

One-Size-Fits-All Battery Charger

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The first step to designing a battery charger is choosing a battery charger IC from the vast field of available solutions. To make an informed decision, a design team must first clearly define the battery parameters (chemistry, cell count, etc.) and the input parameters (solar, USB, etc.). The team must then search for chargers that fit the input and output parameters, comparing numerous data sheets to settle on the best solution. The selection process should allow the team to pick the best solution for the application, until of course, the design parameters change, at which point: back to the data sheets.

What if this step could be skipped altogether? What if a designer could focus on an application solution, treating the battery charger IC as a black box to be filled in with a real IC when the time comes to produce a working solution? At that time, the designer simply reaches to the shelf for a generic battery charger IC, regardless of the essential design parameters. Even if application parameters change (inputs switched out, battery type changed, etc.) the off-the-shelf battery charger IC still fits. No additional data sheet search required.

This problem can be illustrated by looking at two very different battery charger problems:

- ▶ Design team A is tasked with designing a battery charger that takes solar panel input and charges a lead-acid battery. The charger must stand alone—no microcontroller here—but should be versatile enough to support a few different solar panel models. They have one week to produce a schematic design.
- ▶ Design team B has a more involved charger problem. Their design takes a 5 V USB supply and charges a 1 cell Li-ion battery with 1.3 A to a termination voltage of 4.1 V per cell. Above 47°C, they want to decrease their charge voltage to 4 V per cell at 0.5 A, and above 72°C, they want charging to stop. The microcontroller in their system needs to know the battery's voltage, current, temperature, and health. They also have one week to produce a schematic design.

It turns out that both design teams can use the same battery charger IC, and that this device is arguably the best choice available for both applications.

Good Things and Small Packages

The **LTC4162** 35 V, 3.2 A monolithic buck charger boasts an elegant blend of simplicity and versatility. Capable of operating standalone or with a host controller, the LTC4162 enables solutions from basic to complex. A full-featured I²C telemetry system allows a user to optionally monitor the battery and implement custom charging parameters specific to the battery model. A true maximum power point tracking (MPPT) algorithm allows the charger to operate optimally from any high impedance source, such as a solar panel. The charging algorithm is tailored to the chosen battery chemistry: Li-ion, LiFePO₄, or lead-acid.

These features are packed into a 4 mm × 5 mm QFN package with a typical solution size of about 1 cm × 2 cm.

Feel the Power!

Don't let its small size fool you. Even with integrated switching FETs, the LTC4162 can support over 60 W of charge power. Internal thermal self-monitoring of its die temperature enables the LTC4162 to regulate the charge current such that it never overheats, even in the hottest environments and tiniest enclosures.

The PowerPath™ FETs (INFET and BATFET) ensure that the system load (V_{OUT}) is always powered by the input voltage (V_{IN}) if it is present or by the battery if V_{IN} is absent. The use of external N-channel FETs allows for low loss paths with no limit to the amount of current that can be passed to the load.

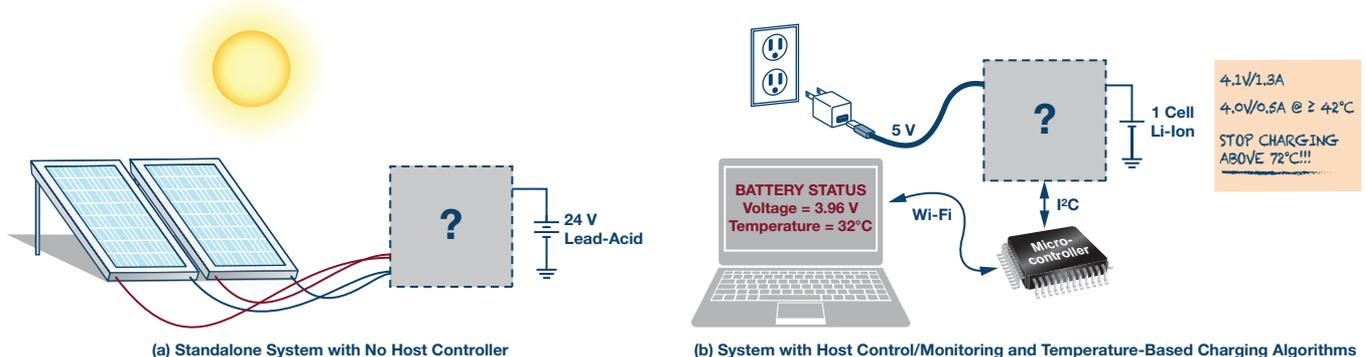


Figure 1. What charger fits? Here are two very different battery charging systems; can they use the same charger IC?

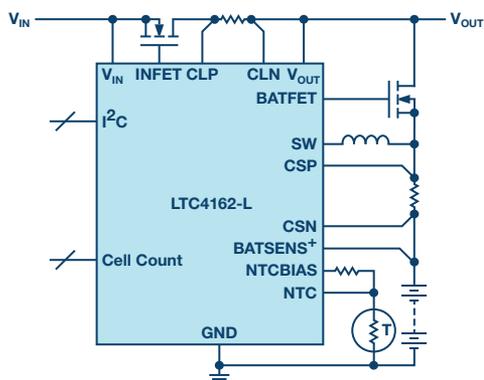


Figure 2. The application circuit for LTC4162 is as simple as it gets for a full-featured switching battery charger.

Telemetry and Control

Although the LTC4162 can operate without a host controller, many aspects of charging can be monitored and controlled through the I²C port. An on-chip telemetry system reads system and battery voltages and currents in real time. Various limits and alerts can be set to notify the host controller when a measured value meets a configurable threshold or when a particular charging state is entered. For example, a common design feature may be to enter a low power mode when the battery voltage drops to a certain lower limit. Rather than have a microcontroller continually poll the battery voltage, the LTC4162 can do the monitoring, and inform the host controller when this limit has been reached. At this point, the host can switch off the main load and enter a low power state.

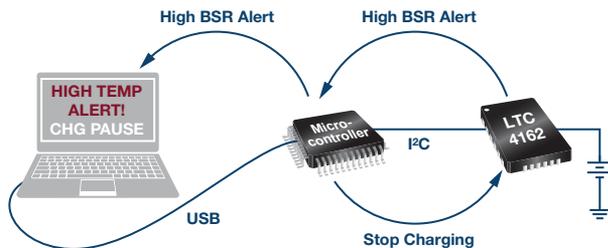


Figure 3. The LTC4162's integrated telemetry system will fulfill almost any monitoring and alert requirements.

The telemetry system is also capable of measuring the battery series resistance (BSR), which serves as an indication of battery health. The BSR measurement can be set to run automatically, and an alert can be configured to notify the host controller that a custom high BSR limit has been exceeded, at which point the host may signal to the user that the battery needs to be replaced.

When the input supply is removed and the system is powered by the battery, the LTC4162 automatically turns off the telemetry system to conserve battery life. If a measurement is needed, the telemetry system can be forced into action via an I²C command, at which point it enters a slower, low power telemetry mode where measurements are taken every five seconds. If desired, the telemetry rate can be set to the high speed 11 ms/read rate at any time.

It's Getting Hot in Here

The LTC4162 enables customizable temperature-dependent charging. For lithium-based chemistries (Li-ion and LiFePO₄), the LTC4162 can employ JEITA temperature-controlled charging. JEITA allows the user to set custom temperature regions, wherein a custom battery charge voltage and current are used to charge the battery. This also allows the designer to decide the hot and cold temperatures at which the battery should stop charging. The default JEITA settings work for many batteries without the need for host processor intervention, but this capability enables the LTC4162 to work with any battery's temperature profile requirements.

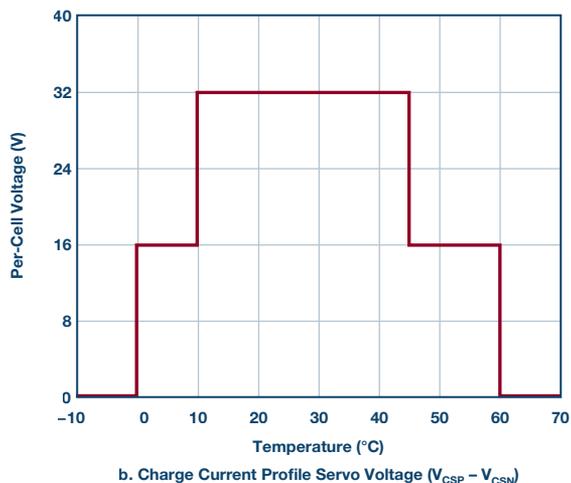
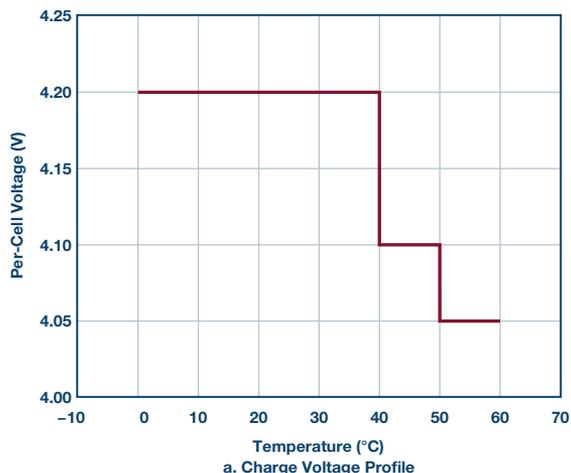


Figure 4. Default Li-ion JEITA profile.

Similarly, for lead-acid batteries, a temperature compensation algorithm linearly decreases the target voltage in each charging stage as temperature rises. These voltages can be offset with I²C commands, and the compensation slope can be modified by simply changing the thermistor.

MPPT and Input Regulation

For the sake of simplicity, many solar panel regulation circuits set the maximum power point voltage as a constant value. In reality, V_{MPP} drifts with illumination, and a partially obstructed solar panel can have multiple power peaks. By sweeping the entire voltage range of the panel connected to its input supply, the LTC4162's advanced maximum power point tracking (MPPT) algorithm accounts for all variables, always settling on the max power point. In addition to occasional sweeps of the solar panel range, the LTC4162 dithers the input regulation voltage, constantly seeking out minor changes in the V_{MPP} . These features require no custom programming, so panels can be switched out without charger modification.

The benefits of input regulation extend beyond solar panel sources. Many USB cables, for example, have a significant amount of series impedance and this causes voltage droops at the charger input when current is drawn. The undervoltage current limit feature of the LTC4162 regulates this current such that a minimum voltage is maintained at the input.

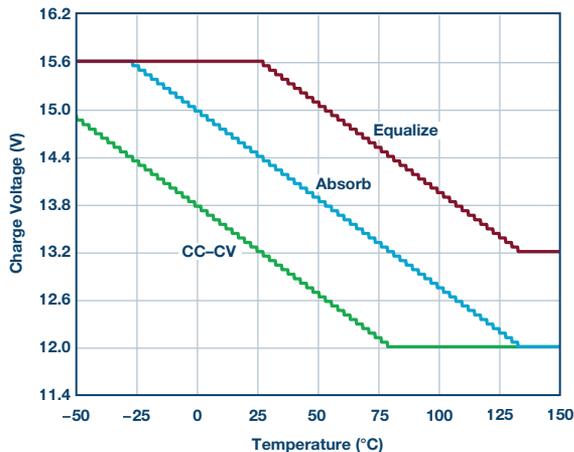


Figure 5. Default 12 V lead-acid temperature profile.

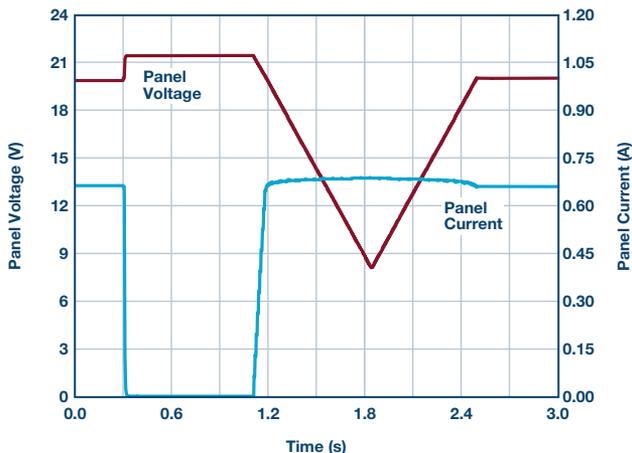


Figure 6. Solar panel global sweep.

USB Power Delivery

LTC4162 is also compatible with the USB Power Delivery specification that allows up to 100 W of power to be sourced through a USB Type C cable. The input current limit of the LTC4162 can be configured such that an input adapter is not overloaded. When the input current limit is reached, the system load can still pull as much power as it needs from the input, but the battery charge current is reduced such that the input current limit is not exceeded. For USB PD, this means that one LTC4162 circuit can be supplied by various power adapter profiles.

Low Power Ship Mode

When a product needs to be shipped or stored for a long period of time, an I²C command can place the LTC4162 into a low power state, reducing the current drain on the battery to about 3.5 μ A. Optionally, the circuit can be configured to cut power from the system load during this period.

IC Variants

To simplify the design and documentation, the LTC4162 is broken into variants based on battery chemistry, charging parameters, and whether or not MPPT is enabled by default. Table 1 shows all of the available LTC4162 variants.

Table 1. 18 IC Variants Allow the User to Choose the Perfect Part for Any Application

| IC Part Number | | Battery | |
|--|--|---------------------|--|
| MPPT Disabled by Default | MPPT Enabled by Default | Chemistry | Cell Voltage |
| LTC4162EUFD-LAD LTC4162EUFD-L40 LTC4162EUFD-L41 LTC4162EUFD-L42 | LTC4162EUFD-LADM LTC4162EUFD-L40M LTC4162EUFD-L41M LTC4162EUFD-L42M | Li-ion | I ² C adjustable 4.0 V fixed 4.1 V fixed 4.2 V fixed |
| LTC4162EUFD-FAD LTC4162EUFD-FST LTC4162EUFD-FFS | LTC4162EUFD-FADM LTC4162EUFD-FSTM LTC4162EUFD-FFSM | LiFePO ₄ | I ² C adjustable 3.6 V fixed 3.8 V rapid charge |
| LTC4162EUFD-SAD LTC4162EUFD-SST | LTC4162EUFD-SADM LTC4162EUFD-SSTM | Lead-acid | I ² C adjustable fixed |

Each variant is pin-compatible and can be swapped out with another version during prototyping. LTC4162 variants are interchangeable to simplify the creation of products that use the same circuit but use different battery chemistries, charging voltages, or input sources.

To simplify the documentation, data sheets for the LTC4162 are broken into chemistry-based variants; there are separate data sheets for the Li-ion, LiFePO₄, and lead-acid versions.

Conclusion

Before members of a design team spend all day reading data sheets for various battery chargers, power monitors, and solar regulators—before spending hours writing code for a custom temperature-dependent charging algorithm and manually polling measurements to detect when limits are exceeded—they may want to consider reaching for a one-size-fits-all battery charger. There is a good chance the LTC4162 is the best device for the job.

About the Author

Zachary Pantely is an applications engineer for Analog Devices' Power by Linear Group. He is currently designing and supporting demo boards to showcase the features of various battery chargers, supercapacitor chargers, multi-output bucks, and energy harvesting devices. In addition to hardware work, Zack is involved in GUI and firmware programming to showcase the features of products with digital interfaces. He graduated from University of Massachusetts Lowell in 2015 with a double major in electrical engineering and sound recording technology. He can be reached at zachary.pantely@analog.com.

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