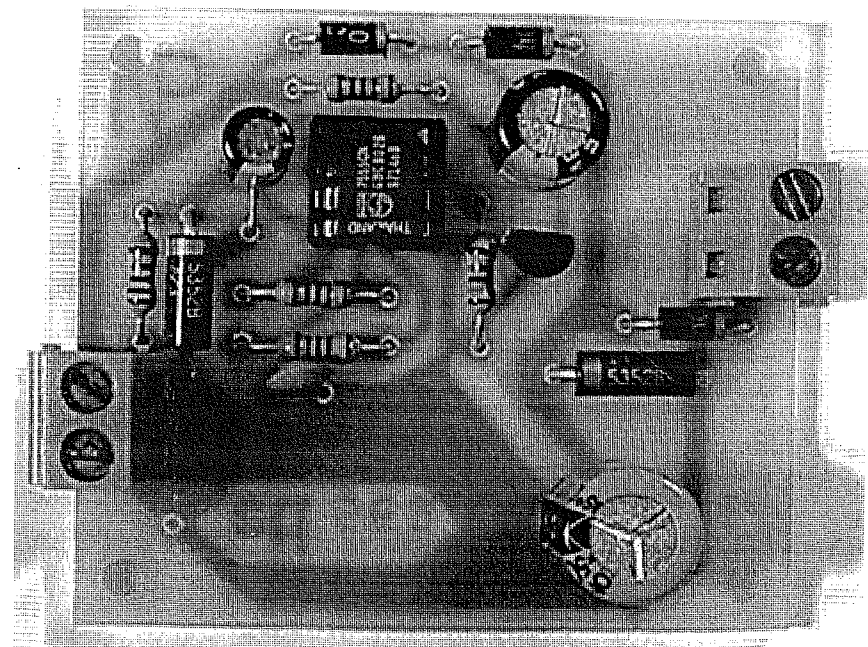
Construction and timing

The type of solar panel used is not very critical in the unit. Almost any unit will do the job. Typically no more power than 6W is required with an output voltage of 12 to 20V. If you want to shorten the

Parts List	
Resistors	
All 0.25W, 5%	
R1	1k — ON BOARD
R2, R5	10K
R3	56K
R4	1K8
Capacitors	
C1	33uF 25/35VW RB electro
C2	47nF ceramic
C3	47uF 50/63VW RB electro
C4	220uF 25VW RB electro
Semiconductors	
IC1	CMOS555 timer/TLC555/ICM7555
Q1	BC547
D1,D2,D3	1N4004
ZD1,ZD2	Zener Diode 15V 5W/1N5352
Miscellaneous	
RL-220R Load Resistor, PCB, 64 x 49mm, code ZA1135; 2 x Terminal Block; IC Socket 8-Pin & solder.	

charging time by hooking up two solar panels in parallel, the power rating of ZD2 has to be higher than 5W. This is because when the battery is fully charged, the output power from the solar panels has to be absorbed by the zener diode ZD2. When the light intensity is at its peak (1000 W/square metre), the zener diode ZD2 has to buffer a fair bit of power from two or three solar panels in parallel.

There are only a few components on



board so assembly of it should take no more than 20 minutes. No tuning and adjustment is required. However, be careful with the polarity of the diodes, transistor and capacitors. Before you house the circuit into your desired case, it is necessary to test the circuit first.

The tools required to test the circuit are very simple, two multimeters, an uncharged lead acid 12V battery (or a 220R load resistor if you don't have a spare battery) and the sun. First connect the testing arrangement as shown in Fig.2. One meter is configured as a current and the other one as a voltage meter. The polarity of the meter's probes have to be correct so that a positive reading is obtained when the current or voltage is in the right direction. Orient the solar panel towards the sun and you should get POSITIVE readings on the current meter. On a typical sunny Sydney winter morning you can expect 100mA (assuming one solar panel is used). The voltmeter should read something like 15V. Tilt the solar panel slightly to affect the amount of light falling upon it and you should observe either a drop or increase in meter readings.

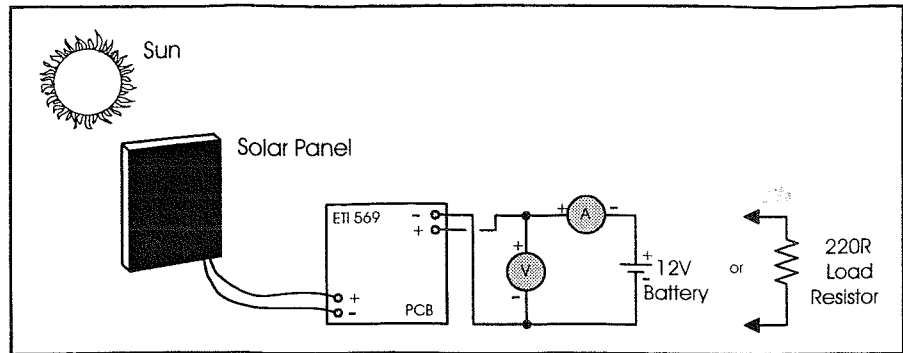


Fig.2: Test set up for the ETI-569. If a battery is not available at time of setup, then use a 220R resistor as the load. With the load resistor in circuit, when applying a nominal supply of 12 volts to the input the amp meter should read around 45mA.

There are two things you must check. No matter how you tilt the panel, even on a hot summer day, the voltmeter should never read more than 16V (under no load condition). If it does, ZD2 has probably failed. If you cover the solar cell with a dark piece of cloth, the current polarity shown in the meter should be positive and the reading be either nil or extremely small. If the NEGATIVE reading on the current meter is significant while there is no sun, diode D3 is probably malfunctioning.

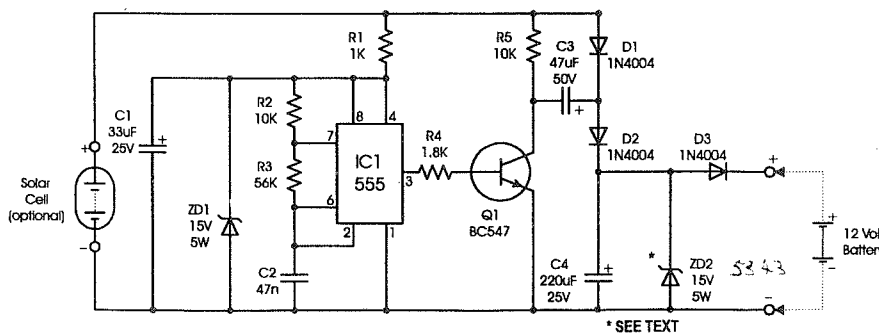
We would suggest that you leave the

set-up as it is in Fig.2 outdoors for a week or so, depending on the capacity of the battery to be charged. Start off with a completely discharged battery and see if it charges at all during a week.

The two meters are only temporary fixtures. They are there purely for the convenience of checking the charging conditions any time you wish.

After the circuit is proven, you can pop it into your desired case and securing the board by the mounting holes on each corner of the PCB.

ETI-569 -How it works



When the solar cell is creating a voltage much greater than the battery, the typical charge-type situation, then the circuit may be considered to consist merely of the solar cell and the battery. Current will flow from the solar cell into the battery. All other components are present solely because this situation does not always pertain.

For instance, it may well be that because of night or cloud, the solar cell is actually not developing sufficient energy to charge. In this situation, the biggest danger is that the battery will discharge through the circuit or the solar cell. D3 protects against the situation

At the opposite extreme, the battery might already be fully charged. It is necessary to have some form of voltage clamp to ensure that the battery is not damaged. This is achieved by ZD2 which effectively stops the battery ever going over 15V.

A third problem is to ensure that when the solar cell voltage is below the battery voltage, but not at zero, the unit will still charge. The rest of the circuit is designed to cover this eventuality. The heart of the circuit is a voltage doubler built around the 555 and the two capacitors C3 and C4. To see how it works, consider the situation with pin 3, IC1 at Vcc, so that the collector of

Q1, and thus the negative plate of C3 is effectively at ground. Then current will flow from the solar cell, through D1 onto the positive plate of C3. D2 is reverse biased by the battery.

When pin 3 IC1 goes low, the collector of Q1 goes high, pushing the positive plate of the battery up to Vcc. But C3 has Vcc impressed across it already, so the new voltage is 2Vcc. This switches off D1 and turns on D2. Current now flows into C4.

When IC1, once again, causes the positive plate of C3 to drop to Vcc, D2 reverse biases, thus providing C4 with only one discharge path, through the battery. In this way it is possible to provide a charging current even though the solar cell has less potential across it than the battery.

Note that this is strictly true only if 2Vcc is less than 15V, because of the operation of ZD2.

R2, R3 and C2 set up the frequency of operation of IC1. ZD1 is designed to protect the 555 from an over voltage situation, and R1 and C1 to stabilize the operating voltage of the oscillator.