Home Brew – **Junkbox Multi-purpose Solar Power Regulator** ZS6KR

General The main purpose of regulating a solar panel output is to prevent battery overcharging when left unattended as most panels can reach 17-19V when fully illuminated. With a direct connection the battery is the voltage-determining component in the system and after reaching full charge it will be forced to rise further and cause sever gassing etc.
Consulting various references on the internet and the ARRL Handbook, one can come to the conclusion that there are umpteen possible ways to prevent battery overcharging when a solar charging system is left unattended. Much depends on the power capability of the panel. If consumption more or less equals input then you can connect direct; but if consumption is varied and your panel supplies a constant energy, there must be an automatic disconnection when the battery is full. Conversely the connection must be re-established when the voltage has dropped to a predetermined level. From an electronics point of view, this is a simple voltage detector function.
The author has examined one commercial comparator-type and came to the conclusion that it was a slapped together, poorly designed circuit; giving impetus to start this project and build a controller useful for HF or VHF field operation or to monitor a shack battery charged from a panel outside.

Efficiency A supply voltage rising to 18,8V and only 13,8V being utilized points to a waste of energy while charging. At 4A charging current that means 20W is not utilized. A 60W panel can thus only transfer a maximum of 40W to the battery. This is the price paid when using simple regulators and only switching regulators will give a virtually 95% energy transfer, but are expensive and probably generate considerable noise on your HF radio in close proximity.

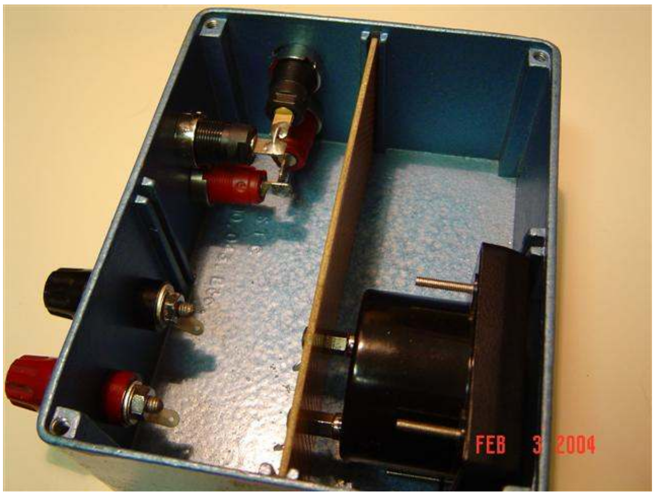
Idle time What to do with available energy after the battery has been disconnected? Charge another battery? It's there for you to use or not to use. More electronics may be needed to again regulate voltage or, if the load is heavy enough like a motor or such-like, the voltage will conveniently drop to 14V or so. The panel is also quite happy when left open circuit. It is even happy when short circuited but is bound to increase its own temperature which makes it inefficient.

Specifications for field use:

1. Srurdy construction with few protrusions
2. Splash proof
3. Charging current indication
4. Battery full indication
5. Auxiliary output after battery is full
6. Unattended operation
7. Direct panel-battery option (attended operation)
8. RF proofing

Junk box consultation: Finding a suitable enclosure is the first step and the author purposely used the ugliest second-hand die-cast aluminium box in stock. Then a suitable meter that would fit was also found as well as banana sockets and a piece of Veroboard to fit across as shown.

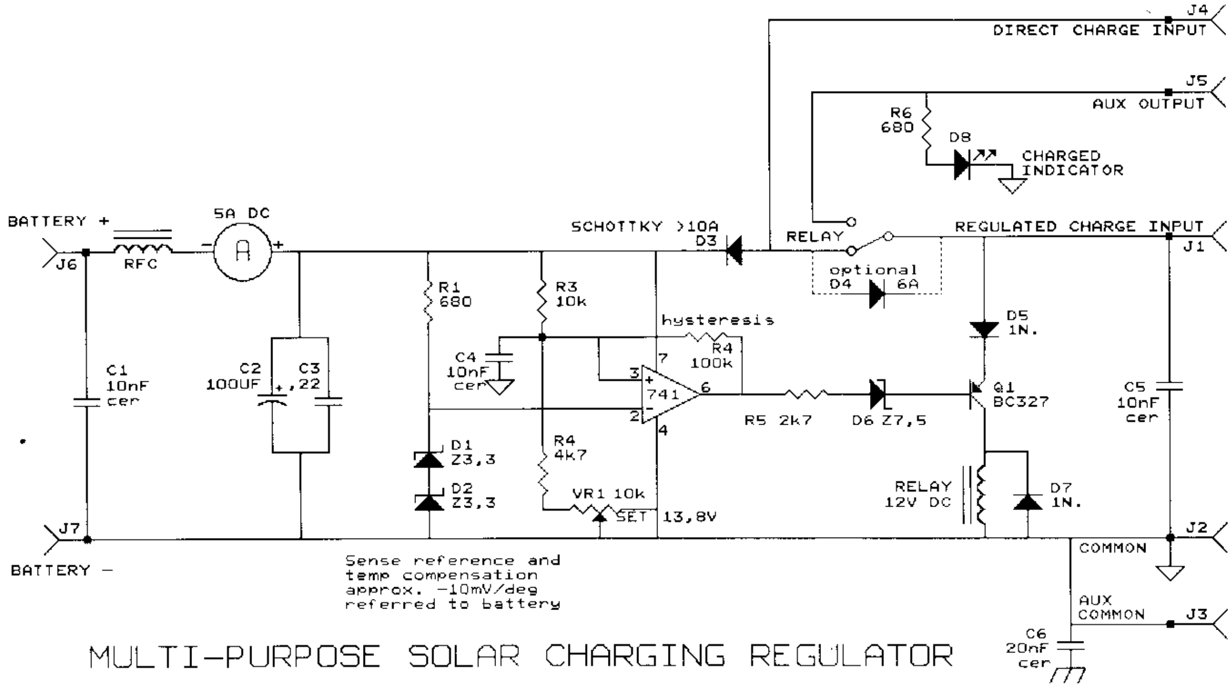
Construction: Doing some reasoning about ergonomic placement of parts, a mechanical layout as shown was decided on. (the electronics is a minor aspect and we first do the dirty work)
Note that the meter is mounted on the Veroboard and two 5mm male-female stand-offs were used to bring its face within 3mm of the box wall. Solder lugs were also added under the mounting screws. The meter is upside-down so that eventually the whole unit uses the box lid as its bottom. The battery terminals were the binding-post type while the panel input and aux output can be ordinary- or Fluke-type banana sockets.
A neat window was made in the box wall for the meter face to show and a piece of 3mm perspex slid in between the meter face and box wall to serve as a protective window.



Electronic design: The circuit is shown on the next page and embodies all the specifications discussed. Starting on the left, we have the battery fed via a 5A DC meter (or a shunted 5mA meter) and ferrite cored choke. Assuming galvanic or induced RF to possibly come in via the terminals, C1, the choke and C2+C3 should be an effective low-pass network.
The comparator is a LM741 referenced by D1+D2= approx 6,6V and battery sensing is done via the network R3,R4,VR1. The output is low when charging. Q1 is thus on, the relay is on and its contacts are engaged as shown. The solar panel supplies energy from J1 via D3. The latter is a high-current type with low voltage drop and serves to isolate the battery when the panel is not outputting power ie: cloud or darkness conditions. Once the battery has reached the trip level as set by VR1, pin6 output goes high, D6 stops conducting, Q1 goes off and the relay switches over to AUX OUTPUT. An LED connected to that indicates to the user that the battery is now full.

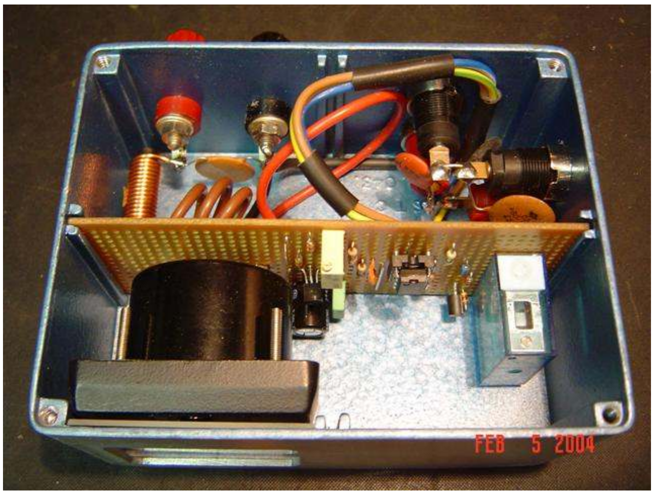
The metal box is not earthed but RF grounded via C6. C5 can kill any RF picked up by the solar panel leads which are usually quite long. Finally, the panel +ve can be plugged in to J4 if so desired and the battery is again charged via D3 and, if the full indication is required, D4 must be fitted to keep Q1 as well as the AUX OUTPUT operational.

Lastly, low value zener diodes have a negative temperature coefficient. The total value for D1+D2 is about -5mV/deg C which, translates to -10mV/deg C at the battery terminals due to the fact that the total zener voltage is half of that of the battery. This is only an attempt at compensation as a 12V battery has a -24mV/deg C characteristic, (-0,1V every +4 deg C) but is better than nothing as encountered in most designs.
Then there is the question of hysteresis. What differential between switch-off and switch-on do we decide on? The author contends that during field-day operation one would want as much energy replenishment as possible, as soon as possible. When using a small solar panel, overcharging is unlikely unless you go for an afternoon nap, and a direct coupling will be ok. Batteries fed by larger panels should rather be regulated but be subject to only a 1 volt hysteresis.



Components: Some hints are in order here:

D3: stripped from old XT/AT PC power supply. These have excellent 15-20A Shottky double diode rectifiers for the 5V supply. They are in a typical 3-legged power transistor type package with two diodes printed on them. Reverse breakdown was measured around 25-30V. The cathode is the centre leg and both outer anode legs can be connected together. Voltage drop is very low around 0,1V. Mounted just under the RHS disc capacitor on the bottom surface. **RFC:** There are many of these to be found in the same supplies in all shapes and sizes. See an example used close to the left box wall.



VR1: anything handy preferably with easily accessible adjustment.

Meter: Was a Minipa 5mA ex-fleamarket with deformed spring that needed considerable TLC. A hole was carefully made into the side of the meter window for the BATTERY FULL LED to be pushed in horizontally. Being inside the box and inside the meter, the LED will be quite visible in daylight. The shunt should be of thick wire to carry 5A and prevent it warming up and so altering the reading. It can be seen coiled behind the meter.

Relay: Ordinary SPDT 12A contacts 12VDC coil (240Ω) PCB mount as shown.

Direct: The direct socket (J4) is not shown and was added as an afterthought. It was mounted directly next to J1.