## Pack selection guidelines

FMA recommends that you read all three sections of the *LiPo Handbook*, available in the Support section of the FMA Direct Web site (www.fmadirect.com).

Use FMA's LiPo Calc II to preview LiPo pack configurations based on your motor operating and flight parameters.

> LiPo Calc II is available on the FMA Direct Web site (www.fmadirect.com). Click "LiPo Expo" under "Technical" at the bottom of the home page, then click "LiPo Calc II." There is also a link in the site's "General Index" page.

LiPo Calc II is driven by the wattage required to fly the model and the watt-hours needed to fly for an expected period. Be aware that LiPo Calc II does not take into account the fact that cells lose capacity, therefore run time, with increasing current draw.

To use LiPo Calc II, fill in the fields at the top, then click the Update Values button. LiPo Calc II fills in the table, providing a lot of data to help you choose an appropriate pack configuration. Click a column heading for an explanation of the data in that column. Complete instructions are in the LiPo Calc help file ("Click here for help").

FMA Direct **LIPO CALC II**
CLICK HERE FOR HELP
*Click Column Heading for a Description*

Cell Series: 3 | Amps: 12
Pack Voltage (nominal): 11.1 | Throttle: 60
Fresh Charge (VDC): 12.6 | Update Values
Cut off Voltage (VDC): 9 | = Editable Fields

| FMA Base PN | Nominal Cell Capacity (mAh) | This battery used in | Battery "C" Rating | Full C Discharge Derating | Parallel Requirement | Configuration | Total mAh | Full C mAh (Derated) | Time @ Full Capacity (Minutes) | Time @ De-rated Capacity (Minutes) | Cell Weight (gms) | Total Weight (gm-Cells Only) | Total Cells |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Super High Discharge Type** | | | | | | | | | | | | | |
| CP0350 | 350 | | 25 | 80% | 2 | 3s2p | 700 | 560 | 05:49 | 02:48 | 11 | 66 | 6 |
| CP0750 | 750 | | 20 | 80% | 1 | 3s1p | 750 | 600 | 06:15 | 03:00 | 19 | 57 | 3 |
| CP0950 | 950 | | 25 | 80% | 1 | 3s1p | 950 | 760 | 07:54 | 03:48 | 27.5 | 82.5 | 3 |
| CP02100 | 2100 | | 18 | 80% | 1 | 3s1p | 2100 | 1680 | 17:30 | 08:24 | 46 | 138 | 3 |
| CP03200 | 3200 | | 20 | 80% | 1 | 3s1p | 3200 | 2560 | 26:40 | 12:48 | 80 | 240 | 3 |
| CP04800 | 4800 | | 20 | 80% | 1 | 3s1p | 4800 | 3840 | 40:00 | 19:11 | 121 | 363 | 3 |
| **Customer Defined** (Allows you to enter custom data) | | | | | | | | | | | | | |
| N/A | 500 | | 5 | 90 % | 5 | 3s5p | 2500 | 2250 | 20:50 | 11:15 | 15 | 225 | 15 |

Update Values

*Calculations are approximate and may be affected by several variables, including input parameters, battery age, throttle management, and even charging practices and charger quality. Time calculations are linear and may not predict actual system performance. To increase run time, consider increasing capacity by connecting packs of same voltage and capacity in parallel. Going from a 1p configuration to a 2p will double run time, all other things being equal.*

**Current rating.** Each Cellpro Revolution Pack is rated for a certain continuous discharge rate. However, battery life will be significantly shortened if you operate at this rate throughout an entire flight. When calculating battery requirements, a 50%C average discharge rate is a good starting point. This allows for short periods of high discharge for take off and aerobatic maneuvers, with moderate discharge for the rest of the flight.

**Replacing another brand of LiPo pack.** To achieve high discharge current, other LiPo brands must parallel multiple cells. In contrast, Cellpro Revolution cells are generally capable of higher discharge rates. If the packs you are replacing have three or four cells in parallel (3p or 4p), you may need only a 1p or 2p Cellpro configuration. With Cellpro Revolution Packs, you'll not only lower your power system weight, but you'll also spend less.



# Cellpro Revolution LiPo Battery Packs

WorleyParsons/FMA Lithium Polymer battery packs for RC aircraft applications

User's guide for F-series and N-series packs

Cellpro REV-OLUTION

## About Cellpro Revolution Packs

- Built from lightweight Lithium Polymer Cells that deliver continuous current at rates up to 25C (depending on the particular pack).
- Each pack has a node connector that enables the Cellpro 4s Charger and Cellpro components to monitor and control the voltage of individual cells within the pack.
- Cellpro Revolution Packs are part of a complete system that extends pack life, maximizes flight times and greatly improves safety by preventing overcharging and overdischarging.
- Packs work with both brushed and brushless ESCs.

Cellpro Revolution Packs are the next-generation Lithium Polymer technology. Manufactured by WorleyParsons and marketed by FMA Direct, this unique power technology offers high energy density, low weight, long life, safe operation and environmentally-friendly chemistry. FMA Direct offers a full line of LiPo packs and compatible electronics at www.fmadirect.com. LiPo technical and application information is available in the Support section of the Web site.

## Precautions

- Follow all instructions in this manual to assure safe operation.
- Before charging a Cellpro Revolution Pack, allow it to cool to approximately body temperature. During discharge, inner cells become hotter than outer cells. If a pack is charged when hot, cells will be damaged because their different temperatures result in different charge rates. (Note that the Cellpro 4s Charger automatically senses pack condition, as influenced by pack temperature, and protects against charging damage when the pack is too warm.)
- Damaged or faulty lithium polymer cells may ignite. Charging may accelerate ignition, so always supervise charging. If a pack is involved in a crash, remove it from service, put it in a non-flammable environment and monitor it.

**WARNING!** Recommended charge rate is 1C, but if you use FMA balancing chargers, maximum charge rate can be increased to 3C. Charge rate is limited to 5A maximum through the Cellpro pack's node connector; however, if the power connector is used to supplement the Cellpro node connector, charge current can be increased. WP/FMA, Inc. will not be liable for damages that result from improper use of this product. **This product may ignite under certain conditions. Read all safety precautions completely before using this product!**

**FMA, Inc.** ● 5713 Industry Lane, Suite 50 ● Frederick, MD 21704
Sales: (800) 343-2934 ● Technical: (301) 668-4280 ● www.fmadirect.com

FMA Direct

## About the Cellpro system

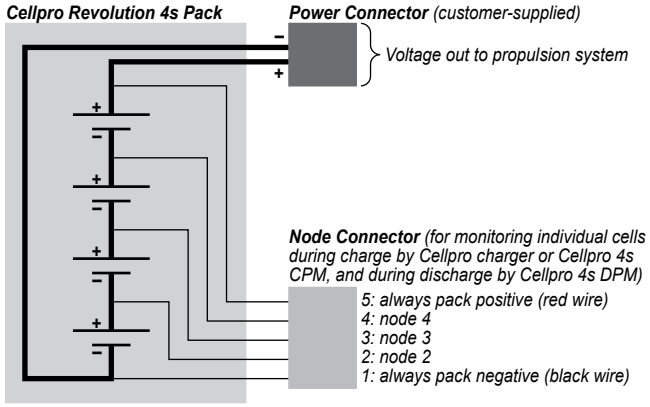
The Cellpro product line includes:

- Cellpro Revolution Packs: F-series packs currently feature up to 20C discharge rate, while N-series packs are currently rated as high as 25C depending on the model purchased.
- Cellpro 4s Charger, a cell-balancing charger.
- Cellpro 4s Discharge Protection Module (DPM), optional for your propulsion system.
- Cellpro 4s Charge Protection Module (CPM), for charging CellPro Packs with a non-cell-balancing LiPo charger.
- BalancePro HD-to-Cellpro Adapter, for charging Cellpro Packs with the BalancePro HD 6s Charger.

Cellpro Revolution packs use separate connectors for charging and discharging:

- The customer-supplied **Power Connector** attaches to your propulsion system for flying. Cellpro Revolution Packs are delivered with unterminated power wires (heatshrink tubing covers bare wire ends to prevent shorting). You must solder an appropriate connector to the power wires.
- The **Node Connector** enables the Cellpro 4s Charger or Cellpro CPM to monitor individual cell voltages during charging to prevent overcharging. It also enables the Cellpro DPM to monitor individual cell voltages during discharge (flying) to prevent overdischarging.

The schematic below for a 4s pack shows how these two connectors are wired in. In a 3s pack the node 4 wire is not connected; in a 2s pack the node 3 and node 4 wires are not connected.




**WARNING**

**Do not put pins, wires or other objects into the Cellpro Node Connector. This connector integrates with FMA Direct accessories which monitor cell voltages. If you damage the integrity of this connector, the accessories may not work correctly. Also, if you short the pack through mishandling, the warrany is void.**



## Flying with the Cellpro 4s DPM

The Cellpro 4s Discharge Protection Module (DPM) provides a warning when any cell in its connected pack approaches the preset low voltage cutoff. When the first cell reaches the preset voltage, the Cellpro 4s DPM pulses voltage to the ESC (soft cutoff) so you can prepare for landing. Soon after, the motor will stop (hard cutoff). After the hard cutoff, you may be able to reset the Cellpro 4s DPM by pulling the throttle low and advancing it again. Restarts are possible, but the number depends on how fast the cell with the lowest voltage recovers above the minimum operating voltage. When the pack is fully exhausted, there will be no power to the motor.

The amount of time available near the end of a battery run is dependent on several factors, including:

- Pilot flying style.
- Throttle setting. (Pulsing, cutoff and the number of restarts may be greater if the initial warning occurs at a high throttle setting.)
- Ambient temperature.
- Battery temperature.
- Capacity difference between cells in the pack. (If all cells in a pack are close to the same capacity, warning and restart times will be shorter. Conversely, if cell capacities vary more widely, warning and restart times will be longer.)

Just remember, when the motor starts pulsing, immediately throttle back and prepare to land. After the initial warning pulses, a low throttle setting gives you the longest remaining motor run time.

It's a good idea to ground-test the entire propulsion system before flying with it. Take it through a full run and keep pushing it until the motor won't restart. You'll get a feel for flying time, and gain hands-on experience with end-of-run motor behavior.

Discharging through a Cellpro 4s DPM and charging with a Cellpro 4s Charger maximizes pack life. If you don't discharge through a DPM, set your ESC's low voltage cutoff to a minimum of 3.3V times the number of cells in the pack. For example, cutoff voltage for a 3s pack should be not less than 9.9V.

## Non-hobby applications

Cellpro Revolution Packs are designed and sold specifically for use in remote control hobby products and toys. The associated safety and control devices provide flexible operation in that environment. **Use of Cellpro Revolution Packs without Cellpro safety and control devices is prohibited without written approval from FMA, Inc.**

If you are planning to use LiPo packs and/or devices in a non-hobby application, you must first discuss your plan with FMA, Inc. Battery Power Solutions Division engineering at 1 (800) 342-2934 ext. 13. In most instances of moderate- to high-volume production, an application-specific safety and control system is most cost-effective. FMA Battery Power Solutions Division serves OEMs with:

- Application analysis.
- Cell and pack selection and recommendations.
- Adaption of off-the-shelf FMA products for safety and control.
- Design and manufacturing of application-specific charge and control systems for volume production.
- Design and manufacturing of turnkey battery power systems for commercial, military, industrial and medical applications.

## Optional discharge protection with the Cellpro 4s DPM

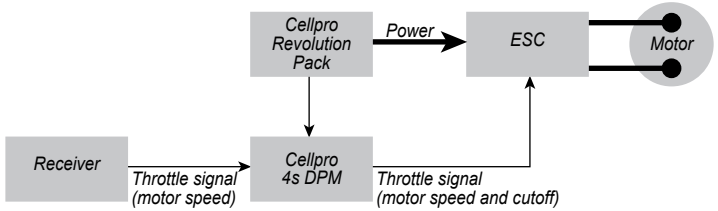
You can power your propulsion system directly from a Cellpro Revolution Pack. However, for best performance, FMA recommends attaching each Pack to a **Cellpro 4s Discharge Protection Module** (DPM). Discharge protection maximizes run time, extends pack life and eliminates cell damage that would otherwise be caused by running voltage too low.

During discharge (flying), the Cellpro 4s DPM monitors individual cells within the connected pack and pulses the motor when voltage gets low. A complex algorithm determines when the first cell reaches a preset voltage. At this time, the Cellpro 4s DPM works with your existing ESC to cut voltage to the motor.

Two Cellpro DPM models are available:

- **CP4S-DPM-BEC** works with a conventional ESC equipped with a Battery Eliminator Circuit (BEC). The receiver's throttle channel connects to the CP4S-DPM-BEC, which in turn connects to the ESC's throttle input. This connection also provides power from the ESC to the receiver. Note, however, that interference generated by the ESC and/or motor can propagate into the receiver through the throttle connection, which may cause the receiver to operate erratically.
- **CP4S-DPM-OPTO** works with an ESC having optical isolation in the throttle circuit, which prevents interference from propagating back into the receiver via the throttle connection. You can also use this model with a BEC ESC if you need optical isolation for the throttle. Note that this configuration requires a separate battery to power the receiver and servos.

This simple diagram shows how components are connected in the aircraft. Details are in the Cellpro 4s DPM user's guide.




## Limited warranty for Cellpro Revolution Packs

WorleyParsons warrants this product to be free of manufacturing defects for the term of 60 days from the date of purchase. Should any defects covered by this warranty occur, the product shall be repaired or replaced with a unit of equal performance by WorleyParsons or an authorized WorleyParsons service station.

**Limits and exclusions**

This warranty may be enforced only by the original purchaser, who uses this product in its original condition as purchased, in strict accordance with the product's instructions. Units returned for warranty service to a WorleyParsons service center will be accepted for service when shipped postpaid, with a copy of the original sales receipt or warranty registration form, to the service station designated by WorleyParsons.

This warranty does not apply to:

- Consequential or incidental losses resulting from the use of this product.
- Damage resulting from accident, misuse, abuse, neglect, electrical surges, reversed polarity on connectors, lightning or other acts of God.
- Damage from failure to follow instructions supplied with the product.
- Damage occurring during shipment of the product either to the customer or from the customer for service (claims must be presented to the carrier).
- Damage resulting from repair, adjustment, or any alteration of the product by anyone other than an authorized WorleyParsons technician.
- Installation or removal charges, or damage caused by improper installation or removal.

**Removing heat shrink tubing from pack voids warranty.**

**Permitting the pack to exceed 176°F voids warranty.**

Call (301) 668-4280 for more information about service and warranty repairs.



## Installation guidelines

**Temperature limitations and cooling.** Cellpro Revolution Packs perform best and last longest when their operating temperature is kept below 135°F. In no case should temperature exceed 150°F. If pack temperature exceeds 176°F, pack life will be severely shortened. **Permitting a Cellpro Revolution Pack to exceed 176F° will void the pack's warranty.**

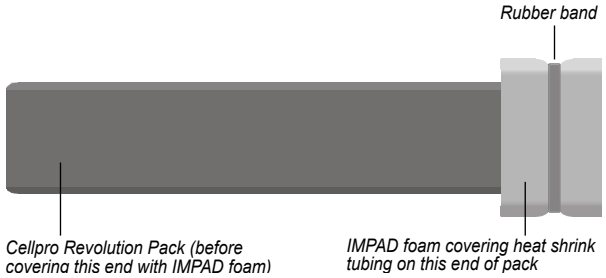
**CAUTION:** Pack temperature will exceed 150°F if the pack is operated at its maximum discharge rate for more than 60 seconds without adequate cooling.

To maintain optimum temperature, your aircraft must provide cooling air to the pack(s). The best way to force air over the pack(s) is to add an air inlet scoop (to force cool air into the battery compartment) and an exhaust vent (so warm air can exit the battery compartment).

Check pack temperature after flights until you are certain cooling air is doing its job. You can use temperature indicators available from FMA Direct (see below). For more accurate temperature measurements, use a handheld non-contact infrared thermometer. Note that inner cells will become hotter than outer cells. This is unavoidable, but emphasizes the need for forced-air cooling.

**Vibration and impact protection.** Do not fully cover Cellpro Revolution Packs in foam. The packs must have cooling air flowing over their surfaces. Covering a pack's entire surface would trap heat, causing temperature to rise too high, and ultimately shortening pack life.

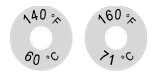
Use FMA's IMPAD foam to isolate Cellpro Revolution Packs from vibration. (IMPAD is a special shock-absorbing foam that protects RC electronics and batteries much better than standard foams.) Cut an IMPAD sheet into 1" to 1-1/2" wide strips. Wrap the strips around the heat shrink tubing on each end of the pack, and secure the strips with rubber bands.




*continued*

## Checking operating temperature

Temperature indicators are available from FMA Direct to help you determine whether a pack is operating in its optimum temperature range. Typically, you'll place 140°F and 160°F indicators on the outside of each Cellpro Pack.

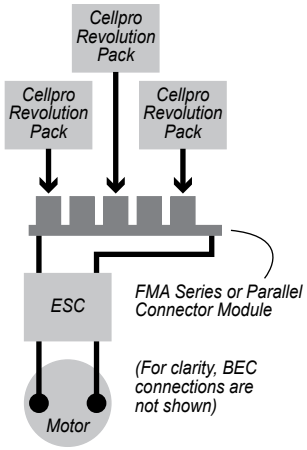



1. Fly moderately during the pack's first flights.
2. After each landing, examine the 140°F indicator. If its center is black, the temperature exceeded 140°F, so the pack is not able to supply sufficient power for your propulsion configuration. Install a different propeller or a larger capacity battery pack. Remove the 140°F indicator and place a new one on the pack.
3. Fly again, then repeat step 2. When the 140°F indicator's center remains white, and you are flying your normal style, the pack is matched to the aircraft.

**Note:** If the 160°F indicator turns black, the pack is operating much too hot. Replace the pack with a larger capacity one.

**Power connector and wiring.** Throughout the propulsion system you must use wire and connectors rated for (at least) the expected maximum current. Select wire based on its current-carrying capacity and wire length. Consult American Wire Gauge (AWG) tables for guidance. In general, minimize the use of connectors and keep power wires short to reduce power circuit resistance.

**Connector Modules.** Cellpro Revolution Packs can be easily combined into higher voltage and capacity configurations by plugging them into FMA Series and Parallel Connector Modules. The diagram at right shows three Cellpro Revolution Packs plugged into a Module. Mating connectors for packs are available from FMA Direct.



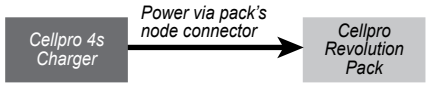



## Charge protection

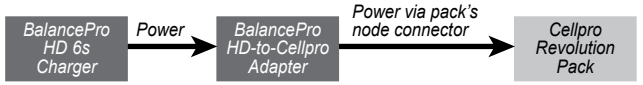
LiPo cells and packs can be destroyed during charging by applying a voltage that's too high. What happens when charge voltage is too high? With as little as 10 minutes of overvoltage (6V per cell), the cell envelope begins to expand, which severely damages the cell. Continued overvoltage causes the envelope to swell from increasing internal gas pressure. Under extreme conditions, the envelope may vent (open) in less than 20 minutes. This destroys the cell. If supply current is high, venting may be accompanied by flames. For these reasons, **charge protection is required when charging Cellpro Revolution Packs.**

Three charge protection options are available:

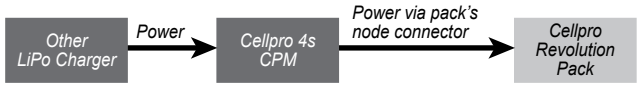
- **Cellpro 4s Charger.** Charge protection is built into the Cellpro 4s Charger. Charging is simply a matter of plugging your Cellpro Revolution Pack into the Cellpro 4s Charger as shown below (other important operating details are in the Cellpro 4s Charger user's guide). With this arrangement, each cell is individually charged to the optimum 4.2V. When the process is complete, the pack is not only charged, but balanced (all cells in the pack are within 10mV).




- **BalancePro HD 6s Charger and a BalancePro HD-to-Cellpro Adapter** (below).




- **Another LiPo-compatible charger and a Cellpro 4s Charge Protection Module (CPM).** The Cellpro 4s CPM monitors individual cell voltages and cuts charging power to the pack when the first cell reaches 4.2V. Unlike the Cellpro 4s Charger, the Cellpro 4s CPM does not balance packs. When charging Cellpro Revolution Packs using a Cellpro 4s CPM, **never exceed a 1C charge rate.**




Each Cellpro 4s CPM handles charging for one Cellpro Revolution Pack. Cellpro 4s CPM units can be wired together for simultaneously charging multiple Cellpro Revolution Packs from one charger (the Cellpro 4s CPM user's guide provides a two-unit wiring example).