Smart Charger Notes & Assembly Instructions

GENERAL INFORMATION

This battery charger has three modes of operation, **BULK**, **ABSORPTION** and **MAINTENANCE**. To operate the charger, you must first connect the charger to a battery and then apply the AC. The charger then checks the battery voltage through R1 and R2 to see if it should attempt to charge the battery. R1 and R2 sample the battery voltage and operate a CHARGE ENABLE function. If the battery is severely discharged and has a terminal voltage of less than 6.0V (for a 12V battery) the charger **WILL NOT** attempt to charge the battery. Therefore, YOU MUST CONNECT A BATTERY TO THE CHARGER in order TO TEST OR OPERATE the unit.

Provided that the battery voltage is adequate, and a battery is connected properly, applying the AC causes the charger to enter the **BULK MODE** and the **CHARGING** LED will light. In this mode the output current is limited to a bulk value (I_{bulk}) which equals .25V/Rs amperes. While the battery is charged in this mode, the circuit monitors the battery voltage . As the battery accepts charge the current decreases, I_{bulk} is a limiting value.

When the battery reaches 95% of 2.3V per cell, the charger enters the **ABSORPTION** mode and the **FINAL CHARGE** LED will also light. During this mode, both LEDs are lit as the charger attempts to raise the battery voltage to 2.4V per cell while monitoring the current.

When the current tapers down to 1/10 of I_{bulk}, the charger will enter the **MAINTENANCE** mode and both the LEDs will go out. In this mode the charger will maintain the battery at 2.3V per cell. This is **NOT** a TRICKLE CHARGE. The charger will issue **zero** current if necessary. During **MAINTENANCE**, if the battery voltage drops to 90% of full charge, the charger will re-enter the bulk mode and the cycle repeats.

If a load is applied to the battery while the charger is connected, the charger will contribute its' bulk current to the load. If the load discharges the battery sufficiently, the charger will repeat the three state process described above when the load is removed.

This charger can be connected to the battery indefinitely, it will not overcharge the battery.

In order to obtain maximum life from any battery, it is recommended that you discharge at a rate not to exceed C/20 (5% of the A-Hr rating) and charge at a rate not to exceed C/10 (10% of the A-Hr rating), where C is the Ampere-Hour rating of the battery. In normal battery use, hardly anyone adheres to these recommendations.

Since the Electro/Chemical process in any battery is not 100% efficient, you typically must put back 140% of what you take out in order to fully restore the battery. Recharging at a rate of C/10 leads to the familiar 14 hour recharge time quoted by many battery manufacturers.

In the battery industry, the chemistry is constantly being improved. Today most batteries can tolerate a charging current as high as C/5 (20% of the A-Hr rating) without seriously degrading the life of the battery.

I_{bulk} is calculated using the following formula.

$$I_{bulk} = \frac{.25V}{Rs}$$

If you have a small battery, 7 Amp-Hr or less, set I_{bulk} to 1/2 Amp or less. In our small current KITs you can obtain a I_{bulk} of 1/2 Amp by mount only one 1/2 Ω resistor at Rs.

.25V divided by an Rs of 1/2 Ω equals 1/2 Amp. To obtain a I_{bulk} of 1 Amp, mount two 1/2 Ω resistor, one at Rs1 and another at Rs2 .

If you have a larger battery, 7 Amp-Hr or greater, set I_{bulk} to 1 Amp or greater. The maximum current available depends on the KIT you have. Refer to the component layout and parts list for specific details.

Larger batteries may be charged with this charger by simply allowing more recharge time. Boats equipped with two 80 Amp-Hr batteries, which see intermittent use, are being successfully maintained with our 1 Amp charger.

1.0 - CIRCUIT BOARD ASSEMBLY

1) Read the **"GENERAL KIT ASSEMBLY INSTRUCTIONS"** supplied with the kit. These instructions will explain how to assemble the printed circuit board.
2) Next, read these instructions **(Smart Charger Assembly Instructions)** completely from start to finish **before starting construction.**
3) Assemble the circuit board by installing only the **required** board mounted components at this time.

NOTE : The circuit board can be used to make different versions of the charger. Refer to the component layout, schematic and parts list for the details of the specific charger you are working with.
Not all parts are used with every version of the charger.
Not all jumpers (J1 through J6) are used with every version of the charger .

2.0 - OFF BOARD COMPONENT PREP

A easy way to shrink heat sensitive insulation is to " Flip your BIC". Using a low cost lighter will do an adequate job in just fractions of a second. Use care, of course, not to burn the insulation.

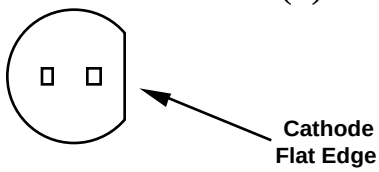
2.1 - Q1

1) Cut the leads of Q1 so that all three leads are about 1/2 inch long.
2) Connect a 2 inch long RED wire to the Base of Q1. Refer to the component layout for a sketch showing the orientation of Q1. Start by stripping 1/4 of an inch off one end of the wire. Lay this wire parallel against the base lead of Q1 and solder. Then insulate this junction with a 1/2 inch length of shrink tubing. The free end will connect to the circuit board
3) Repeat the above using a 2 inch length of WHITE wire for the collector of Q1.
4) Repeat the above using a 2 inch length of BLUE wire for the emitter of Q1.
5) Cut the free end of these wires so all three are the same length. Strip 1/8 of an inch and tin the end. Connect the three wires to the circuit board. RED to PAD #1, WHITE to PAD #2 and BLUE to PAD #3. Q1 will mount to the rear wall of the enclosure after the board is installed.

2.2 - LEDs

NOTE: In our typical charger, only 2 LEDs are used.
A **Green** LED for CHARGING - **DSc**.
A **Red** LED for FINAL CHARGE - **DSf**.

1) Cut both leads of each LED so that they are about 1/4 inch long. The Cathode (-) of a LED is identified by a flat spot on the plastic housing. The other lead is the Anode (+).



1) Connect a 6 inch length of **BLACK** wire to the **CATHODE** of DSc, the **Green** LED. Strip 1/4 of an inch off the wire, lay this wire parallel against the cathode lead of DSc and solder.
2) Repeat the above using a 6 inch length of **Green** wire for the **ANODE** of DSc, The **Green** LED.
3) Cut the free end of these wires so they are both the same length. Strip 1/8 of an inch and tin the end. Connect the wires to the circuit board. Green to PAD #C+, Black to PAD #C-. DSc will mount to the front wall of the enclosure after the board is installed.
4) Next connect a 6 inch length of **BLACK** wire to the **CATHODE** of DSf, the **Red** LED. Strip 1/4 of an inch off the wire, lay this wire parallel against the cathode lead of DSf and solder.
5) Repeat the above using a 6 inch length of **Red** wire for the **ANODE** of DSf, The **Red** LED.
6) Cut the free end of these wires so they are both the same length. Strip 1/8 of an inch and tin the end. Connect the wires to the circuit board. Red to PAD #F+, Black to PAD #F-. DSf will mount to the front wall of the enclosure after the board is installed.

2.3 - TRANSFORMER

1) Cut all three secondary leads (RED/WHT - WHT - RED) of the transformer to a length of three inches. Strip 1/8 inch off each lead and tin. Save the wire, it will be used later. Do not connect these leads at this time.
2) Cut both primary leads (BRN - BLK) of the transformer to a length of 5 inches. Save the wire, it will be used later. **DO NOT** TIN these leads.

3.0 - MECHANICAL ASSEMBLY

1) Mount the transformer into the enclosure with the primary leads (BRN - BLK) towards the front. Secure with 6-32 X 5/16 screws from the outside of the chassis and 6-32 Kep nuts inside the chassis. Kep nuts have a lockwasher attached.
2) Install the AC switch in the front panel cut-out. Orient the switch so two lug are towards the top of the enclosure and one lug is towards the bottom.
3) Mount the two fuse holders in the rear panel. The soft white washer mounts on the inside of the enclosure against the metal wall. Orient the fuse holders so that the side lugs face inward. **CAUTION**, these side lugs do rotate slightly when a fuse is inserted or removed. **DO NOT FACE THESE LUG OUTWARD OR UPWARD**, they may (when rotated) contact the enclosure top and short out.

4.0 - CIRCUIT BOARD INSTALLATION

1) Mount the four Male-Female stand-offs to the bottom side of the circuit board with the Male threads through the board. Secure the board to the stand-offs with a #4 Kep nut on the top side of the board. Kep nuts have a lockwasher attached.
2) Connect a 4 inch length of RED wire, salvaged from the transformer secondary, to the (+) OUTPUT pad of the circuit board.
3) Attach the OUTPUT cord to the enclosure using the grommet provided. Install with 4 - 5 inches of cord inside the enclosure. Separate the two conductors.
4) Position the circuit board over the power transformer, inverted (components facing down) with Q1 “hanging" down outside the front of the enclosure. Connect the three transformer secondary leads to the circuit board at this time. RED/WHT to PAD #T1, WHT to PAD #T2 and RED to PAD #T3.

NOTE: The OUTPUT cord has one conductor that is "RIBBED" and one conductor that is SMOOTH. All zip cord is marked in this way. We will use the "RIBBED" conductor for the NEGATIVE output and the SMOOTH conductor for the POSITIVE output.

5) "Flip" the circuit board over (components facing up) and connect the "RIBBED" (NEGATIVE) output lead to the board, (-) OUTPUT pad.
6) Position the board down into the enclosure and secure the four Male-Female stand-offs to the chassis. Use 4-40 X 1/4 screws with lock washers **under the screw heads** on the **outside** of the chassis.
7) Connect the RED (+) output lead from the circuit board to the end lug of the output fuse holder. Connect the smooth (POSITIVE) lead of the output cord to the side lug of the output fuse holder.
8) Mount the LEDs into the front panel by first installing the LED clip into the panel from the outside, then installing the LED into the clip from the inside.
9) Mount Q1 to the rear wall using the insulation hardware supplied.

NOTE: There are extra holes on the rear panel. Use the uppermost, center hole for mounting Q1

Check the mounting surface on the inside of the enclosure, make sure it is free of any burrs. The mica insulator should rest smoothly against the inside surface. Q1, the 4-40 screw, Mica insulator and insulated shoulder washer are all inside the enclosure. The flat washer, split ring lockwasher and nut are on the outside. Tighten the nut only so that the split ring lockwasher is completely compressed, **not too much harder**. The leads of Q1 may point slightly to either side. Q1 DOES NOT have to be mounted vertically.

NOTE: At this power level, conductive thermal grease is not required.

5.0 - FINAL ASSEMBLY

NOTE: The INPUT AC cord has one conductor that is "RIBBED" and one conductor that is smooth. We will use the "RIBBED" conductor for the AC Common and the SMOOTH conductor for the AC Hot.

1) Attach the INPUT AC cord to the enclosure using the grommet provided. Install with 6 - 7 inches of cord inside the enclosure. Separate the two conductors.
2) Connect the SMOOTH wire of the input cord to the side lug of the input fuse holder.

NOTE: For the next few steps, we will refer to the lugs (#1, #1a and #2) on the AC switch. All references are made viewing the switch **from the REAR**. See SKETCH on Component Layout Drawing

NOTE: The FASTON lugs are intended to be crimped to the wires. If you do not have a crimping tool, you may solder the wires to the FASTON lugs. Use care if soldering.
Do not let the wire and/or solder protrude and interfere with the lug attachment area.
The Red FASTONS will have one wire attached.
The Blue FASTON will have two wires attached.
DO NOT, repeat, **DO NOT SOLDER** the wires directly to the AC switch, it will be damaged.

NOTE: The FASTON lugs are a very snug fit and require a bit of care when installing **onto the switch**. Suggest you hold the switch firmly and "wiggle" the FASTON as you install it.

3) Combine the BROWN wire of the transformer and the RIBBED end of the input AC cord together and attach the Blue FASTON lug. Connect this FASTON to terminal **# 2** of the AC switch.
4) Connect the BLACK lead (salvaged from the power transformer) to the end lug of the input fuse holder. Install a Red FASTON lug to the other end. Attach this FASTON to terminal **# 1a** of the AC switch.
5) Connect a Red FASTON lug to the BLACK primary lead of the transformer. Attach this FASTON to terminal **# 1** of the AC switch.
6) Connect an alligator clip, with RED insulating boot, to the smooth (POSITIVE) output wire.
7) Connect an alligator clip, with BLACK insulating boot, to the "RIBBED" (NEGATIVE) output wire.
8) Install the proper input and output fuses. Refer to the parts list for the proper values.
9) Attach the four rubber feet to the bottom of the enclosure. Attach the top to the chassis with the ventilating cutouts toward the rear, secure with four self-tapping sheet metal screws. Construction is now complete.

OPTIONS

1) The CHARGE ENABLE function may be defeated by NOT installing R2. Use caution when operating under these conditions. If you have a reversed and/or damaged cell in your battery, the charger will stay in the BULK mode forever.

2) An auxiliary DC source can be connect via the AUX and GND pads. D3 in combination with BR1 form an "OR" gate. A typical application is solar cell (isolated by D3) in day use and generator derived AC Voltage at night. The raw DC applied to C1 is solar "OR" generator, depending on which is the higher value. Generator off during the day and solar has very low or no output at night. Automatic switch over provided by the "OR" gate interconnection. If your solar panel has an isolation diode built in, replace D3 with a shorting jumper.

3) An optional DC power indicating LED may be installed using DSp and R3. When the DC voltage to the chip is greater than 8 volts, pin 7 is at a low (short to ground) and the LED will light.

4) **This charger circuit presents a DC load of only 175 µ A when the AC is off or not present.** For extremely remote sites, subject to loosing AC power, and requiring the absolute minimum load on the battery, J4 to J5 may be used in place of J5 to J6. When the DC input voltage to the chip is less than 8 volts, pin 7 is an open circuit and the sensing networks of RA, RB, RC and R1, R2 are disconnected from the battery. Under these conditions, the load on the battery is extremely small, usually non-measurable leakage. R1 and RA are typically in the 100KΩ range so the normal load produced by the sensing networks is already quite low, so use this option only if necessary. If you use this option, DO NOT use the DSp LED.