

Astro Flight #123 Lithium-Ion Digital Charger/Discharger for A123 battery packs software version 1.2

Thank you for choosing our Astro Flight Battery Charger. You have just purchased a charger made especially for the A123 lithium Ion cells. With proper care it should give you many years of service. **Before using this unit, please read these instructions carefully.** The Astro Model 123 Lithium Ion Charger is specially designed to charge and discharge A123 Lithium Ion battery packs. This charger can handle any pack containing from one cell up to 10 cells in series(3.6 volts to 36 volts). Cells may be arranged in parallel to increase the battery pack capacity. For example a 4s4p pack of 2300 mahr cells will have a voltage of 14.4 volts but a capacity of 9200 mahr. **All cells in a single battery pack must be of the same capacity and in the same state of charge.**

The Model #123 Lithium charger uses a proprietary 8 bit microprocessor to perform all of the necessary mathematical computations required to insure foolproof charging and discharging Lithium Polymer battery packs. A two line digital display indicates the status of the charging sequence and shows you the charge current, the number of cells in the battery pack, the battery voltage, the duration of the charge, and the actual number of milliamp hours of charge put into the battery pack. A built in voltage converter boosts the input from 12 volts to 40 volts so that battery packs containing one to nine cells can be charged. This charger is designed to be powered from a 12 to 15 volt regulated power source. We recommend using our Astro Model #120 power supply or your 12 volt automobile battery. **Never use an automobile battery charger as a power source, for it could damage your new Model #123 Lithium Charger.**

Safety warning!!! Always stand by your battery while it is charging. Never charge inside your vehicle from the cigarette lighter outlet nor any other power outlet. These cannot provide the proper power required. Even more importantly if the battery fails and catches on fire your vehicle may be damaged. Do not charge under the hood. We have provided a 4 foot cable that should reach from auto battery to the ground. Charge with both charger and battery on the ground with battery away from vehicle. There are two power cords on the charger/discharger. The four foot long cord with the alligator clips is the **input cord** and should be connected to the 12 volt power source. The short cord is the **output cord** and is fitted with a Deans Ultra Connector. Connect the **output cord** to the Lithium Ion A123 battery being charged or discharged. The charger has a current adjust knob on the front panel. Charging current can then be adjusted between fifty milliamps and eight amps. Discharging current is electronically limited to 1.25 amps.

Six messages are displayed during a normal charging sequence.

1. The amount of charging current flowing into the battery pack.
2. The number of cells the charger “thinks” the battery contains.
3. The charging mode.
4. The voltage of the battery being charged.
5. The duration of charge in hours, minutes and seconds.
6. The number of milliamp-hours of charge put into the battery pack.

When the Lithium charger software detects fully charged condition, charging will automatically stop. The digital display will indicate the maximum battery voltage reached, the duration of the charge and the total milliamp hours of charge delivered to the battery. The buzzer will then beep three times.

Three messages will be displayed during the discharging sequence.

1. The voltage of the battery packs being discharged.
2. The duration of the discharge in hours, minutes and seconds.
3. The total number of milliamp hours delivered to the load.

When the Lithium Polymer battery has been discharged to a voltage of approximately 3 volts per cell, the discharging will automatically stop.

Charging your Lithium Ion A123 Battery

Connect the alligator cords to a 12 volt regulated power supply, like our Astro Model 120, or a 12 volt automobile battery. After a few seconds the digital display should first announce “**Astro Flight Lithium**” and the software version **V1.2** then after 3 seconds the display will change to “**waiting for battery**”.

Wait for the display to say “**waiting for battery**” then connect the short output cord to the Lithium Polymer battery you wish to charge. The charging sequence will automatically begin. If your battery is not connected, has a loose connection, is connected backwards, or is drained to less than 2.7 volts, the microprocessor will not detect the battery and “**waiting for battery**” will still be displayed. If your battery is properly connected, the display will begin indicating the charge current, the battery voltage, the duration of the charge and the milliamp hours delivered to the battery. **Always start charging with the current adjust at zero amps and slowly increase the charging rate until the rate equals the capacity of the battery pack.** We recommend charging Lithium Polymer batteries at a 1C rate (a rate equal to the mahr. rating of the cells). For example, we recommend charging a 2300 mahr pack at 2.3 amps. After a few minutes the charging current may decrease slightly as the battery voltage rises, so you may want to re-adjust the rate.

During the first few seconds of charging the display will show the charging mode and the number of cells that the micro processor **thinks** are in the battery pack. The display will read 1C1 on a single cell, 2C1 on two cells and 3C1 on three cells etc.

Warning!!! If the display reads more cells than your battery contains STOP AT ONCE!!!! Something is wrong. Your battery could have a damaged or high resistance cell, it could already be fully charged, or you could be trying to charge too fast. Turn the current back to zero and try to determine what is causing the problem.

The Cell count is fixed at the beginning of Phase 1, but the charger will continue charging your battery **for 30 seconds** regardless of the battery voltage. It acts like a dumb charger during this first phase. This is necessary in order to be able to charge packs that have been discharged to a very low voltage. For this reason it is not recommended that you charge a pack that is already full charged. If you do this your charger will charge for about 1 ½ minutes before turning off and you will slightly over charge your cells. If your pack voltage is over 3.5 volts per cell it is almost full, there is no need to charge it further.

The resting voltage of **A123 Lithium Ion** cells is a very accurate indication of their state of charge. A cell voltage of 3.1 volts indicates that the cell is almost empty. A cell voltage of 3.4 volts indicates that the cell is a little more than half charged. A cell voltage of 3.6 volts indicates that the cell is fully charged

Warning! If your battery is already charged do not try over charge it.

- A fully charged single cell will have a voltage of 3.55 to 3.60 volts
- A fully charged 2 cell pack will have a voltage of 7.10 to 7.20 volts.
- A fully charged 3 cell pack will have a voltage of 10.65 to 10.80 volts.
- A fully charged 4 cell pack will have a voltage of 14.20 to 14.40 volts.
- A fully charged 5 cell pack will have a voltage of 17.75 to 18.00 volts.
- A fully charged 6 cell pack will have a voltage of 21.30 to 21.60 volts.
- A fully charged 7 cell pack will have a voltage of 24.85 to 25.20 volts
- A fully charged 8 cell pack will have a voltage of 28.40 to 28.80 volts
- A fully charged 9 cell pack will have a voltage of 31.95 to 32.40 volts.
- A fully charged 10 cell pack will have a voltage of 35.50 to 36.00 volts

After 30 seconds the charger automatically switches from Mode 1 to Mode 2. During mode 2 the charging current will turn on and off at one minute intervals. The charging current will continue for 59 seconds then turn off for 1 second. This charging sequence is depicted on the drawing on page 5. The Mode 2 charging cycle will continue until the battery voltage reaches 3.6 volts per cell. If the battery was more or less empty, mode 2 will last about 45 minutes. At the end of mode 2 the battery will be about 95% full and the Model 109 Lithium charger will then switch to Mode 3.

In Mode 3 the charging current is turned on and off periodically. You will notice that the battery voltage goes slightly above 3.6 volts per cell when the charging current is on and slightly below 3.6 volts per cell when the charging current is off. The micro processor slowly decreases the charging duty cycle as the resting cell voltage approaches 3.6 volts per cell. This charging sequence is depicted on the drawing on page 5. When the resting battery voltage reaches 3.6 volts per cell, the battery is declared charged and charging stops.

After charging is complete, the digital display will indicate that the battery charging is complete. The display will show the highest resting voltage reached and the number of milliamp hours of charge put into the battery.

Discharging your Lithium Polymer Battery

You can use the discharge function to measure the capacity of your battery. **First fully charge the battery** then after it is fully charged disconnect the alligator

Clips to the power source then reconnect the alligator clips to your 12 volt power source. Discharging will automatically begin.

During Discharge the digital display will indicate battery voltage, duration of discharge in hours, minutes and seconds, and the milliamp hours delivered from the Lithium Polymer battery to the electronic load in the charger.

When Discharge is complete the discharging will automatically stop. As long as the pack remains connected, the display will be frozen with the values of final discharge voltage and the number of milliamp hours taken from the pack. **To go back to charging**, remove the battery pack, wait for the display to say **“waiting for battery”** and then connect the next battery.

Error Messages

“Over voltage error”

The **“Over Voltage Error”** message is displayed if a battery pack with more than 39 volts connected to the charger. A battery containing 10 cells should be less than 39 volts.

The **“Batt Fault”** may be displayed If the battery is disconnected while it being charged and the charger attempts to charge an open circuit. This is very likely to occur if the charging current is higher than three amps.

The **“Batt Fault”** will be displayed during mode 2 or model 3 if the battery voltage goes above 4.3 volts per cell based on the cell count detected in mode 1.

If you see the **“Over Voltage error”** message, it means that charging has stopped and the charging sequence is frozen. Please remove the lithium battery pack and disconnect the alligator clips from the 12 volt power source. Then set the charge current to minimum and reconnect the lithium battery. If you have modified your charger to a different connector, please check to make sure that the polarity of your connector is correct and that you have done a good solder job. Wiggle all connections just to be sure.

“Shorted Output”

The **“Shorted Output”** message will occur if the lithium battery voltage drops below 3 volts while charging. This should never happen on a good lithium battery. You either have a bad connection, or a bad battery. Another possibility is that you have long wires between the charger and the battery. These wires should be no longer than 1 foot. Find out what is wrong before proceeding.

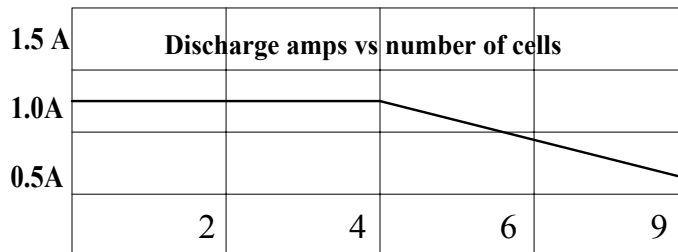
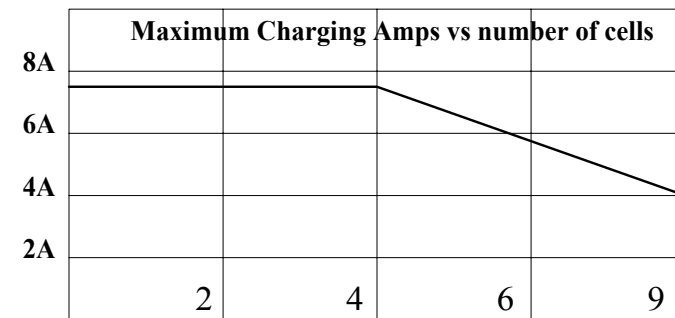
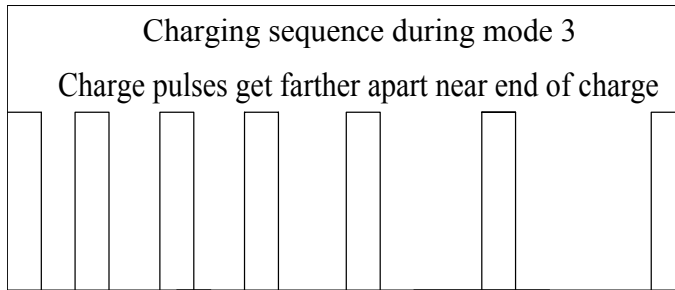
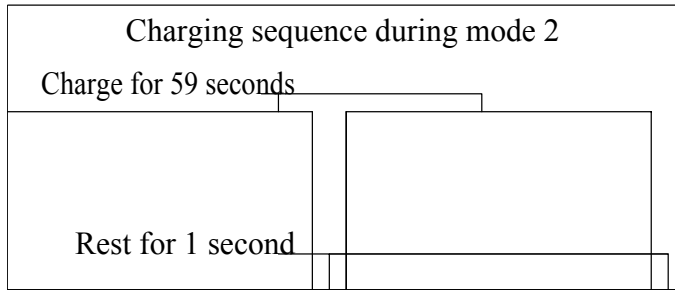
The **“Shorted Output”** message will also occur in mode 2 and mode 3 if the Resting battery voltage drops below 3 volts per cell based on the cell count detected during mode 1. Again you either have a bad connection or a bad battery or long wires.

To continue first remove the lithium battery pack then disconnect from the 12 Volt source and then re-connect the 12 Volt source to reset microprocessor in the charger. Then reconnect the battery to continue charging.

“Timed Out” The **“Timed Out”** message will be displayed if the charger has not reached Mode three within **one hour**. Remove lithium battery then reconnect to continue charging. On future charges you may want to increase charge rate a bit.

This item contains an ULTRA PLUG (reg. trademark) connector.

I hope that you will enjoy my latest charger design, and I would like to thank Doug Ingraham for designing the computer software.
Sincerely, Bob Boucher



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Preventing Lithium Battery Failures

by
Bob Boucher

LITHIUM ION CELLS can be damaged by over discharging to very low voltages, by discharging at high currents, and by overcharging. These problems are aggravated when the cells are connected in series to form higher voltage batteries. If all the cells in a battery pack are not balanced both in voltage and in capacity, the voltages of all the cells will not remain equal during charging and discharging.

ALWAYS DISCONNECT YOUR BATTERY PACK FROM YOUR SPEED CONTROL AFTER FLYING. Your speed control draws 20 to 40ma and will drain your battery to dangerously low voltages if left over night. **If ANY cell in your pack is discharged below 2.0 volts**, permanent and irreversible chemical damage will slowly and completely destroy the cell within 30 days. If a cell is exposed to this low state of discharge overnight it can sometimes be saved by applying a slow “trickle” charge until the cell voltage reaches 2.8 volts or more and remains at this voltage after charging current is removed. By “trickle” we mean a charge rate between 5% and 10% of cell rated mahr capacity. For example on a 2300 mahr cells, “trickle” means 100 to 200 milliamps. I have recovered cells as low as 1.4V by trickle charging for one to two hours. It doesn’t always work, but I have recovered cells most of the time. The longer the cell has been exposed to low voltage, the lower the chances of recovery. After recovery I recommend fully charging the cell to 3.6 volts, and then running a discharge test at a “1 Cell” rate to measure its capacity. “1 C” means discharging a 2300 mahr cell at 2 amps. If the battery capacity has deteriorated to less then 75% of its rating when new, it is time to discard that pack.

IF ANY CELL IS DISCHARGED TO BELOW 2.8 VOLTS BUT ABOVE 2.0 VOLTS it is in a stable voltage region and may remain in that condition for a long time without damage. But the internal resistance of the cell may have become much higher than normal. If you try to charge this cell at a normal “1 C” rate, its voltage may jump up by as much as one volt or more. But if the charging current stopped, the voltage will drop back the original value. This cell is not **ACCEPTING** the charge. **Stop at once.** If you continue to charge at a “1 C” rate, the cell will puff up and be ruined and may even start **BURNING**. Always monitor the voltage behavior of any lithium battery pack for the first minute to be certain that the charge is progressing normally. In multi cell packs that have no taps this is about the only way of detecting a problem. If your cell has a separate connector with battery taps, use a battery balancer like our Astro Blinky #106. It will detect a low voltage cell even if the total pack voltage looks OK. If you do not have a balancer or a balance connector on your pack you can still detect the problem by observing the abnormal voltage rise when attempting to charge at the “1 C” rate. Good condition packs will show a very small voltage rise of less than 0.1 volts per cell. A three cell pack in good condition will only show a 0.1 to 0.3 volts rise. If you observe a large jump in voltage, **stop. Something is wrong with your pack.**

DISCHARGING AT HIGH CURRENTS CAN ALSO DAMAGE THE CELLS IN YOUR BATTERY PACK. Repeated discharges at very high current levels and high temperatures can destroy the battery within 25 to 50 cycles. The cells will develop “micro shorts” that result in rapid self discharge and in noticeable increase in cell resistance. And as more high current discharges are run, the more damage is done. The symptom will be packs that won’t hold a charge and that show bad voltage drop under load. **When you see your balancer trying in vain to keep a pack balanced, it is time to have that pack repaired or safely discarded.** These A123 Lithium Ion cells can deliver over 100 amps or “40C” rates. These very high ratings are usually described as “Burst” or “Take off” ratings for high power durations of 30 to 60 seconds with 60 seconds rest in between bursts to let the cells cool down. My experience with high rate cells is that that continuous discharge at “40C” will usually result cell damage within 50 flights. Continuous discharge at “20C” seems to be okay. In my opinion it is better to install a larger pack so that you can fly 10 to 20 minutes per charge and thereby obtain 500 to 1000 long flights instead of installing a small super high performance pack that limits flights to 5 minutes and is worn out in 50 flights.

WHEN IS MY PACK WORN OUT? The rule of thumb is to discard your pack when its measured capacity has decreased to about 75% of its initial value when new. Of course, to be sure of its initial capacity, do not rely on the printed sticker on the pack. These are nominal or average values. I recommend the following procedure. When I get a new pack I balance it, then I fully charge it usually at a more modest “2/3C” rate. Then I discharge the pack at 1 amp with my #109 Astro Flight charger/discharger. I write down the battery capacity observed. That is my benchmark. For example, if the new 2100 mahr pack measured 2000 mahr this is acceptable for a new pack. If this pack doesn’t fly your model as long as it used to, then you should repeat the amp hour measurement. If the result is close to 1500 mahr (3/4 of 2000) it is time to discard the pack.

OVERCHARGING LITHIUM POLYMER CELLS SHOULD BE AVOIDED. Most chargers including our Astro 109 charger will stop charging when the resting voltage of the battery pack reaches 4.2 volts per cell. If the pack is out of balance by 0.1 volt or more, it is possible for one cell to be above the safe limit of 4.3 volts per cell. For this reason cell balancing is recommended. If there is **any doubt** about its condition use both a balancer and your charger in a trickle mode to try and recondition the pack before attempting a fast charge.

NEVER HAVE A SPEED CONTROL CONNECTED WHILE CHARGING. Do not charge your Lithium Polymer battery pack in you model. If something goes wrong and the battery voltage goes higher than the control is rated for, the control can blow out, then short your battery and cause a fire.

LITHIUM ION BATTERY PACKS ARE VERY TEMPERATURE SENSITIVE. If a fully charged three cell lithium pack is placed in the freezer and left there for on hour the pack voltage will be depressed and the pack will exhibit a very high resistance to both charging and discharging. When running your motor it will deliver low power for the first minute or so until it warms itself during discharge. If the same three cell battery pack were fully charged then put in the hot sun or in the trunk of a car parked in the hot sun the pack temperature can exceed the safe 160F. Running a pack this hot will damage it and even may cause it to fail. Be SAFE and let the battery cool down before using it. When charging, keep your packs between 70 and 100 degrees F.

When using Lithium Batteries, take your time and proceed with deliberate caution. These batteries are not toys.
Thank You
Bob Boucher