

Charge Controller Selection and Wiring

Why You Need a Charge Controller

Solar panels produce unregulated voltage - a nominally "12 V" panel can output up to 22 V open-circuit. A charge controller protects the battery from overcharge, manages the multi-stage charge profile (bulk, absorption, float), and in many cases provides a protected load output to prevent deep discharge.

PWM vs. MPPT

PWM (Pulse Width Modulation)

Simple and cheap. The controller connects the panel more or less directly to the battery and chops the current. Efficient only when the panel's operating voltage is close to the battery voltage. Fine for small, well-matched systems where cost matters more than harvest efficiency.

MPPT (Maximum Power Point Tracking)

Continuously sweeps the panel's voltage-current curve to find the operating point that yields maximum power output. Typically delivers 10 - 30% more energy than PWM, especially in cool or partly-cloudy conditions, or when panel voltage is significantly higher than battery voltage. MPPT recovers the most when the panel's V_{mp} is significantly higher than the battery voltage; PWM suits panels whose V_{mp} is close to the battery voltage. Recommended for any challenging installation.

Recommendations for LoRa Mesh Nodes

Small systems: 5 W panel + 3.7 V LiPo or small LiFePO4

A dedicated solar LiPo charging board with built-in MPPT is the simplest and cheapest approach. Examples:

- CN3791-based boards (switching MPPT-style solar charger; widely available on AliExpress, ~\$3 - 8 as of 2026-06-08)
- Waveshare Solar Power Manager (~\$12 - 15 as of 2026-06-08)

These handle cell-level charging directly and fit neatly into a small enclosure alongside the node. Note: these small charger ICs have **no low-temperature charge cutoff** — never charge any lithium chemistry below 0 C (32 F), and add a BMS with low-temp protection or a controller with a battery temp sensor for cold-climate builds.

Medium systems: 10 - 20 W panel + 12 V LiFePO4

A dedicated MPPT controller is warranted. Good options at modest cost:

- **Renogy Wanderer 10A** - inexpensive, reliable, widely available
- **Victron SmartSolar 75/10** - premium, Bluetooth monitoring via the VictronConnect app, excellent LiFePO4 support. Higher cost but extremely reliable for permanent installs. (The 75/10 has no dedicated load output; the comparable Victron load-output controllers are rated 15 A on the load terminal.)

Wiring Sequence

Always follow this order to protect the controller:

1. Connect battery to controller first
2. Connect panel to controller

3. Connect load to controller

Disconnect in reverse order: load → panel → battery.

LiFePO4 Charge Profile

LiFePO4 uses a different charge profile from lead-acid. Key voltages per cell (4S = 12.8 V nominal):

- **Absorption voltage:** 3.55 - 3.65 V/cell (use ~3.60 V/cell as the canonical absorption)
- **Float voltage:** 3.375 - 3.40 V/cell (use 3.375 V/cell). Do NOT float at 3.60 V/cell — that holds the pack near 100% SoC continuously and accelerates aging.

For a 4-cell (12 V nominal) pack: absorption = 14.4 V (range 14.2 - 14.6 V), float = **13.5 V** (range 13.5 - 13.6 V). Do not float a LiFePO4 pack at 14.4 V. Also do NOT equalize LiFePO4.

Warning: Most cheap PWM controllers are factory-calibrated for lead-acid (14.4 - 14.8 V absorption, with a ~13.5 - 13.8 V float). Using lead-acid absorption settings on LiFePO4 can overcharge and damage the cells. Verify that your controller has a LiFePO4 mode or use a controller specifically designed for LiFePO4.

Load Output and Low-Voltage Disconnect (LVD)

Many charge controllers have a dedicated "load" terminal that automatically disconnects the load when the battery drops below a programmable voltage. Connect your node to this terminal rather than directly to the battery. Set the operating LVD to ~3.0 V/cell (a conservative recommended value; the acceptable range is roughly 2.8 - 3.0 V/cell):

- 12 V system (4S LiFePO4): LVD = 12.0 V (about 10-20% SoC remaining)

This operating LVD is distinct from the hard BMS undervoltage cutoff (~2.5 - 2.7 V/cell, ~10 - 10.8 V for a 4S pack). The conservative 12.0 V LVD leaves reserve before the BMS cell-undervoltage cutoff and prevents deep discharge, which is a primary cause of premature LiFePO4 cell death.

Fusing

Always fuse the battery positive lead as close to the battery terminal as practical (ABYC: within ~7 inches). A short circuit without a fuse can dump hundreds of amps through wiring and cause a fire.

Use automotive blade fuses. **Size the fuse to protect the WIRE, not the load:** the fuse rating must be at or below the ampacity of the smallest conductor it protects, AND at least ~125% of the continuous load current. Choose the next standard fuse size that satisfies both conditions. Never simply use "2× the load" or "the next size above the wire's ampacity."

Example: a node drawing 500 mA peak - a 2 A fuse on the battery lead is fine, because 2 A is above ~125% of the load and well within the ampacity of typical hookup wire. Always confirm the chosen fuse is at or below the conductor's ampacity.

Revision #4

Created 2026-05-03 04:12:17 UTC by Mesh America Admin

Updated 2026-06-08 22:53:41 UTC by Mesh America Admin