

Meshtastic Motherboard (revision D)

1 Features

- Integrated MPPT Charging Circuit
- Wide Battery Compatibility
- Buck/Boost DC/DC Converter
- For 868 MHz and 915 MHz LoRa networks
- Compact Design
- Uses RAK4630 LoRa Module, compatible with
 - Meshtastic
 - MeshCore
 - Reticulum
- USB-C Connector for programming
- Easy Mounting Options

2 Applications

- Off-Grid LoRa Nodes
- Environmental Monitoring
- Disaster Recovery Networks
- Agricultural Monitoring
- Educational Projects

3 General Description

This Meshtastic Motherboard is a compact, integrated solution designed to power Meshtastic (or any other LoRa firmware compatible with RAK4631/RAK4630) nodes using solar energy. By combining an MPPT charging circuit, a buck/-boost DC/DC converter, and a LoRa communication module on a single PCB, it simplifies the deployment of off-grid communication networks.

The MPPT charger, based on the CN3795 chip, efficiently converts solar energy to charge a variety of battery types, ensuring optimal performance even under varying environmental conditions. The TPS63000 buck/boost converter maintains a stable 3.3 V output, accommodating the voltage fluctuations inherent in solar-powered systems.

Designed with user convenience in mind, the board includes features like a USB-C connector for firmware updates, Qwiic/STEMMA-compatible I²C connectors for sensor integration, and accessible interfaces for debugging and development. Its compatibility with Meshtastic firmware for the WisBlock RAK4631 ensures a seamless setup process, allowing users to quickly deploy reliable, solar-powered communication nodes.

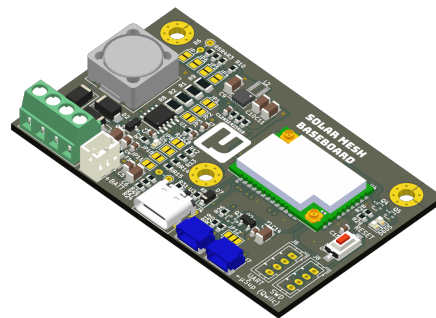


Figure 1: 3D render of the product.

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5 Absolute Maximum Ratings

Table 1: Absolute Maximum Ratings of Meshtastic Motherboard

Parameter	Rating
Maximum Input Voltage	30 V
Maximum Battery Voltage	5.6 V
Maximum Charging Current	480 mA
Operating Temperature Range	−40°C to +60°C

Note: Stresses above those listed under Absolute Maximum Ratings can cause permanent damage to the device.

6 Electrical Specifications

All specifications are in $-40^{\circ}\text{C} \leq T_A \leq 60^{\circ}\text{C}$ unless otherwise noted.

Table 2: Meshtastic Motherboard Electrical Specifications

Parameter	Symbol	Min.	Typ.	Max.	Unit	Note
Solar Input Voltage	V_{solar}	6.5		30	V	See Section 9.3.
Battery Voltage	V_{batt}	1.8		5.6	V	See Section 9.2.
MPPT Voltage Range	V_{MPPT}	7		29	V	
System Voltage (regulated)	V_{sys}		3.3		V	
Charging Current	I_{charge}			480	mA	See Section 9.1.
BLE Tx Power	$P_{TX,BLE}$	−20		4	dBm	
LoRa Frequency	f_{LoRa}	863		928	MHz	¹
LoRa Tx Power	$P_{TX,LoRa}$			+22	dBm	²
LoRa Sensitivity	S_{RX}	−134			dBm	BW = 250, SF = 12
LoRa Sensitivity	S_{RX}	−121			dBm	BW = 250, SF = 7
Operating Temperature Range	T_{oper}	−40		+60	°C	
Weight	W_{total}		21		g	

¹ The RAK4630 is certified by RAKwireless under both **CE** and **FCC** and supports full LoRa frequency range.

² For more details about LoRa RF, see SX1262 datasheet.

7 Detailed Description

The **Meshtastic Motherboard** is a compact, solar-powered charging and power management board designed specifically for Meshtastic LoRa nodes. It integrates an efficient MPPT charger for various battery types, a buck/boost converter for stable 3.3 V operation, and an onboard RAK4630 LoRa module soldered directly to the PCB.

At the heart of the charging circuit is the **CN3795** MPPT charger from Consonance. Unlike the simpler CN3791, the CN3795 supports multiple chemistries and battery configurations, such as:

- 1S Li-Ion / Li-Pol
- 1S or 2S Lithium Titanate Oxide (LTO)
- 1S LiFePO₄

This flexibility is particularly valuable in outdoor, year-round installations where temperature resilience is critical. While Li-Ion batteries may be sensitive to sub-zero charging conditions, LTO batteries provide a wide operating range (typically -30°C to $+55^{\circ}\text{C}$), making them well-suited for permanent or autonomous Meshtastic/LoRa nodes, even in harsh climates.

The circuit includes a reverse polarity protection diode at the solar panel input, using a Schottky diode D1. This adds a small voltage drop (up to 0.5 V) but improves robustness.

To ensure accurate current regulation, the VCC rail that powers the rest of the board is tapped directly after the inductor L1 and before the current-sensing shunt resistor. This avoids unwanted current draw affecting the charging control logic inside the CN3795.

The LoRa module and peripherals are powered through a **TPS63000** buck/boost converter from Texas Instruments. This converter is capable of operating from input voltages ranging from 1.8 V to 5.5 V, making it ideal for batteries whose voltage may drop below or exceed the 3.3 V logic level. The converter ensures stable operation across the full battery voltage range, regardless of solar input or battery type.

The design uses the **RAK4630** module, which is soldered directly to the PCB using castellated holes. This approach eliminates the need for the more expensive RAK4631 development board and allows a more compact and cost-effective layout. The RAK4630 is fully compatible with RAK4631 and the same firmware can be used for this module.

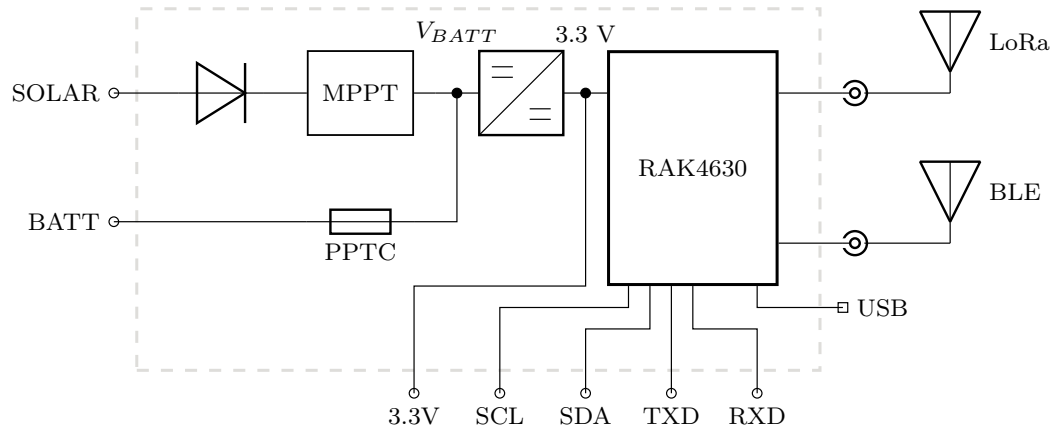
A USB-C connector is provided for serial communication and firmware flashing. Note that USB power is not used to charge the battery or power the node; solar and battery sources are the only valid power inputs.

The board provides:

- Two I²C connectors (QWIIC / STEMMA compatible)
- UART breakout
- RESET button
- SWD debugging interface
- JST-PH battery connector or screw terminal

- Screw terminal for solar panel connection
- Three M3 mounting holes for easy installation

Figure 2: Block diagram of the Meshtastic Motherboard.



8 PCB Revision History

8.1 Revision A

- Initial release.
- Used a through-hole USB-C connector.
- Power terminals spaced further apart.
- Manual soldering of radio module and other components.

8.2 Revision B

- USB-C connector replaced by an SMD version, assembled by machine.
- Power terminals (J1, J2) moved closer together to allow dual-terminal mounting.
- RESET button replaced with a more soldering-friendly type.
- Resistor R13 changed from 150 Ω to 120 Ω , enabling 12 V input operation.
- Switched from solid pad connections to thermal reliefs for GND areas, improving hand soldering of the radio module.

8.3 Revision C

- Added 2-pin JST-PH battery connector (many Li-Ion batteries use this).
- Added battery overcurrent protection via PPTC fuse (trips above 750 mA).
- All test points moved to the bottom side for improved accessibility.
- Buck/boost converter layout redesigned for improved grounding and copper area, per manufacturer guidelines.
- MPPT section layout improved; capacitors repositioned and space made for the fuse.
- Back of PCB now includes a **Powered by Meshtastic** logo.

8.4 Revision D

- RAK4630 now machine-assembled (more consistent quality).
- Removed resistor R17 between VIN and VINA on TPS63000; this improves startup at voltages as low as 1.8 V.
- QWIIC (STEMMA) connectors J5 and J7 now share a single I²C bus for easier sensor chaining.
- I²C 2 bus is no longer used.

9 Board Settings and Features

The board provides several configuration options using onboard solder jumpers and unpopulated resistors. These settings define battery chemistry, MPPT voltage threshold, charging currents, and are briefly described in Table 3 and in detail in the following subsections.

Table 3: Board Settings Overview

Setting	Jumpers	Description
Charging Current	JP1–JP3	Set the maximum charging current from 120 to 480. More in section 9.1.
Battery Type	JP4–JP7	Maximum battery voltage, choose value according to your battery chemistry. More in section 9.2.
MPPT Voltage	JP8–JP11	Set the target voltage point where maximum power is extracted from the solar panel. More in section 9.3.

9.1 Charging Current Selection

Charging current is selected using jumpers JP1 to JP3. If no jumpers are connected (default), the charging current is limited to 120. The selected current is the *maximum* the circuit will deliver – real current may be lower depending on solar panel capability.

Table 4: Battery Charging Current Selection

Jumper(s)	Charge Current	Recommended Battery Capacity (min)
None	120	≥ 250
JP1	240	≥ 500
JP1 + JP2	360	≥ 720
JP1 + JP2 + JP3	480	≥ 960

You may connect more than one jumper simultaneously in this section (e.g., JP1 + JP2) to increase current. Choose the current based on your battery’s safe charge rate. A common rule of thumb is to not exceed **0.5C**, i.e., charge at a current lower than half the battery capacity. Lower current improves battery lifespan and thermal safety.

9.2 Charging Voltage Selection

Battery charging behavior is configured via solder jumpers JP1 to JP7 and an optional resistor R6.

The charging voltage corresponds to the full-charge voltage of the battery chemistry. Only one jumper from JP4 to JP7 should be soldered at a time. For custom voltage configurations (e.g., LiFePO₄), a THT resistor must be fitted in place of R6.

Always connect only one jumper among JP4–JP7 to avoid misconfiguration. For LiFePO₄ and other custom chemistries, jumper JP7 must be used in combination with a precisely calculated resistor at position R6.

Table 5: Battery Charging Voltage Selection

Battery Type	Charging Voltage (V)	Jumper Configuration
1S LTO	2.77	JP6
1S Li-Ion / Li-Pol	4.18	JP5
2S LTO	5.56	JP4
1S LiFePO ₄	3.55	JP7 + $R_6 = 140\ \Omega$
Custom type (< 5.6 V)	V_{BATT}	JP7 + $R_6 = \frac{326}{V_{BATT}-1.22}\ [\Omega]$

Section 12 explains in detail how charging voltage and current is used.

9.3 Configuring MPPT Voltage Threshold

The MPPT voltage is set using solder jumpers JP8–JP11. Choose only one solder jumper according to your solar panel specification.

Predefined V_{mppt} voltage values are 13.76 V, 17.77 V and 19.38 V for PCB revision A, and 11.35 V, 17.77 V, and 19.38 V for PCB revisions B, C and D. This is determined by solder jumpers JP8 (resistor R13), JP9 (resistor R14), and JP10 (resistor R15) and JP11 (unpopulated THT resistor R16). This last option is prepared in case none of the preset voltages suit the user needs. In such a case, simply solder a resistor at position R16 with a value:

$$R_{16} = R_{12} \cdot \frac{V_{\text{mppt}} - 1.705}{1.205} \quad [\Omega]$$

where R_{16} is the resistor value we look for in Ω , R_{12} is the resistor value $15\ \Omega$, and V_{mppt} is the operating voltage at maximum power of the solar panel.

Section 11 describes in detail how to choose V_{mppt} for intended application and selected solar panel.

9.4 UPS Mode

In addition to solar-powered operation, the **Meshtastic Motherboard** can be powered directly from a regulated voltage source. This configuration is particularly useful in fixed installations where a stable power supply is available, such as in homes or remote monitoring stations. In this setup, the board continuously draws power from the connected source, while the battery serves as a backup and provides power only during outages – effectively operating as an uninterruptible power supply (UPS).

No special configuration is required to enable UPS mode. Simply connect the external DC source to the SOLAR input terminals, ensuring correct polarity. Then set the appropriate MPPT voltage using jumpers JP8 through JP11, as described in the Section 9.3. Note that the configured V_{mppt} must be lower than the input source voltage to ensure proper regulation and energy flow.

Recommended jumper settings for different PCB revisions and voltage ranges are summarized in Table 6.

Table 6: UPS Mode Jumper Configuration by Source Voltage

Source Voltage Range	PCB Rev. A	PCB Rev. B, C, D
12 V DC	JP11 + $R_{16} = 120\ \Omega$	JP8
13–18 V DC	JP8	JP8
18–20 V DC	JP9	JP9
20–30 V DC	JP10	JP10

While precise tuning of the MPPT voltage is not critical in UPS mode, the selected jumper should ensure that V_{mppt} remains below the nominal input voltage. The onboard switching regulator and CN3795 charging controller will handle power distribution and battery management automatically.

9.5 Antennas

The **RAK4630** module is equipped with two **IPEX connectors** – one for the **LoRa** radio and one for **Bluetooth**. Each connector is labeled on the module, allowing easy identification.

Users can connect either a compact antenna with an IPEX connector directly, or use a short **IPEX-to-SMA pigtail cable** to attach an antenna with an SMA connector. The choice of antenna and cabling is left to the user and is not included with the **Meshtastic Motherboard**.

A popular choice among Meshtastic users is the flexible antenna from the manufacturer **Gizont**, which offers a model for 868 or 915 LoRa communication with a typical length of 167. This antenna is typically terminated with an **SMA Male** or **SMA-RM Male** connector, which matches the common cabling setup for Meshtastic nodes.

Table 7 lists common antenna and cable options available from popular sources.

Table 7: Common Antenna and Cable Options

Item	Recommendation / Notes
IPEX to SMA cable (pigtail)	Available on AliExpress; choose variant “IPEX to RPSMA-K”
Bluetooth antenna (2.4 GHz)	IPEX-terminated Bluetooth antenna (same frequency as WiFi); widely available on AliExpress
LoRa antenna (868 MHz)	Gizont flexible antenna; recommended variant is “RP-SMA M”

Warning: Never power on the board without antennas connected. Operating the radio without a proper load may cause permanent damage to the RF circuits, either destroying them or severely degrading their sensitivity.

9.6 I²C Connectors and Sensor Support

The **Meshtastic Motherboard** is equipped with two **JST-SH SM04B connectors** with I²C bus and 3.3 V power supply – commonly known under brand names such as **Qwiic** (by SparkFun), **STEMMA** (by Adafruit) or **µSup** (from Czech retailer Laskakit). These connectors provide access to the I²C bus, making it simple to connect a wide variety of sensors.

- Connector J5 is wired to the I₂C1 interface on the RAK4630 module.
- Connector J7 is connected to the I₂C2 interface on PCB revisions A through C.
- Starting with PCB **revision D**, both J5 and J7 are connected to the I₂C1, providing access to the same bus.

Power control for I²C devices is managed via the JP12 solder bridge:

- **Right bridge closed:** sensors are powered permanently. This is default setting.
- **Left bridge closed:** sensor power is controlled via pin P1.02 of the RAK4630.

The standard **Meshtastic firmware** includes a **telemetry** module which automatically initializes I²C sensors connected to the **I₂C1** bus. If a compatible sensor (e.g., BME280 for temperature, humidity, and pressure) is connected, it will automatically send measurements over the LoRa network.

10 Firmware Upload

The **Meshtastic Motherboard** comes with the RAK4630 module already flashed with the correct bootloader via the SWD interface. This makes firmware updates and flashing new software extremely easy using the built-in USB interface – no external programmer is needed.

10.1 Flashing Meshtastic or Other Firmware

To upload firmware via USB, follow these steps:

1. Connect the board to a power supply (e.g., by attaching a charged battery to the battery connector).
2. Plug a USB-C cable into the USB connector on the board and connect the other end to your computer (Linux, macOS, or Windows).
3. Quickly press the **RESET** button twice. The RAK module will enter USB Mass Storage mode, and a new external drive will appear on your computer.
4. Download the appropriate firmware file in **.uf2** format for the RAK4631 module (RAK4630 and RAK4631 are electrically compatible).
5. Drag and drop the **.uf2** firmware file into the newly mounted USB drive.
6. Wait for the copy process to complete. The drive will automatically unmount, and the module will reboot.
7. Done. The new firmware is now running. You can interact with the node via the USB serial interface or Bluetooth, just like any standard Meshtastic device.

10.2 Firmware Compatibility

The RAK4630 module used on the **Meshtastic Motherboard** is fully compatible with the RAK4631 from an electrical and software point of view. This means any firmware built for RAK4630 or RAK4631 will run reliably on this board. This includes a wide range of projects such as:

- **Meshtastic** – the default and recommended firmware for mesh communication.
- **MeshCore** – a community-developed modular firmware platform.
- **Reticulum** – a versatile communications stack for resilient networking.

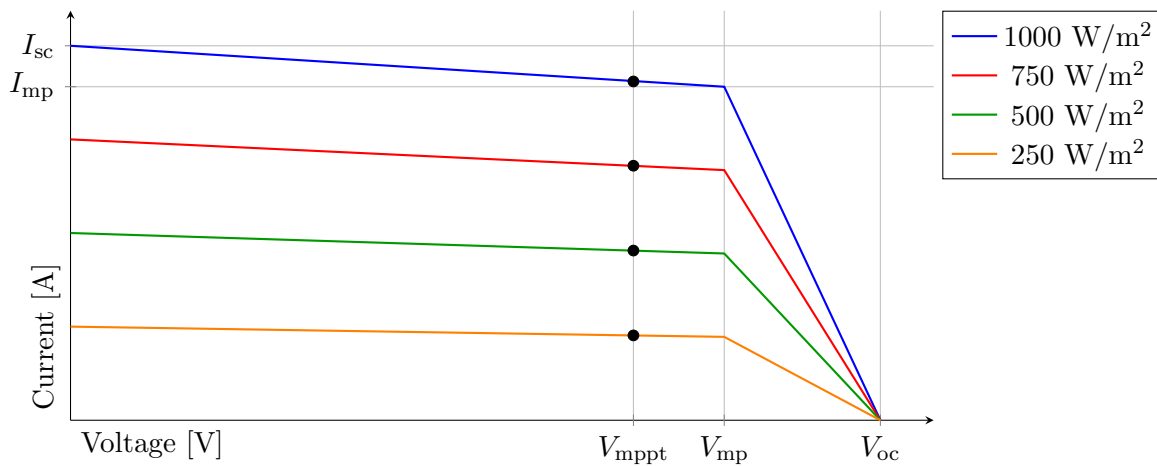
When choosing firmware, always make sure to select the version targeted for the RAK4631 module in .uf2 format.

11 Understanding Solar Panels

Understanding how solar panels work helps in selecting an appropriate panel based on its electrical parameters and in correctly configuring the MPPT (Maximum Power Point Tracking) voltage for the intended application.

Figure 3 shows simplified **I-V characteristics** of a typical solar panel and how they change with varying irradiance levels. These curves demonstrate that the panel behaves like a current source at low voltages – capable of delivering near its maximum current (short-circuit current, I_{sc}) – and gradually transitions to voltage-source-like behavior as the current decreases to zero at the open-circuit voltage V_{oc} .

Figure 3: I-V Characteristics of a Typical Solar Panel Under Different Irradiance Levels



This nonlinear behavior is due to the panel's internal structure, which operates similarly to a photovoltaic diode. Incoming light generates current through the photovoltaic effect, but as voltage increases, internal diode and resistive effects begin to dominate. Eventually, further increases in voltage cause a rapid drop in current. This steep decline defines the *knee* of the curve, which lies just beyond the Maximum Power Point (marked as V_{mp} in the plot).

This product integrates an MPPT charge controller based on the CN3795 IC, which employs a constant voltage tracking method. As shown in Figure 3, the voltage at the maximum power point, V_{mp} , remains

relatively stable across different irradiance levels. This enables the controller to maintain the panel voltage near V_{mp} , achieving efficient power conversion in most lighting conditions. Compared to basic constant-voltage or PWM controllers, this method offers significantly improved energy harvesting.

Key solar panel parameters include:

- V_{oc} – Open-circuit voltage: the maximum voltage the panel produces under no load conditions.
- I_{sc} – Short-circuit current: the maximum current delivered when the output is shorted.
- V_{mp} – Voltage at maximum power point: the voltage at which the panel delivers its maximum power.
- I_{mp} – Current at maximum power point: the current corresponding to V_{mp} .

The MPPT voltage setpoint should meet the condition $V_{mppt} \approx V_{mp}$. Setting V_{mppt} exactly at V_{mp} allows for optimal energy harvesting. However, due to environmental and operational variations, configuring V_{mppt} close to V_{mp} is typically sufficient. For instance, if the panel's datasheet specifies $V_{mp} = 17.42\text{ V}$, the **Meshtastic Motherboard** can be configured to regulate the input voltage near this point by soldering jumper JP9, which sets $V_{mppt} = 17.79\text{ V}$.

Since this value is slightly above the panel's maximum power voltage, users requiring more precise adjustment can use jumper JP11 in combination with resistor $R_{16} = 195\ \Omega$ to fine-tune the MPPT voltage.

If V_{mppt} is set significantly lower than the panel's specified V_{mp} – for example, 12 V for a panel with $V_{mp} = 17.42\text{ V}$ – the system will still function and charge the battery correctly. However, the solar panel will not operate at its maximum power point, and the energy harvesting efficiency will be reduced. In this case, the charger will draw less current than the panel could provide, resulting in longer charge times and suboptimal utilization of available solar energy.

Nevertheless, this configuration can be advantageous for its simplicity: users without access to soldering tools or uncertain about the optimal MPPT configuration can rely on the factory-default jumper JP8, which sets $V_{mppt} \approx 12\text{ V}$. This ensures broad compatibility with most solar panels with $V_{mp} > 12\text{ V}$, offering plug-and-play usability with reasonable performance.

12 Battery Charging Overview

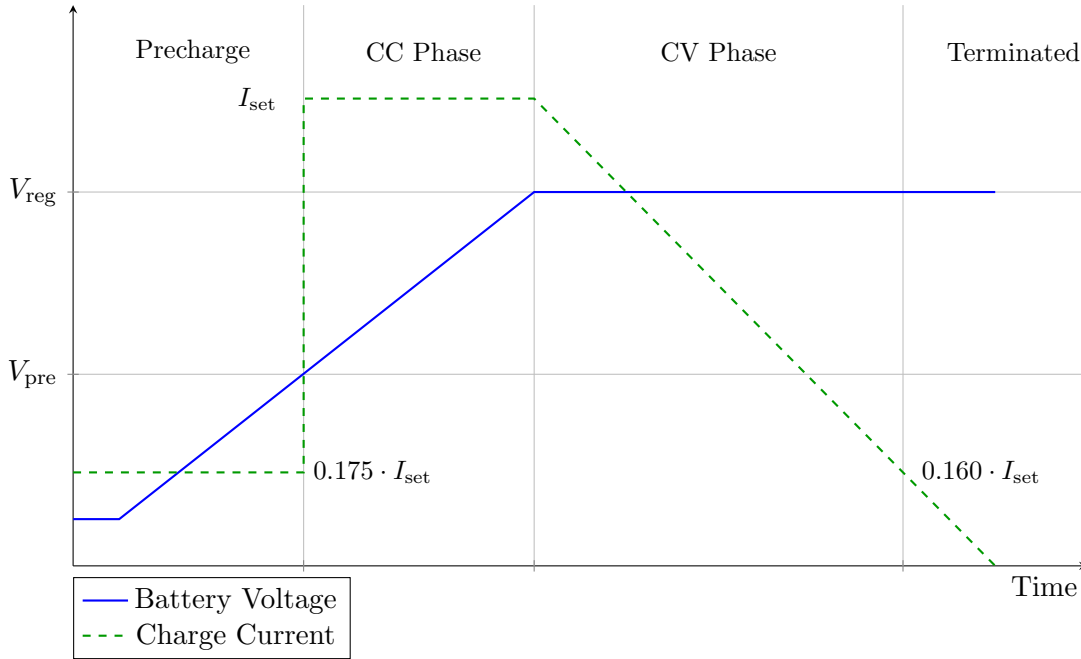
The **Meshtastic Motherboard** integrates the CN3795 battery charger IC, which supports multiple lithium-based chemistries including Li-Ion, LiFePO₄, Lithium Titanate, and others. The charger operates using a constant current / constant voltage (CC/CV) charging profile. The charging behavior is governed by the battery regulation voltage V_{reg} and charge current limit I_{set} , both set by solder jumpers on the board (see Table 5 and Table 4 for more informations).

Figure 4 illustrates the typical battery charging profile, showing transitions between different charging stages: precharge (trickle charge), constant current (CC), constant voltage (CV), and charge termination.

A charging cycle begins when the voltage from the solar panel exceeds the under-voltage lockout (≥ 6.5) threshold and is higher than the battery voltage by at least 0.3 . The LED D4 is turned on and charger then evaluates the battery voltage to determine the appropriate charging mode.

If the battery voltage is below V_{pre} , which is 66.5% of the regulation voltage V_{reg} , the charger enters **precharge mode**. In this mode, the charge current is internally limited to approximately 17.5% of the maximum current I_{set} . This ensures safe preconditioning of deeply discharged batteries.

Figure 4: Typical Battery Charging Profile



Once the battery voltage exceeds V_{pre} , the charger switches to **constant current (CC) mode**, supplying the maximum charge current I_{set} . If connected solar panel is not able to provide maximum current, then the maximum current of the panel is used for charging.

As the battery voltage approaches V_{reg} , the charger transitions into **constant voltage (CV) mode**, holding the output voltage constant for the rest of the charge cycle. During this phase, the charge current begins to decrease as the battery becomes fully charged.

Charging is **terminated** when the current decreases to 16% of the maximum current I_{set} . At this point, the LED D4 turns off. However, in MPPT solar-charging mode (solar panel is providing its maximum power), charging continues until the battery voltage exceeds V_{ter} , which is 95.8% of V_{reg} , even if the charge current has already fallen below the termination threshold. This ensures maximum energy is harvested and the battery is fully charged.

If the battery self-discharges or an external load draws current after charging completes, a new charge cycle automatically begins when the charge current rises above 58.8% of the maximum current I_{set} . This behavior ensures the battery remains charged without requiring user intervention.

To protect the battery from input transients or load dumps, the CN3795 includes an overvoltage comparator that disconnects battery if the input voltage exceeds 107% of V_{reg} . Charging resumes automatically once the overvoltage condition is cleared.

Table 8 summarizes charging parameters for common lithium-based battery chemistries supported by the **Meshtastic Motherboard**. It includes the minimum and maximum voltage per cell, the regulation voltage V_{reg} used in the constant voltage phase, the corresponding precharge threshold voltage $V_{pre} = 0.665 \cdot V_{reg}$, and charge termination limit $V_{ter} = 0.958 \cdot V_{reg}$ for MPPT solar-charging mode.

Table 8: Charging Parameters for Various Lithium-Based Battery Chemistries.

Battery Type	Cell Voltage	V_{reg}	V_{pre} (66.5%)	V_{ter} (95.8%)	Note
1S Li-Ion / Li-Po	2.754.20	4.20 V	2.79 V	4.02	
1S LiFePO ₄	2.53.6	3.60 V	2.39 V	3.45	
1S LTO	1.502.80	2.77 V	1.84 V	2.65	
2S LTO	3.005.60	5.56 V	3.69 V	5.33	

Figure 5: Schematics of the Meshtastic Motherboard revision D.

14 Mechanical Dimensions

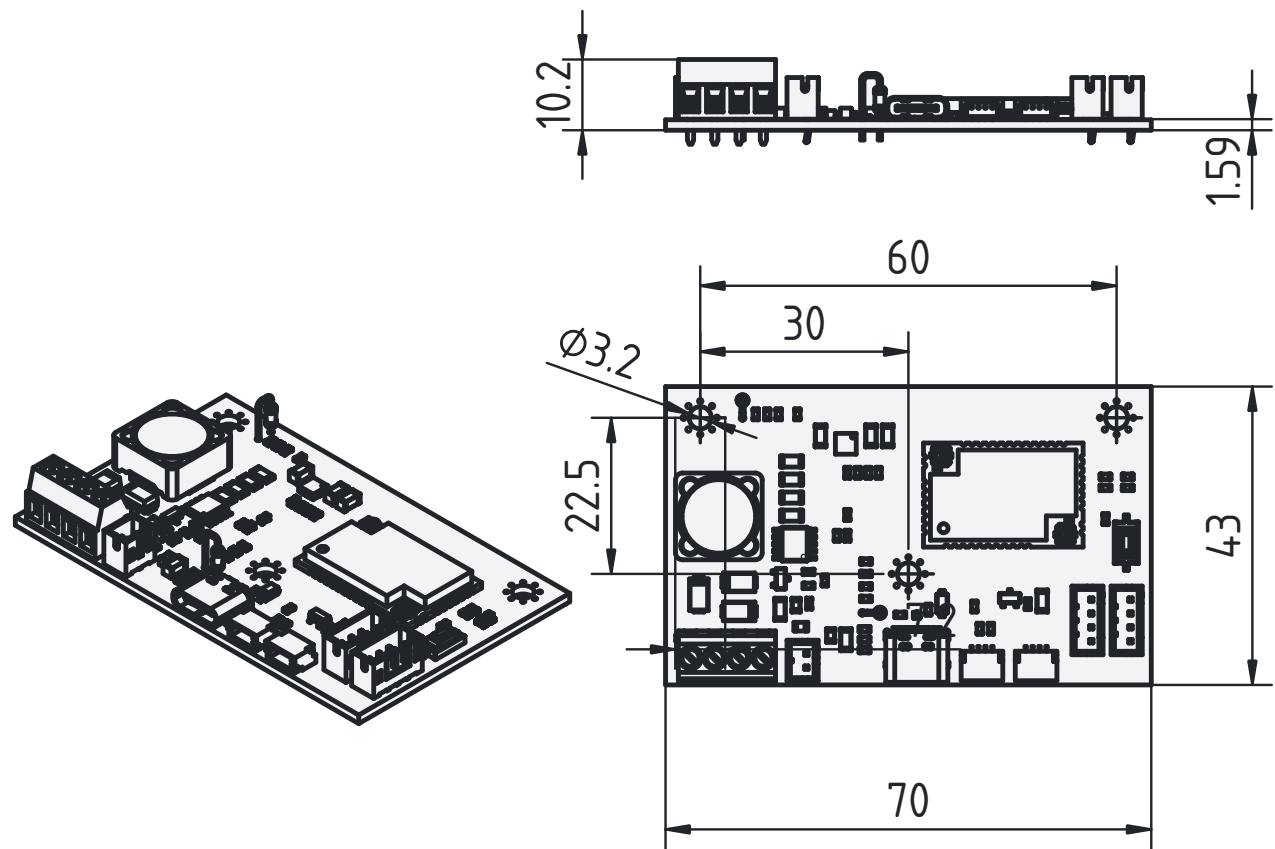


Figure 6: Mechanical dimensions of the Meshtastic Motherboard revision D. Dimensions in mm.