Parallax Solar Battery Charger for SLA Batteries

Preliminary documentation

How it works

General

The Solar Battery Charger is used to control the charging process of SLA Batteries. It is powered from an assembly of solar panels. For operation, the Solar Battery Charger requires an input voltage generated by a solar panel in the range from 16V to 30V at a current of up to 8A. The Solar Battery Charger is designed for Sealed Lead Acid (SLA) batteries only, with a nominal voltage of 12V.

Power Input/Supply

The solar panel is connected to the unit via the two terminal blocks SOL+ and SOL-. Diode D1 protects the unit from damages in case the polarity of the solar panel is reversed.

An ATTiny26 microcontroller is used to operate the unit, and handle various measurements. This will be described in this text in more detail further below. For the operation of the controller, and an optionally connected Parallax serial LCD display, a stabilized Voltage of 5V DC is required. As the input voltage can vary in a wide range, a switching DC/DC converter with the LM2574 (IC1) is used. This device works over a wide input voltage range, can source up to 0.5A output current, has a thermal shutdown, and current limit protection features, and requires only four external components (C1, C2, D2, L1).

Charging Circuit

The positive pole of the solar panel is connected to the positive battery pole directly with D1 in series. The battery minus is fed through T1, a power FET, and R8, a 0.1 Ohm shunt resistor to the solar panel minus. T1 acts as a low-end switch – when it is closed, the power from the solar panel is fed into the battery. While charging a battery, T1 is periodically turned on and off, where the ratio between on and off times is used to control the average charge current. This so-called “PWM” (Pulse Width Modulated) signal is generated by the microcontroller. The advantage of such a PWM control is that the power dissipation in T1 is minimized compared to a linear mode of operation where T1 would act as a variable resistor.

Photocoupler PC1 is used to interface the 5V PWM signal from the microcontroller to the required gate signal for T1. The Z-Diode D3 together with R2 keeps the maximum source-gate voltage (18V) within the allowed limits, and R6 makes sure that the gate is discharged fast enough when PC1 “opens”.

Monitored Voltages

The ATTiny26 microcontroller comes with an integrated 10-bit A/D converter and an analogue multiplexer, allowing to switch various I/O pins through to the ADC. Here, three voltages are monitored by the microcontroller:

- The input voltage from the solar panel via the voltage-divider R1/R2 applied to the ADC9 input.
- The battery voltage. Actually, while T1 is open, the voltage at the battery minus is fed into the ADC2 input via the voltage-divider R11/R12. The battery voltage is then calculated as the difference between the current solar panel voltage and the voltage measured at this point.
- The average charge current. The voltage across the shunt resistor R8 is proportional to the charge current. A low-pass filter (R7/C3) is used to filter out the PWM signal before entering the microcontroller's input ADC0. When necessary, the microcontroller can be configured so that the ADC0 and ADC1 pins act as inputs of a differential stage with an optional 26 dB (20 x) amplifier. This can be used to "boost up" the low voltage levels across R8. ADC0 acts as the positive input where ADC1 is the negative input, connected to ground in this case.

The Microcontroller – Device Operation

An ATTiny26 (IC2) is used to handle various tasks, like measuring voltages, handling safety issues, controlling the charge process, and handling the user-interface by controlling the indicator LEDs (LED1, LED2, and LED3), reading the optional pushbutton switches (S1, S2, S3), and sending serial data to the optional Parallax Serial LCD display connected to the "LCD" header.

The serial interface for the LCD display requires a precise timing. Therefore, a crystal (XT1) is used to generate the clock signal for the microcontroller, and not its internal RC-clock.

As soon as the voltage from the solar panel rises above 7V, the DC/DC converter (IC1) starts operation, and generates the 5V supply for IC2 which then performs a power-on reset, and begins to execute the control program.

The control program always first enters into an initial mode where T1 is turned off, and the voltage from the solar panel is monitored. As long as this voltage is below a minimum of 16V, no other operation is performed, except blinking the yellow LED (LED2) to indicate low voltage from the solar panel.

When the solar panel voltage (V_{sol}) rises above 16V, the current battery voltage, V_b is determined next. Therefore, the voltage at BATT- (V_{b-}) is measured. V_b is then $V_{sol} – V_{b-}$. Various results are possible that require different actions:

- $V_b = 0V$: There is a short between the BATT+ and BATT- terminals. No charging will be performed, and the red LED1 will blink fast.
- $V_b <= 7V$: The battery connected to BATT+ and BATT- is dead. No charging will be performed, and the red LED1 will blink slowly.
- $7V <= V_b <= 14.5V$: Good battery, charging will be performed as described, further below – the yellow or green LED3 will blink slowly.
- $14.5 < V_b < V_{sol}$: Good battery, no charging required, the green LED3 will be permanently on.
- $V_b = V_{sol}$: There is no battery connected at all, the yellow LED2 will blink slowly.
- $V_b > V_{sol}$: The battery has wrong polarity. No charging will be performed, and the red LED1 will be on continuously.

Besides driving the three LEDs as described above, the controller also sends status information as serial data via pin PA4. So, when a Parallax serial LCD display is connected to the "LCD" pin header, it will show the current status of the unit.

Configuring the SLA Charger

By default, the charger is configured to charge the battery up to a boost voltage of 14.5V, and then maintain a flat voltage of 13.8 where the charge current is limited to a maximum of 4A. Depending on the capacity of the SLA battery, it may be necessary to adjust the charge current, and there might also be the need for changing the settings of the boost and flat voltages.

To modify these settings, three pushbuttons (S1, S2, and S3) are used. S1 acts as the "Mode" selector. Pushing it once, enters the "Set Current" mode, pushing it twice enters the "Set Boost Voltage" mode, and pushing it three times finally enters the "Set Flat Voltage" mode. When one of these modes is selected, the pushbuttons S2 and S3 act as "-" and "+" buttons, allowing to decrease or increase the selected value.

When one of the configuration modes is selected, and after the "-" or "+" button has been pushed at least once, pushing the "Mode" button once again returns the charger back to the normal operation mode. This will also be the case when no button is pushed within a time period of 10 seconds.

When a Parallax serial LCD display is attached to the charger, the selected mode, and the current value will be shown there. The mode and the values are also depicted by various states of the LEDs (on, off, blinking). These combinations are to be defined yet.

The SLA Charger Hardware

The components of the SLA charger are assembled on a PCB sized about 2.65" x 2.65", and all components are through-hole, so the board can be easily assembled by hobbyists.

Terminal block connections for 14 AWG wires are used to attach the battery and the solar panel to the board.

The copper traces conducting the solar and charge currents have been made as wide and short as possible to cover the high current that may flow through them.

The power transistor T1 is located at one side of the PCB, so various kinds of heat sinks may be attached when necessary.