UltraSmartCharger^{TM}

User Guide

Version 1.1

Covers:

Charger board versions 1.07 and 1.08
Firmware versions 0.524+

Contents

Welcome

Thank you for your support of the UltraSmartCharger project! This guide is intended to get you up and running quickly with the many features of this device. Remember this charger does so much more than simply charge your batteries; you can finally take charge (no pun intended) of the health of your rechargeable batteries in order to get the most quality use of them, thus saving you money and helping the environment. Suggestions for improvement of this guide are always welcome. Thanks again and enjoy!

Functionality

The UltraSmartCharger does more than just charge your batteries! It can fully discharge then recharge them, ensuring health and long-term stability. It can also analyze batteries, following a cycle of multiple charges and discharges. The analyze feature is great for determining whether the battery still holds the manufacturer's stated capacity (usually stated in mAh – milli-Amp hours) after repeated uses.

The Charger can charge one battery while discharging or analyzing another, or any combination of the three available modes! You set the function to perform individually as you insert batteries.

The Charger will only charge AA size, 1.2V Nickel-Metal Hydride (NiMH & NiCd) and 1.6V (NiZn) type batteries. This charger is not designed for charging or analyzing Lithium Ion batteries – inserting them into the charger may damage your charger.

All activity on the charger is logged to an SD card you provide, and is simultaneously output serially via the FTDI connector for viewing on your computer.

Board Overview

Optional External Load

Mode Switch

Charge Current

Select Button

GND Pin (forgot silk screen)
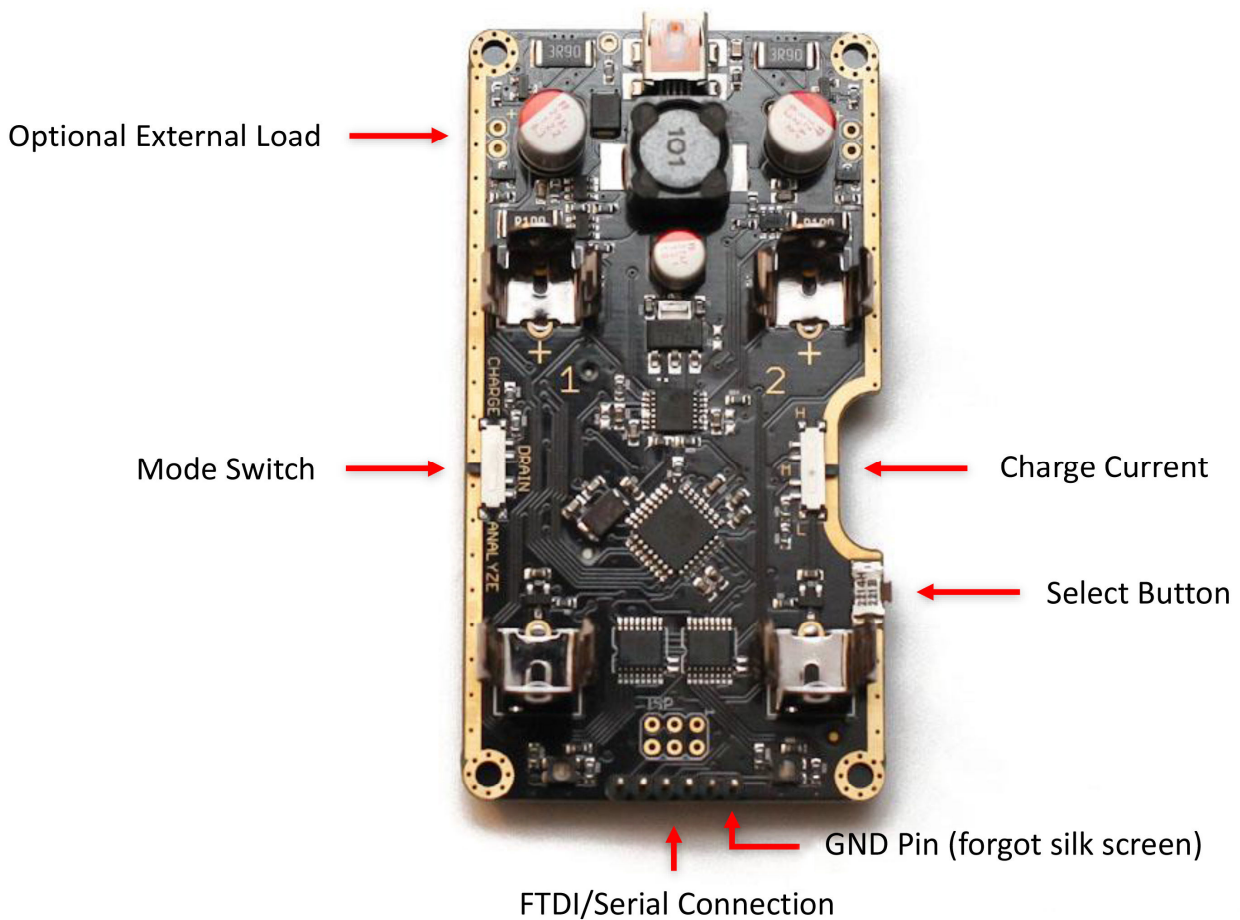
FTDI/Serial Connection

Figure 1: Charger topside view with annotations

Figure 1 gives a general overview of the unit's appearance, and highlights many of the elements you will be interacting with regularly. Let's give them all a quick description:

Mini USB Connection (not labeled)
At the top of the board is the Mini-USB connector for powering (only – no data connection) the charger under normal use. You will want to use a regulated 5V power source with up to 1A current capacity. The circuit can charge with up to 2A, but this power to be supplied through an extra header pin.

Optional External Load (left side indicated, also on right side)
The two sets of two solder points outboard of the round capacitors near the USB connection are for connecting wires to external discharge loads. What does this mean? You can hook up a much higher wattage resistor or other load than the onboard circuit uses to increase the speed at which the unit discharges a battery (either in the discharge mode or the analyze mode).

Charge Current Switch (right side)

Midway down the right side is the charge current switch. High (H), Medium (M) and Low (L) settings are available. High charges as 950 mA , Medium at 475 mA, and Low at 190 mA (these are all effective rates). There is only one charging circuit on the board, which switches between the two batteries when both are present and set for charging on medium and low modes – High mode charges only one battery at a time. Read more about this in the Mode Selection and Operation section of this guide.

Mode Switch (left side)

The Mode Switch allows the selection of what you would like to do with each battery in the charger. That's right, you can have the unit charge, drain, or analyze each battery independently. See the section on Mode Selection and Operation for exactly how this works.

Select Button (right side, just past the SD card insertion notch)

This button works with the mode switch to determine exactly what you would like to do with each battery you insert. For instance, a one-second push with the Mode Switch in the 'discharge' position will cause a cycle of 'discharge then charge'. More detail and a list of all your options is in Mode Selection and Operation, later on in this guide.

Battery Clips (two sets, labeled 1 and 2)

Insert your AA (HR6) size batteries (the only size this charger will accept) into the clips with the positive end near the number or "+" indication. The clips will be stiff and will take a bit of force to snap each battery in. Make sure to keep your hands free of the circuit board when you do this so that you do not pinch your fingers or scrape across the board, possibly removing a component. Be careful removing batteries also, they tend to like to fly out once free of the springy clips! You may insert one or two, and each will be treated independently based on the mode switch position when it is inserted.

FTDI Connection / Ground Pin (bottom of board)

The FTDI connection is for capturing data via serial connection during use, and for reprogramming the board with upgrades or enhancements (ours or your own!).   The silkscreen is missing on v7 boards (the initial production run as delivered to Kickstarter backers), but the GND pin is to the right as shown in Figure 1.   For more information on the FTDI connection, see the 'Reprogramming' section.

ICSP (or simply ISP) Header (near bottom of board, between the negative end battery clips and just above the FTDI conection)

The In-Circuit Serial Programming points – unpopulated with headers at delivery - is for reprogramming via a 2x3 pin cable programmer versus inline FTDI implementations. Both the FTDI header and the ICSP support the same functionality and neither has advantages over the other for the UltraSmartCharger. Use whichever you feel most comfortable with.

To use ICSP, simply solder in the male headers and connect your programmer with the number 1 pin on your connector to the upper-right corner, as viewed in Figure 1. You could also use POGO pins to reprogram via the ICSP, if you desire.

SD Card Slot (bottom of board, not pictured except for finger notch on right side)

The UltraSmartCharger has an SD card slot on the bottom for logging its activities. The file created will be named 'DATA.CSV' and have a date stamp of Jan 1, 2000, 00:00

every time, due to not having a real-time clock on board. This is not normally a problem, as multiple uses of the charger will simply append data to the file, and each cycle will identify itself with a 'cell detected' message. Additionally, each power cycle/reset event will result in a new line of the file appended with wording about the hardware and software versions you are using.

If you wish to keep separate logs for each battery you have, it is suggested that you label them (Dymo labelmakers are one good choice) and move the file off the SD card after each use – or at least rename them, so that you do not end up with a huge text file to sort through. Note that the charger has no way of telling which of your batteries you inserted, so be careful to rename the log files to reflect which battery or batteries were in the charger for that cycle.

Please note that only SD cards of up to 2GB in size and formatted with FAT16 (standard format for this size) are supported in this charger. Several hours of logs add up to between five and seven MB, so even a 2 GB card is plenty to dedicate for use with your UltraSmartCharger!

Mode Selection and Operation

This section includes a description of all the possible modes of the UltraSmartCharger and how to select them. It includes everything in the Quick Start Guide plus some additional detail. Please read through this section if you are having problems or if the unit is not functioning as you thought it should before checking the online forums for help. Many times the answer will be right here!

Mode switch position:

- Charge:
    - Short press: Normal Charge.
    - Medium press: Attempt to revive a dead battery then normal charge.

- Discharge:
    - Short: Discharge Only.
    - Medium: Discharge, then Charge.
    - Long: Discharge, Charge, Discharge, Charge.

- Analyze:
    - Short: Charge, Discharge, Charge.
    - Medium: Charge, Discharge, Charge, Discharge, Charge.
    - Long: Charge, Discharge, Charge, Discharge, Charge, Discharge, Charge. (Charge, then 3 full cycles)

Button Press/Push Duration Definitions:

- A short press is one that is less than 1/4 of a second.
- A medium press is one that is for about 1 second.
- A long press is one that is for 3 seconds or longer.

Step-by-Step Actions for Use:

1. Insert an SD card to enable logging.
2. Set Mode and Charge Current switches to desired positions.
3. Insert Battery/Batteries.
4. LED(s) will light up white to indicate that batteries are detected and waiting for a button press.
5. As soon as the button is pressed, the LED will go out.
6. Depending on the duration of the button press, the charger will operate as described above.

If after inserting a battery, the button isn't pressed within 10 seconds, the charger will default to the same mode as if there was a short button press. After the button is released, the LED will flash white a number of times to indicate which duration button press it detected: 1 = Short, 2 = Medium, 3 = Long.

You can set separate modes for each cell - e.g. you can set 1 battery charging, change the mode switch and set another one discharging or analyzing at the same time. To reset what you want to do for a particular battery, remove it, wait a few seconds, and then change the mode switch if needed, reinsert the battery and press the button appropriately. This will not affect the other battery's mode. Alternatively, you can cancel the current operation on both channels by quickly pressing the button 3 times in a row – the LEDs will change to purple to indicate that the current operation has been cancelled.

Bad Battery Detection

Before starting to charge a battery, the charger will test the cell to ensure that it is suitable for charging (attempts to reject non rechargeable cells such as Alkaline and Carbon Zinc batteries) If the internal resistance is too high, the charge will be aborted and a purple indication will be shown on the LED. If the cell voltage is too high, it will be rejected as being full (flashing green) To override this condition and recharge a battery anyway, simply repeat the button press for the same duration as before and this will override the bad battery detection for this one time only. When charging high resistance cells, the charging current will be automatically reduced as required.
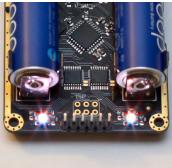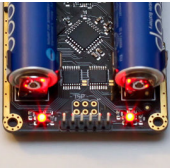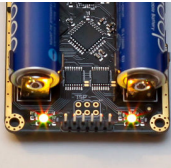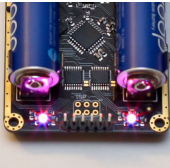
LED Indicators
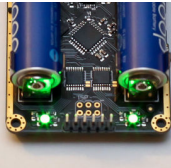
Waiting for Button Press	Charging	Discharging	Bad Battery	Done!
White	*Red*	*Yellow*	*Purple*	*Green*

Table 1: Charger LEDs showing various states

Table 1 shows the various states the charger is normally in and the corresponding colours you will see from the LEDs. Note that these examples all show the same state for both batteries, but since you can select a different mode for each battery (one charging versus the other analyzing/discharging).
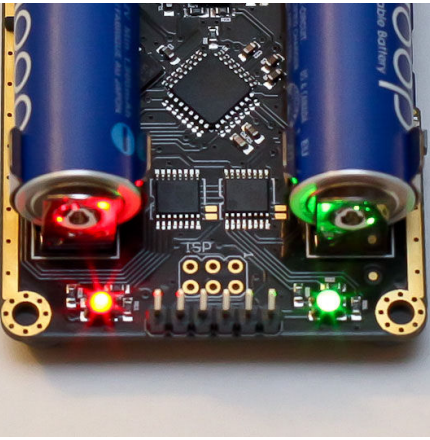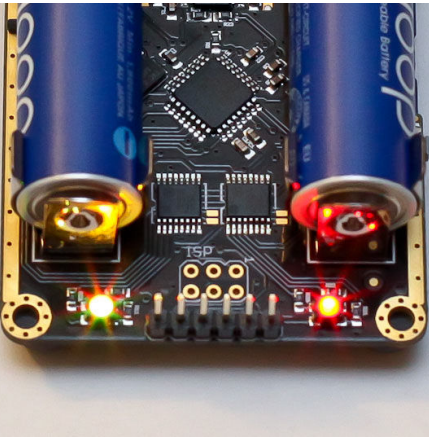
Examples of this follow.

Left: Charging, Right: Done!	Left: Discharging, Right: Charging
Red / Green	*Yellow / Red*

Table 2: Examples of dissimilar states for left and right batteries

Color	Meaning
Off/Black	No Cell detected/Activity Paused
White	Cell Detected
Red	Charging
Yellow	Discharging
Green	Charging Complete
Aqua	Discharge Complete
Purple	Error – e.g. IR too high, Exceeded Capacity Limit, Over Temperature Limit, User Cancel.
Flashing Green	Already Full
Flashing Blue (Slow)	Waiting to Charge
Flashing Blue (Fast)	During Startup: No SD Card Detected
Alternating Red/Green	Top Off Charge
Alternating Red/Purple	Charging very slowly due to high Internal Resistance

Table 3: Common LED Colors

Updating the Firmware

From time to time, updates to the computer code running the UltraSmartCharger will be released. This will be typically through Paul Allen's website at http://www.paulallenengineering.com or at the user forums at http://www.ultrasmartcharger.com.

Most updates will be bug fixes or feature updates. Bug fix updates are recommended for all to download and install (in this case, flash) to the Charger. Feature changes are optional and you may choose to not use these and keep your charger working the same way.

The GND pin can also be remembered as being nearest battery clip #2 or, as viewed from the bottom of the board, the closest to the Open Hardware logo.

You will need an Adafruit FTDI Friend, SparkFun FTDI Basic Breakout or similar. It is best to use an FTDI board running at 3.3V as that is the voltage that the controller on the charger operates at. If you only have a 5V FTDI board, you can still use it to update the firmware on the controller, however it's not recommended to use it for monitoring data out of the charger as it will cause the controller to run at 5V and this will cause the temperature readings to incorrect.

Modifying Charger Operation

As the charger firmware is open source, advanced users are able to modify the source code and adjust any aspect of the charger that they wish.

For other users, a configuration tool is available from the UltraSmartCharger web site which can be used to modify almost all aspects of the charger operation – e.g. charging currents, capacity limits, etc. The configuration tool saves the modified settings to a file which can then be copied on to the SD card – the charger will then read that file during startup and adjust its operation to suit. More information can be found on http://www.ultrasmartcharger.com

Caveats

- When Charging NiZn batteries, it is recommended that you use the "High" charge rate mode. Lower charge rates are done by alternating charging for 5 seconds and then resting for 5 seconds – this can lead to voltage and current fluctuations with some cells and may lead to the cells not terminating correctly.
- When connecting an FTDI board to the charger, the charger may reset when connecting to the virtual COM port or when Windows restarts – this is due to the feature required to restart the controller when updating the firmware. A workaround for this is to not connect the FTDI board directly to the charger, but instead use Male to Female jumper leads and only connect the ground, RX and TX pins. The DTR line should be left disconnected except when you are wanting to update the firmware. If you are using a 5V FTDI board, ensure that the 5V line is also connected so that the controller isn't running at a lower level than any of the lines coming from the FTDI board.
- If the USB power source isn't able to supply enough current, the charger will reset during charging. If you check the log file, this will be confirmed by a line that says "Brown Out." A USB port that can supply 500mA will normally be good enough for charging at the normal maximum charging rate.