Homebrew

Low Cost PV Regulator

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Building solar panels or batteries is beyond the capabilities of the average person. Building a regulator for your PV system is not.

This regulator design is capable of handling up to 30 amps for a 12 volt or 24 volt system. To build it, you need to be able to read schematics and know basic construction techniques. If you've built small homebrew projects before, this should be no problem.

A regulator's job is to connect the solar panels to the battery when it needs charging, and to disconnect them when it doesn't. The regulator should also prevent battery power from being dissipated in the solar panels after the sun has gone down. The ideal regulator would not generate any heat while controlling your precious solar power. This regulator design achieves this with a minimal number of parts, at low cost.

Operation

The regulator connects or disconnects the panel dependent on the battery voltage. The user sets this voltage, so any type of battery can be accommodated. The switching portion of the regulator uses a field effect transistor, or FET (Q2). FETs are amazingly efficient. At 20 amps, I measured only 0.2 volts drop across the FET used in this regulator.

The brain of the regulator is a 555 IC. This part is usually used as an oscillator, but it contains the circuitry needed for an on/off regulator. Pin 5 in U1 sets the reference voltage for U1. The output of U1 pin 3 goes to 12 volts when the input to U1 pin 2 falls below one half of pin 5. The output of U1 pin 3 goes to 0 volts when the input to U1 pin 6 rises above pin 5.

The battery voltage is divided by potentiometers R2 and R3 and applied to U1 pins 6 and 2. Setting the on/off voltage limits with R2 and R3 allows a voltage range. Within this window of voltage, the regulator can be on or off depending on whether the battery voltage is rising or falling. Below the lower limit, the regulator is always on. Above the upper limit, the regulator is always off. In operation, when the regulator is on, the battery voltage rises to the upper limit, then shuts off. It will remain off until the battery voltage drops below the lower limit, then the regulator turns on.

Preventing discharge at night is easily accomplished with a diode. But unless you pick your diode carefully, it can be a source of power loss. Diodes have a small voltage drop in the forward direction. A standard power diode can have a drop of 0.6–1 volt. At 15 amps, this would translate into 9–15 watts of wasted power. In this project, we use a Schottky diode, which can reduce the voltage drop to 0.4–0.7 volts. At 15 amps, it wastes 6–10.5 watts of power. This may seem fussy, but you probably paid $5 a watt when you bought the panels.

Construction

There are 12 and 24 volt versions of this regulator. For the 12 V version, install all the J1 jumpers (denoted by connecting the two dots to the left and right of the J1 designator) and install all parts *except* the ones beginning with (2). For the 24 V version, install all the J2 jumpers and install all parts *except* the ones beginning with (1).

A good approach would be to install all the parts except D1 and Q2 on a perfboard. Layout isn't critical, but it would be wise to allow for a good common for all parts going to ground. When building, keep in mind that the regulator will most likely be connected to a large battery. Make sure there is no possibility of a short. A small aluminum box can serve as a protective enclosure and heat sink.

My prototype had a barrier terminal block with three screw terminals on the top and solder tabs on the bottom. This was used to make the solar panel and

battery connections. It was positioned so the drain lead (D) of Q2 could be soldered directly to the solder tab.

FET Mounting

The diode (D1) was not installed in the enclosure of the prototype. You may want to connect the source of Q2 to pins 1 and 3 of D1, then connect pin 2 to the terminal strip. Before installation, the FET (Q2) can be damaged with static electricity. Avoid touching the leads until required by installation. The diode (D1) and FET (Q2) require heat sinks. The mounting surface on the FET (Q2) is connected to the drain (D). The drain (D) is grounded on the FET so it can be mounted to the regulator enclosure. The diode will generate the most heat.

The diode (D1) mounting surface is connected to its cathode, which should not be grounded. Use a TO-247 isolation mounting kit for D1. The kit should consist of a very thin insulating material to go between D1 and the enclosure. An insulating washer goes between the mounting screw and the mounting hole of D1.

The diode actually operates with less voltage drop (which is good) at higher temperatures (max 115° C; 239° F). On the other hand, the FET has the lowest resistance when kept cool.

Adjustment and Testing

First verify the wiring accuracy of your board. Connect a 12 or 24 volt battery or a power supply to the battery terminals on the regulator. Measure the voltage at U1 pin 5. It should be 6.8 volts for the 12 V version, and 12.5 volts for the 24 V version, +/- 0.7 volts. Record this reading as V1. Measure the voltage at the battery terminals, and record this reading as V2. Calculate the R3 and R2 settings.

R3 Turn Off

Decide on the *off* voltage for the regulator. R3 voltage equals V1 times V2, divided by the *on* voltage. If you choose 14.0 volts as the *off* voltage, R3 is 6.8 x 12.0 / 14.0 (which equals 5.83). Adjust R3 (U1 pin 6) to 5.83 volts with respect to ground.

R2 Turn On

Decide on the *on* voltage for the regulator. R2 voltage equals V1 times V2 times 0.5, divided by the *off* voltage. If you choose

Above: The components laid out on perfboard.

13.0 volts as the *on* voltage, R2 voltage is 6.8 x 12.0 x 0.5 / 13.0 (which equals 3.13). Adjust R2 (U1 pin 2) to 3.13 volts with respect to ground.

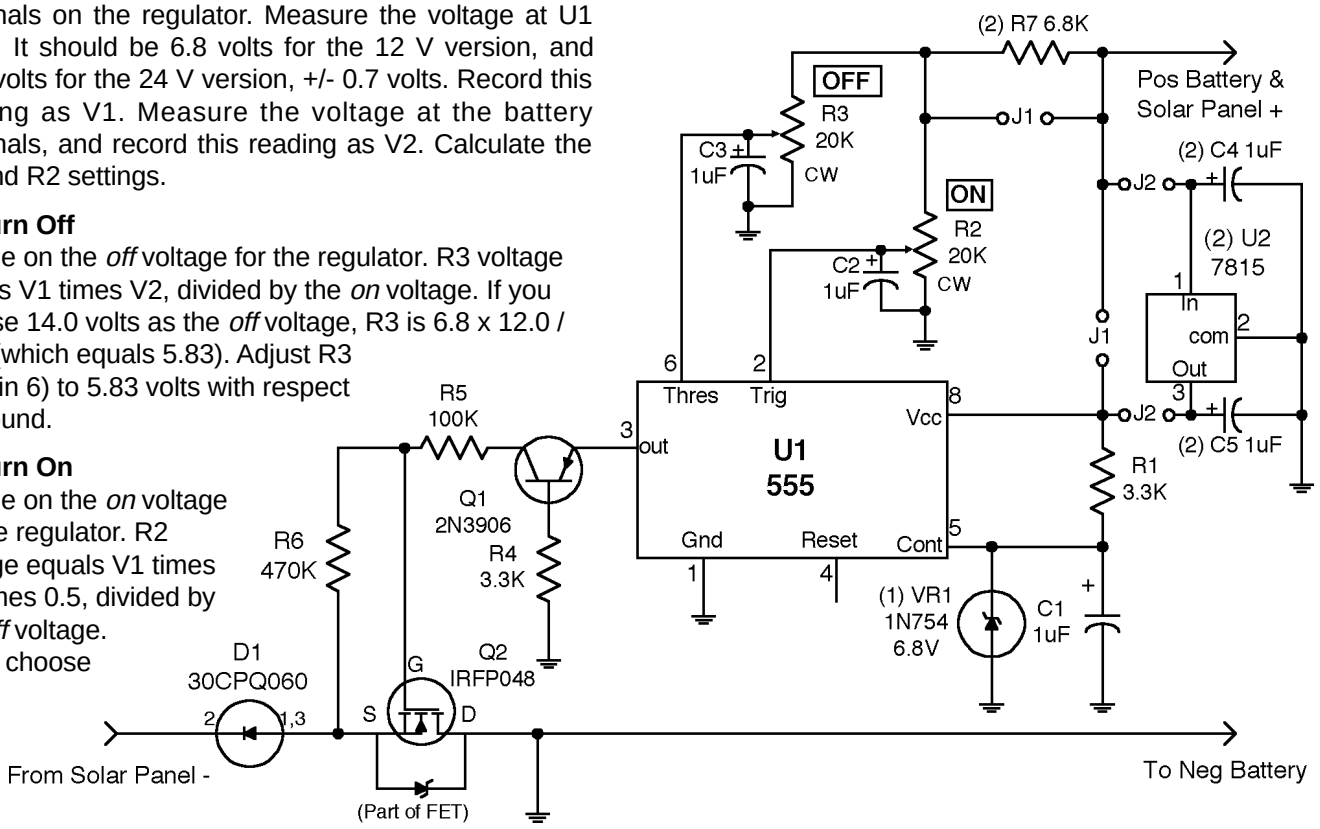
If you have a variable power supply connected to the battery terminals you can verify the adjustments. As you vary the supply above and below the *on* and *off* voltages, you should see U1 pin 3 change from 0 volts to approximately the same as the Vcc (supply voltage) of U1. Do not exceed 18 volts for the 12 V version, or 35 volts for the 24 V version.

Precautions

Do not connect anything to the negative terminal(s) of the solar panel(s) other than the regulator.

It is possible for the regulator to oscillate if the on and off voltages are too close. This is due to the resistance

PV Regulator Schematic



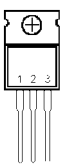
in the wiring from the regulator to the battery. If this occurs, increase the *on* to *off* voltage span and use larger wire from the regulator to the battery. See examples of systems in other *Home Power* articles for safe installation of regulators.

Above: The FET installed.

Parts List

Qty	*Code*	*Description*	*Cost*
1	Q1	2N3906 PNP transistor	
1	Q2	IRFP048 N channel HEXFET	
1	VR1	1N754 6.8 V 0.5W zener diode (1)	
3	C1-5	1µF 25 V electrolytic capacitors (1)	
5	C1-5	1µF 25 V electrolytic capacitors (2)	
2	R1,4	3.3K 0.25W 5%	
2	R2,3	20K ten-turn trimmer potentiometer	
1	R5	100K 0.25W 5%	
1	R6	470K 0.25W 5%	
1	R7	6.8K 0.25W 5% (2)	
1	D1	30CPQ060 30 amp Schottky diode	
1	U1	LM 555 timing circuit	
1		8 pin DIP IC socket	
1	U2	LM7805C or LM340T-15 15 V reg. (2)	
		Total	

Lead Assignments



	Q2		D1		U2
1	Gate	1	Anode	1	Input
2	Drain	2	Cathode	2	Common
3	Source	3	Anode	3	Output
Tab	Drain	Tab	Cathode	Tab	Common

Q2, D1, and U2 have similar style cases

Access

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Sources for parts:

Radio Shack, 100 Throckmorton St., Fort Worth, TX 76102 • 800-843-7422 • 817-415-3011
Fax: 817-415-3240 • support@tandy.com
www.radioshack.com

Digi-Key, PO Box 677, Thief River Falls, MN 56701-0677 • 800-DIGIKEY • 218-681-6674
Fax: 218-681-3380 • sales@digikey.com
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