Charge Controller Selection and Configuration

The charge controller is the brain of your solar power system - it manages battery charging, prevents overcharge and deep discharge, and in MPPT controllers, optimizes power extraction from the solar panel. Choosing the right charge controller significantly affects system efficiency and longevity.

PWM vs. MPPT: Which to Choose

Feature	PWM	MPPT
Efficiency	70-75%	93-97%
Cost	$5-20	$30-150
Solar panel voltage matching	Must match battery voltage closely	Works with any panel voltage above battery voltage
Best for small systems	Under 5W with matched panel/battery	5W+ or when panel voltage exceeds battery voltage
Cold weather performance	Good	Excellent (harvests more from cold-weather voltage boost)

Recommendation: Use MPPT for any permanent deployment. The efficiency gain pays for the cost premium within 1-2 years in most climates, and MPPT controllers last longer and provide better battery protection.

Victron SmartSolar MPPT 75/10: The Standard Choice

The Victron SmartSolar 75/10 ($45-55) is the most popular choice for LoRa mesh solar nodes:

- Input: up to 75V open-circuit panel voltage, 10A max charge current
- Supports 12V and 24V battery systems
- Bluetooth monitoring via Victron Connect app - see real-time voltage, current, and charge state from your phone
- Load output: controllable 10A output for the node; built-in low-voltage disconnect protects battery

- Temperature compensation for accurate charging in extreme climates

```
# Victron MPPT configuration for LiFePO4 battery (12V system):
Charge algorithm: Li-Ion
Absorption voltage: 14.2V
Float voltage: 13.5V
Low voltage disconnect: 12.0V (80% DOD protection)
Temperature compensation: Disabled for LiFePO4

# For LiPo (3.7V single cell, 4.2V max):
# Use a TP4056 Li-Ion charger module, not a Victron
# Victron 75/10 is designed for 12V+ systems
```

Load Output vs. Direct Battery Connection

Most MPPT controllers have a "load output" - a switched output that turns off automatically when the battery voltage drops below a set threshold:

- **Advantages of load output:** Built-in low-voltage disconnect protects battery; the controller manages when to power the node vs. when to conserve battery for recovery
- **Disadvantages:** Load output current limit (typically 10-15A) may not support higher-power loads; adds a small voltage drop (0.1-0.5V)

Best practice: Connect your node through the load output for automatic low-voltage protection. Connect any monitoring equipment (Pi) directly to the battery with its own cutoff relay if the Pi exceeds the load output current limit.

Solar Panel Tilt Optimization

```
# Optimal fixed tilt angle for annual maximum energy:
# Tilt angle = latitude * 0.9

# Examples:
# Portland (45.5°N): 45.5 * 0.9 = 41 degrees from horizontal
# Dallas (32.8°N): 32.8 * 0.9 = 30 degrees
# Phoenix (33.4°N): 33.4 * 0.9 = 30 degrees
# Chicago (41.8°N): 41.8 * 0.9 = 38 degrees
```

```
# For winter optimization (maximize December-February output):
# Tilt angle = latitude + 15 degrees

# For snow-shedding (prevents accumulation that blocks panel):
# Tilt angle = 45 degrees minimum; 60 degrees ideal in heavy snow climates
```

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