Wiring a Solar Power System for LoRa Repeaters

Proper wiring is the difference between a node that runs reliably for years and one that fails intermittently or becomes a fire hazard. (Battery life, not wiring, sets the maintenance interval — plan battery replacement per the chemistry's cycle life.) This page covers the complete wiring path from solar panel to LoRa load, including fusing strategy, wire gauge selection, connector types, weatherproofing, and cable management inside enclosures.

System Wiring Overview

A correctly wired solar system follows this signal path:

```
Solar Panel(s)
 │
 ├─── [Fuse #1: Panel → Controller] ── MC4 cable to controller PV input
 │
Charge Controller (MPPT/PWM)
 │
 ├─── [Fuse #2: Controller → Battery] ── to battery positive terminal
 │
Battery Pack (LiFePO4/LiPo + BMS)
 │
 └─── [Fuse #3: Battery → Load] ── to load (LoRa node, 5V regulator, etc.)
```

Fuse each wire segment at its source so the fuse protects that segment. A typical solar node uses three: PV-to-controller, controller-to-battery, and battery-to-load. Do not rely on one fuse to protect dissimilar-gauge segments. Each fuse protects the wire segment between it and the next power source, limiting fault current to what the wire can safely carry. (The binding requirement in code and standards is overcurrent protection sized to protect each conductor near its source — the exact number of fuses depends on the topology; PWM vs MPPT and parallel PV strings change what is needed.)

Fusing Requirements

Segment	Fuse Type	Rating (for 10 W panel, 7 Ah battery)	Placement
Panel → Charge controller (PV in)	Blade fuse or ANL	Next standard size ≥ Isc × 1.56 (here ~10 A). Optional for a single panel — see note below.	Per the controller manual, typically near the panel junction box positive terminal
Charge controller → Battery	Blade fuse or ANL	Next standard size at or below the conductor's ampacity, and ≥ charge controller rated output × 1.25 (here ~15 A for a ~10 A controller)	Within 7 inches of battery positive terminal (ABYC E-11)
Battery → Load	Blade fuse or resettable PPTC	3 - 5 A (sized to wire gauge, not load)	Within 7 inches of battery positive terminal

Fuse ratings are sized to protect the *wire*, not the load. Size the wire for at least 125% of the continuous load current, then choose a fuse at or **below** the wire's ampacity (the next standard size that does not exceed the conductor's ampacity, per NEC 240.4 / 240.6) so the fuse trips before the wire can be overloaded. Do **not** set the fuse above the wire's ampacity. ANL/bolt-down fuses are commonly used above ~30 - 40 A; MAXI blade fuses cover up to ~80 A. For small LoRa systems (under 10 A total), a waterproof inline blade-fuse holder rated for outdoor use (~$2 as of 2026-06-08) is adequate.

About the PV-side fuse (Isc × 1.56): *Isc* is your panel's short-circuit current, printed on the panel label. The 1.56 multiplier comes from NEC 690.8 (1.25 × 1.25). This fuse exists mainly to protect against reverse current back-fed from *other parallel panel strings*; a single panel feeding one controller has no other source to push reverse current, so a series PV fuse is **optional** for a single-panel system. For parallel strings, size it to the next standard fuse at or above Isc × 1.56 and follow the controller manual for placement.

Wire Gauge Selection

AWG	Conductor Area (mm²)	Max Ampacity (60 °C insulation, bundled)	Typical LoRa System Use
AWG 22	0.33 mm²	3 A	Sensor wiring, signal lines
AWG 20	0.52 mm²	5 A	Load output for single ESP32 node
AWG 18	0.82 mm²	7 A	Load output for small system (5 A load)
AWG 16	1.31 mm²	10 A	Battery-to-controller runs under 3 m

AWG	Conductor Area (mm²)	Max Ampacity (60 °C insulation, bundled)	Typical LoRa System Use
AWG 14	2.08 mm²	15 A	Battery-to-controller runs 3 - 10 m; 10 W panel to controller
AWG 12	3.31 mm²	20 A	20 - 40 W panel runs; Pi gateway battery cables
AWG 10	5.26 mm²	30 A	40 - 100 W panel runs over 5 m
AWG 8	8.37 mm²	40 A	100 W+ systems; long battery cable runs

Always use **stranded copper wire** with UV-resistant and temperature-rated insulation (XLPE or THWN-2 for outdoor; silicone for inside enclosures near heat). Solid wire is not suitable for mobile or vibrating installations. Use tinned copper wire in marine environments.

For voltage drop calculation in long cable runs:

```
Voltage_drop (V) = 2 × I (A) × R_per_meter (Ω/m) × Length (m)

Target: keep drop to less than 3% of system voltage.
For 12 V system, 3% = 0.36 V maximum drop.

Example: 5 A load, 5 m one-way run, AWG 14 (0.0083 Ω/m):
 Drop = 2 × 5 × 0.0083 × 5 = 0.415 V (3.5% - marginal, upgrade to AWG 12)
```

Weatherproof Connectors

MC4 Connectors (Panel Wiring)

MC4 (Multi-Contact 4 mm) connectors are the industry standard for solar panel connections. Common MC4 connectors are rated IP67/IP68, UV-resistant, up to 1000 - 1500 V DC and 30 - 40 A depending on the specific part and cable gauge (current rating scales with conductor cross-section). Never use non-MC4 connectors on the panel-side wiring - the exposed conductors in DIY terminal connections will corrode and introduce resistance. Crimp MC4 connectors with the correct MC4 crimper (not pliers) to ensure proper contact retention. MC4 pairs from different manufacturers (e.g., Stäubli vs Amphenol) are nominally cross-compatible but may have reduced IP rating when mixed - use matched pairs.

Anderson Powerpole Connectors (Load Connections)

Anderson Powerpole connectors (PP15, PP30, PP45 contacts) are the amateur radio and telecom standard for DC power distribution. They are genderless, stackable, and all three contact sizes share the same housing. Wire range is per contact: PP15 ~16 - 20 AWG, PP30 ~12 - 16 AWG, PP45 ~10 - 14 AWG. Crimp the PP30 (30 A) contact onto 12 - 16 AWG wire with a Powerpole ratchet crimper (e.g., Powerwerx TRIcrimp) or similar. ARES (Amateur Radio Emergency Service) has standardized on red (+) and black (−) 30 A Powerpoles for all portable power connections.

Other Connectors

Connector	Rating	Use Case
XT60	~30 A continuous (60 A surge)	High-current battery connections in drone/RC-derived builds
JST PH 2.0 mm	2 A	LiPo cell to embedded board (standard on most Adafruit/SparkFun boards)
JST XH 2.54 mm	3 A	Sensor connections inside enclosure
Dean's Ultra T-plug	30 A	Legacy RC packs; avoid for new designs

Polarity Protection

Reverse polarity can instantly damage unprotected charge controllers, LoRa boards, and BMS units. Many commercial controllers and BMS units include reverse-polarity protection and survive a miswire, but do not rely on it. **Before first connection, verify polarity with a multimeter:** set it to DC volts, put the red probe on the wire you believe is positive and the black probe on the negative; a positive reading confirms your assignment, a negative reading means the leads are swapped. Then implement at least one of the following:

1. **Asymmetric connectors:** MC4 (panel), Powerpole (load), JST (board) are all polarised - they cannot be connected backwards if crimped correctly.
2. **Schottky diode on the input:** A 3 A / 40 V Schottky diode (e.g., 1N5822) in series with the positive line blocks reverse connection. It wastes ~0.3 V at light load, rising to ~0.475 - 0.5 V near its 3 A rating, and continuously dissipates that voltage drop, so it is best for low-current inputs.

3. **P-channel MOSFET reverse protection:** A P-channel MOSFET (e.g., AO3401, IRF9540) provides near-zero-drop reverse polarity protection. Standard in commercial MPPT charge controller input stages.

Cable Routing and Strain Relief in Enclosures

Inside IP65/IP67 enclosures (Polycase WQ series, Bud Industries NBF, PolyBox), cables enter through compression cable glands. Rules:

- Use **double-sealed cable glands** (IP68 rated) for any cable entering an outdoor enclosure - single-seal glands allow moisture wicking along the cable jacket.
- All cable entries should be **on the side or bottom** of the enclosure, never on the top, to prevent water pooling at the seal.
- Leave a **drip loop** on the outside of each cable entry - a short downward curve below the gland that water follows away from the entry point before the cable turns upward.
- Inside the enclosure, route cables along the walls and use **cable ties on standoffs**, not across the PCB or battery. Keep power cables away from antenna cables to prevent RF interference.
- Add a **silica gel desiccant pack** (~1 - 3 g per liter of enclosure volume, so roughly 1 - 2 g per 0.5 L) and include a reusable humidity-indicator card; regenerate or replace the desiccant when the indicator shows above ~40 - 50% RH rather than on a fixed annual schedule.
- Secure the battery with **hook-and-loop strap or foam padding** to prevent it from shifting and chafing cables during thermal expansion/contraction.

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