Thornwave Labs Inc

PowerMon

Bluetooth Low Energy

Advanced Battery Monitor / DC Power Meter

– USER MANUAL –

BRIEF

PowerMon is a Bluetooth Low Energy advanced battery monitor / DC power meter. This tool can be used in any battery or DC powered circuit to monitor, analyze, and log the most important electrical parameters: two voltages (0-72V), current (0-60A using the integrated shunt or up to 1,000A using an external shunt), power (W), energy (Wh), battery charge (Ah) and temperature. Many other parameters are computed: the battery state of charge (% SoC), remaining time on battery at current load, and a multitude of battery / DC power statistics. The device can log the data for up to 3 years, allowing for advanced data analysis and troubleshooting. All battery monitors on the market that log data, do it inside the mobile application but PowerMon logs it inside internal memory. This makes PowerMon superior. The data logging function is only available for devices with hardware revision 2.3 and up (sold after 2019). The device can drive a mechanical or solid-state relay which allows it to function as a low voltage disconnect, high voltage disconnect, over-current disconnect, temperature controller, battery isolator in multiple battery systems, remote on/off switch, timer, and generator control. A mobile device running either Android or iOS and the PowerMonX app (available for free on Google Play Store and Apple App Store) is required for using this device. An older app, PowerMon, is also available to support older devices (pre-2019 models).

FEATURES

- Measures two voltages, current, power (W), charge meter (Ah), energy (Wh), and temperature
- Operates at up to 72V and 60A of continuous current (75A peak current) using the integrated current shunt
- Can sense up to 160mV of voltage drop across an external current shunt allowing current of up to 1,000A to be measured
- Fully differential input for the current shunt, allowing it to be mounted either on the negative side or on the positive side
- Data logging for up to 3 years (for hardware revision 2.3 and up)
- Can drive one relay or SSR (solid-state relay)
- Low/high voltage disconnect
- Over-current disconnect
- Low/high temperature disconnect
- Generator control
- Battery isolator for dual battery systems
- Battery monitor (battery fuel gauge), displays the state of charge in percentage and the remaining time on battery at the current load
- Works with all types of batteries
- Lithium iron phosphate battery charge manager
- Timers
- Can use an external temperature sensor (DS18B20 based)
- User/master password protection
- Very low power consumption (see Performance Parameters)
- Bluetooth LE radio with internal antenna and long range
- 8-pole terminal block for connecting to the system that will be monitored
- ABS plastic enclosure with mounting flanges, completely enclosed in epoxy potting compound
- Measures only 3.0” x 1.55” x 0.75” (76mm x 39mm x 19mm) including the mounting flanges.
- Weatherproof
- Free PowerMonX app is available for Android and iOS. Old PowerMon app is available as well.
- Highly configurable. It achieves top performance with all kinds of current shunts and batteries

TYPICAL APPLICATIONS

- RVs, boats, off-the-grid cabins
- Solar and wind alternative energy systems
- Vehicle batteries, battery isolator
- Backup electrical systems
- Lithium Iron-Phosphate battery charge manager
- Automation: solar irrigation systems, solar streetlights, general-purpose DC timers

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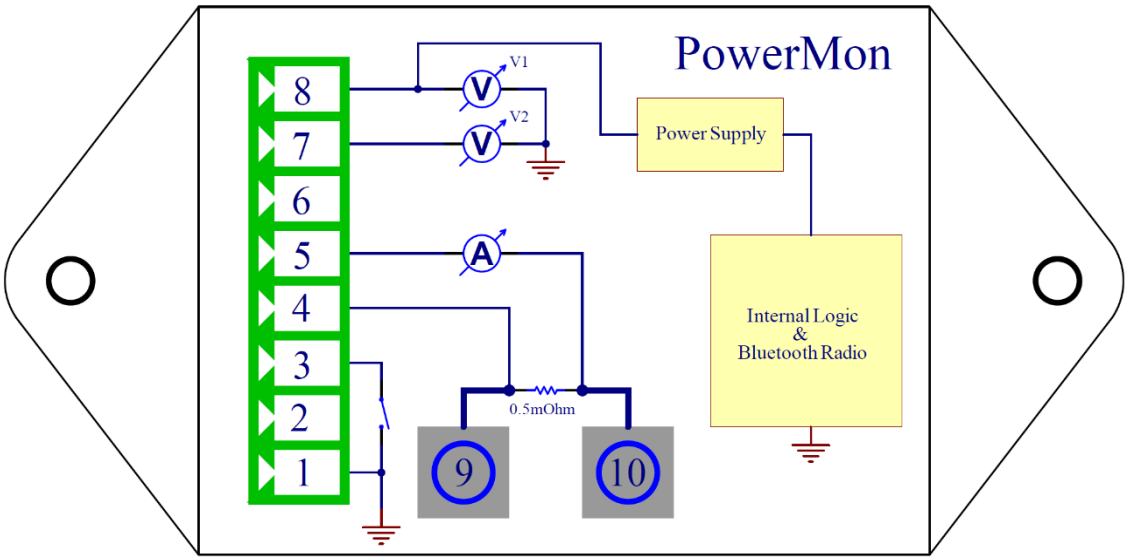
TERMINAL DESCRIPTION / INTERNAL DIAGRAM



No.	Name	Terminal Description
1	GROUND	System ground (battery negative, chassis)
2	MF	Multi-Function (for hardware revision 2.2 and up). Supports pushbutton input or external temperature sensor
3	RELAY	Relay output. It drives a mechanical or solid-state relay. To turn the relay on, the device is grounding this terminal internally
4	ES2	External shunt connection. When using the internal current shunt connect this terminal to ES1 (terminal 5)
5	ES1	External shunt connection. When using the internal current shunt connect this terminal to ES2 (terminal 4)
6	DNC	DO NOT CONNECT!
7	V2	Second monitored voltage. Can measure the voltage of a second battery.
8	V1	This is the main voltage that will be monitored. The device also draws its own power from this terminal.
9	IS1	Internal shunt connection. Do not connect if using an external shunt.
10	IS2	Internal shunt connection. Do not connect if using an external shunt.

SPECIFICATIONS

Absolute Maximum Ratings [1,2]	
Maximum voltage at the V1 and V2 terminals	**+65V (hw rev 2.0)** **+72V (hw rev 2.2 and up)**
Maximum voltage at the RELAY terminal	**+18V (hw rev 2.0)** **+32V (hw rev 2.2 and 2.3)** **+72V (hw rev 2.5 and up)**
Maximum current through the RELAY terminal (maximum relay coil current)	**0.5A (hw rev 2.3 and under)** **2A (hw rev 2.5)**
Maximum current through IS1 and IS2 (using the integrated current shunt)	**60A continuous, 75A peak**
Maximum current (using an external current shunt)	**depends on the external shunt (up to 1,000A)**
Maximum differential current sense voltage ES1 to ES2 (using an external shunt)	**-72V to +72V**
Maximum common mode current sense voltage (ES1 - ES2, IS1 - IS2)	**-2V to +72V**
Operating temperature	**-30°C to +85°C**

1. Stresses greater than those listed under “Absolute Maximum Ratings” may cause permanent damage to the device.
2. All voltages are referenced to ground (terminal 1) unless otherwise specified.

Performance Parameter	Value
Measured voltage (V1, V2)	**0 to 60V (hw rev 2.0)** **0 to 72V (hw rev 2.2 and up)**
Measured voltage accuracy	**max 0.5%, typ. 0.25%** **max 0.2%, typ. 0.15% (hw rev 2.5 and up)**
Measured current (using the integrated shunt IS1, IS2)	**0 to 60A**
Current monitoring accuracy (using the integrated shunt)	**1% - without calibration** **0.25% - with calibration**
Integrated current shunt resistance	**0.5 mOhm / ±1%**
Measured differential voltage on ext. shunt input (ES1, ES2)	**-160mV to +160mV**
Current monitoring accuracy (using external shunt)	**depends on external shunt precision, typically 0.25% (with calibration)**
Temperature	**1°C / 1°F resolution**
Data logging sample rate (for hardware rev 2.3 and up)	**1 sec – up to ~18 days** **2 sec – up to ~36 days** **5 sec – up to ~90 days** **10 sec – up to ~180 days** **20 sec – up to ~1 year** **30 sec – up to ~1.5 years** **1 min – up to ~3 years**
Current draw (current consumed by the device) (using the latest firmware version)	hw rev 2.5 and up
at 12V	**5.4 mA** **3.4mA**
at 24V	**5.7 mA** **3.5mA**
at 36V	**6.0 mA** **3.6mA**
at 48V	**6.3 mA** **3.7mA**
at 60V	**6.6 mA** **3.8mA**
at 72V	**6.9 mA** **3.9mA**

COMPLIANCE STATEMENTS

FCC

ATTENTION: Changes or modifications not expressly approved by Thornwave Labs Inc could void the user's authority to operate the equipment.

ATTENTION**:** This device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference and (2) this device must accept any interference received, including interference that may cause undesired operation.

ATTENTION: Cet appareil est conforme à la Partie 15 des règlements de la FCC. L'opération doit se conformer aux deux conditions suivantes: (1) cet appareil ne peut causer d'interférences nuisibles et (2) cet appareil doit accepter toute interférence reçue, y compris les interférences qui peuvent provoquer un fonctionnement indésirable.

IC RSS-102 RF Exemption

This system has been evaluated for RF Exposure per RSS-102 and is in compliance with the limits specified by Health Canada Safety Code 6.

L'exposition aux radiofréquences de ce système a été évaluée selon la norme RSS-102 et est jugée conforme aux limites établies par le Code de sécurité 6 de Santé Canada.

IC RSS-Gen 8.4

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

SAFETY INSTRUCTIONS

Warning!

Read all the instructions and cautions before using the PowerMon device. Thornwave Labs Inc does not assume responsibility for any injury or property damage caused by improper installation, bad wiring, or use of PowerMon outside of its intended purpose. The device should be installed by a professional.

Warning!

The PowerMon device should not be used for any medical purposes, life-sustaining equipment, safety applications, or any application where equipment failure can cause injury, death, fires, or any other hazard.

Warning!

There are no serviceable parts or fuses inside the power meter! Do not disassemble or attempt to repair! The unit operates with voltages up to 72V which can be lethal or cause serious and permanent injury.

Warning!

Do not submerge under water or other liquids. The device is weatherproof but not waterproof.

Warning!

The device is to be connected to DC circuits only, not exceeding 72V and 60A (using the integrated current shunt). Failure to do so will result in equipment damage. Higher currents are supported when using an external current shunt. Confirm that all connections are tight to avoid excessive heating, sparks, or fire. Never connect the V1 terminal to a power source without using a fuse or circuit breaker. A 0.1A to 2A fuse or circuit breaker is required.

Warning!

Batteries are dangerous! Do not short-circuit a battery or the power meter. Batteries can produce flammable and explosive gases and can generate extremely high currents that can lead to serious consequences including explosion, fire, damage to equipment, personal injury, and even death. It is the user's responsibility to operate the equipment in a safe manner. Do not charge batteries in an enclosed environment unless allowed by the manufacturer of the battery. Never connect a load to a battery without using fuses or circuit breakers, properly sized for the wires/equipment.

Warning!

Although PowerMon coupled with a relay can disconnect power if an over-current condition occurs, it should not be used to replace circuit-breakers. A properly rated circuit breaker or fuse should be used to protect the load and the wiring!

Warning!

PowerMon cannot be used as a charge current limiter or LiFePO cell balancer. A properly sized battery charger is required to recharge LiFePO batteries. Thornwave Labs Inc. does not assume any responsibility for expensive battery damage.

OVERVIEW

Installation. PowerMon was designed to be installed inside an equipment bay, or inside a plastic enclosure where it will be protected from water, high humidity, condensation, and battery or other corrosive gases. The device should not be installed inside an all-metal enclosure since that will significantly reduce the Bluetooth range. Although the device is potted using epoxy, it is resistant to humidity and battery corrosive, the terminal block is not. Use 16-20 AWG wires to make all the required connection in the green terminal block.

Device power. The PowerMon device is drawing its supply power from the V1 terminal. Make sure that V1 is always present. If the device loses power, it will forget the internal clock. Terminal 1 (GROUND) should be connected to the system ground (usually system negative).

Integrated current shunt. When using the integrated current shunt, the ES1 and ES2 terminals should be tied together using a piece of wire bent in a U shape. The current to be monitored should pass through the internal shunt (IS1 - IS2 terminals). An internal current shunt of 0.5mOhm exists in between these two terminals. The aluminum hex set screw terminal blocks (IS1 and IS2) can accept wires up to 6AWG in size. To minimize voltage drop on wires and connections, use the thickest wires that fit inside the terminals (6AWG). The common-mode voltage at IS1 and IS2 can be between -2V and +72V relative to the ground, allowing the current shunt to be placed either on the positive side of the circuit or the ground wire (negative side). The current reading should be positive when charging the battery and negative when discharging. If the current sign is reversed, swap the IS1 - IS2 wires, or simply change the “Flip Current Sign” switch in the device configuration.

External current shunt. To monitor a large current, an external current shunt can be used. This method allows monitoring current up to 1,000A. The external current shunt should be connected to the ES1 and ES2 inputs. To avoid noise, the wires should be as short as possible. Twisting the sense wires reduces noise even further. The IS1 and IS2 terminals should be left unconnected. The common-mode voltage at ES1 and ES2 can be between -2V and +72V relative to the ground, allowing the current shunt to be placed either on the positive side of the circuit or the ground wire. The current reading should be positive when charging the battery and negative when discharging. If the current sign is reversed, swap the ES1 - ES2 wires, or simply change the “Flip Current Sign” switch in the device configuration.

Zero the current offset. Due to the high sensitivity of the current measurement circuitry inside the PowerMon device, the value displayed may have a small offset (measurement is different than zero even when the actual current is zero). Typically, this is less than 0.1A. In situations where the measurement precision is critical, the offset can be reduced to zero. To do this, disconnect the wires from the load side of the shunt or make sure the actual current is zero (turn all the loads off). This can also be achieved by turning the power relay off from the mobile application (in case the system is wired with a relay). Long-tap on the “Current” tab and then “Zero Current”. The operation will take 3 seconds to complete during which do not allow any current to pass through the device. Also, do not zero the current offset if the actual current is different than zero. Doing so will introduce a very large offset. Any current that is flowing through the shunt when the Zero Current operation is performed will become the new indicated zero.

Current calibration. Typically, the device can measure current with better than 1% precision. If higher precision is required, the current measurement can be calibrated allowing up to 0.25% of precision. To calibrate the current reading, an amp-meter capable of measuring current with a precision better than 0.25% is required. Connect the amp-meter leads in series with the shunt and read the actual value of the current. Long-tap on the "Current" tab, tap on "Calibrate Current" and then type the actual value measured by the amp-meter.

The sign of the current does not matter. Once calibrated, the only way to change the calibration is to reset the device to factory defaults or re-calibrate. The device will not accept a calibration current different from the actual current reading by more than 10%.

Power relay control. PowerMon can drive a power relay (either mechanical or solid-state) using the RELAY output (terminal 3). When active (relay turned on), the RELAY terminal is internally connected to the ground by the device. The relay coil should be connected between the power supply (battery positive, typically) and the RELAY terminal. The low/high voltage disconnect, temperature disconnect, over-current disconnect, and generator control functions require the use of a relay / SSR (Solid State Relay).

Low voltage disconnect. When this feature is enabled and the battery voltage drops below a specified threshold, the device turns the relay off, disconnecting the loads to protect the battery from over-discharge. To disconnect the load the voltage must be below a threshold for a configurable amount of time. This feature helps in situations like cranking an engine or a short high current load that causes the battery voltage to momentarily drop. The device will re-engage the power relay a configured amount of time after the voltage goes back above the connect threshold.

This feature allows the PowerMon to also operate as a battery isolator. The relay is used to connect the house battery in parallel with the starting battery (see wiring diagrams at the end of this document). The LVD filter value should be set to 5000ms. The disconnect threshold should be set to 13.2V and the connect threshold to 13.6V. When the engine is started and the alternator charges the starting battery, the voltage will start increasing. When the voltage reaches 13.6V (the connect threshold) the relay engages and connects the house battery to the starting battery, allowing all batteries to be charged. When the engine is stopped the voltage will drop below 13.2V (the disconnect threshold) and the relay disengages, isolating the house battery from the starting battery. The house battery voltage can be monitored using the V2 input. Note that the thresholds (13.6V and 13.2V) are just an example. They can be configured to best fit the application.

High voltage disconnect. This function is similar to the low voltage disconnect, but as the name suggests it will disconnect the load when the voltage goes above the disconnect threshold and will reconnect the load when the voltage goes below the reconnect threshold. This mode can be used together with the low voltage disconnect.

Over-current disconnect. When this feature is enabled and the measured current increases above a user-specified trip value, the device disconnects the load, protecting the batteries and load from over-current. The device will re-engage the power relay a configured amount of time after the current drops below the trip threshold.

Battery fuel gauge. PowerMon computes the battery state of charge and various statistics. This is accomplished by using coulomb counting. For the battery fuel gauge to work properly, charging current should display positive, and discharging current should display negative. If the displayed current sign is wrong, it can be swapped by changing the "Flip Current Sign" switch in the device configuration.

Small errors in measurement and integrating current over long periods of time will introduce errors in the state-of-charge estimation. This is normal and expected. For this reason, the device will re-synchronize its SoC counter with the battery every time a full charge is performed. A full charge is detected based on the chemistry of the battery but in general, it requires the voltage to be higher than a threshold while at the same time the charging current is lower than a threshold. The battery fuel gauge will also take into consideration the Peukert effect. The next table shows the Peukert coefficients used for various battery chemistries.

Battery Chemistry	Peukert Coefficient
Lead Acid - Flooded	1.25
Lead Acid – AGM	1.15
$LiFePO_4$	1.05
Li-Ion/LiPoly	1.05

LiFePO charge manager. PowerMon can manage the charging of a lithium iron phosphate battery. This function cannot be used together with the other disconnect functions. If enabled, the mobile app will automatically disable the other disconnect functions. A relay must be placed in between the battery and the charger, or power source used for charging (the vehicle alternator for example). The function of this relay is to disconnect the charger from the battery if a full charge is detected or the charger is turned off (the engine is turned off for example). To use the LiFePO charge manager, connect the V1 input to the battery positive and the V2 input to the charger positive. The internal shunt and the relay should be wired in between the charger and the battery (see wiring diagrams at the end of this document).

The battery voltage and the total capacity of the battery in Ah should be properly configured. At least one disconnect condition has to be true for at least 2 seconds for the disconnect to take place. The connect conditions must be true for the time specified in "Connect Time" for the connect to take place (default is 10 seconds).

The following table shows the conditions used by PowerMon to decide whether to connect or disconnect the charger from the battery (turn the relay ON/OFF). Current refers to the current flowing in between the battery and the charger. "C" refers to the battery capacity. Care should be exercised to ensure that the current is positive when the battery is being charged and negative if it is being discharged. If wired backward, use the "Flip Current Sign" option to fix it.

Connect Conditions (10 sec. delay used)	Disconnect Conditions (2 sec. delay used)
battery voltage (V1) less than 3.32V / cell **AND** charger voltage (V2) at least 0.2V above the battery voltage (V1)	battery voltage (V1) greater than 3.65V / cell
-	charging current (I) less than C/100 or 1 Amp, whichever is greater
-	full charge is detected: battery voltage (V1) greater than 3.5V /cell **AND** charging current (I) less than C/20

External temperature sensor. PowerMon can read the temperature from an external DS18B20 based sensor. The sensor has three terminals: VCC (red wire), GND (black wire), and DATA (yellow wire). Connect VCC and GND together to terminal 1 (system ground). Connect DATA to the MF terminal (terminal 2). Configure the MF function to temperature sensor in the general configuration. If the sensor is recognized by PowerMon, the temperature reading in the Live Data page will change to “Ext. Temperature”.

Internal clock. PowerMon keeps track of time internally. If the internal clock is not set the device is not logging data.

Timer function. The device supports controlling the relay using a set of up to 16 timers. Each timer contains a start time, stop time and repetition. The start time specifies the time of day (HH:MM) when the relay turns on. Stop time specifies the time of day when the relay turns off. A timer does not need to have both the start and stop times. One of them can be disabled. This kind of timer should be used in pairs: one turns the relay on and the second one turns it off. ‘Repetition’ controls the days when a timer will trigger. This can be either DoW (Day of Week) where the timer repeats on specific days of the week or DoM (Day of Month) where the timer repeats on specific days of the month.

Using multiple timers, users can create very complex time schedules.

Examples:

Timer1: START 4:50PM, STOP 5:10PM, REPETITION DOW Mon Tue Wed Thr Fri Sat Sun

This timer will run every day and turn the relay on for 20 minutes, from 4:50PM until 5:10PM

Timer2: START 8:00PM. STOP: disabled, REPETITION DOW Mon Tue Wed Thr Fri Sat Sun

Timer3: START disabled, STOP: 7:00AM, REPETITION DOW Mon Tue Wed Thr Fri Sat Sun

This set of timers used together will turn the relay on every day at 8:00PM and turn it off the following day at 7:00AM. The same effect can be achieved using a single timer. This is just an example.

Timer4: START 12:00AM. STOP: disabled, REPETITION DOM: 1

Timer5: START disabled, STOP: 12:00AM, REPETITION DOM: 8

This set of timers used together will turn the relay on every 1st of the month at 12:00AM and turn it off 7 days later, on the 8th of the month at 12:00AM.

Monitor. PowerMon monitors the following parameters in real time (two times a second):

Voltage 1 / Voltage 2: These are the voltages measured at the V1 and V2 terminals (referenced to terminal 1 – GROUND)

Current: This the current going through either the internal or the external shunt (depending how the device is wired). The value can be zeroed to eliminate any offset. If higher accuracy is required, it can also be calibrated. The current reading should be positive when charging the battery and negative when discharging. If the sign is wrong, it can be flipped using the "Flip Current Sign" switch in the general configuration.

Power: This value is computed as voltage multiplied by current. Depending on the configuration, either V1 or V2 is used to compute the power.

Power Meter: This value is the accumulated energy. It counts in Wh (Watt-hour), and it can be reset to zero. The measurement is purely informational. It is not used for any other purpose by the device.

Charge Meter: This value is the accumulated coulombs. It counts in Ah (Ampere-hour), and it can be reset to zero. The measurement is for informational. It is not used for any other purpose by the device.

Battery SoC: The battery state-of-charge is displaying in percentage, from 0% to 100%. If the value displays "unset" is because the battery fuel gauge component inside the PowerMon is not yet synchronized with the battery. The fuel gauge will synchronize automatically when a full charge is detected. It is important that the current sign is correct, and the battery fuel gauge is configured correctly (battery chemistry, battery voltage, and battery capacity). For Lithium batteries a small discharge is required (about 10%) before applying a full charge to initially synchronize the SoC reading.

Battery Remaining: The time left before the battery is completely discharged assuming the current rate of discharge. This value is only shown when the discharge current is higher than -0.1A.

Power Status: Displays the current power status of the device (RELAY output status). Possible values are: OFF, ON, LVD (Low Voltage Disconnect – device is OFF due to an LVD condition), HVD (High Voltage Disconnect), OCD (Over-Current Disconnect), LTD (Low Temperature Disconnect), HTD (High Temperature Disconnect) and NCH (Not CHarging – only in LiFePO Charge Manager mode – the relay is OFF, and the Li battery is not being charged). The power can be manually turned OFF. For all disconnect functions to operate the power must be manually set to ON.

Generator Status: This is shown only when the generator control feature is enabled in the device configuration. It displays the generator state (the relay state: ON / OFF)

Temperature: This is the internal device temperature. If an external temperature sensor is connected and configured properly this will change to “Ext. Temperature” indicating that this is now the external sensor temperature.

Device Clock / Device Date: The internal clock and date of the device. It can be set from the system time and date.

Bluetooth Signal: The strength of the Bluetooth signal received from the PowerMon device. It is measured in dBm, and it will be a negative value. The higher the value (closer to zero) the stronger the Bluetooth signal is. If this value is lower than about -90dBm it will become more difficult to connect and maintain a connection to the device. This means that you are either too far from the device or there are too many walls / obstacles in between PowerMon and the mobile phone.

Configuration. The device configuration can be changed using the PowerMonX app. The configuration parameters are grouped in categories based on the function affected by these parameters.

General.

Shunt Specifications: The characteristics of the shunt used. If the PowerMon internal shunt is used, the setting should be set to 60A / 30mV (integrated). This is the default setting.

Max. Shunt Current (amperes): The maximum current that the shunt is expected to see. Typically, this is set to the maximum rated current of the shunt. It can be set lower to potentially increase the resolution of the reading. To do this it has to be set lower than the current that causes a voltage drop of 40.96mV on the shunt. For example, a 500A / 75mV shunt would develop 40.96mV of voltage drop when the current passing through it is 273A. If this value is set to less than 273A, the current resolution is increased by 4 times. This is done at the expense of the range of measurement. Obviously, the maximum current PowerMon can now measure is only 273A.

Power Meter Voltage Source: The voltage used to calculate power and energy. Voltage1 or Voltage2 can be selected.

Flip Current Sign: This allows the current sign to be flipped by software. Can be used to correct the shunt being wired backward. Should be set such that the discharge current is displayed as a negative value and the charge current shows positive. This is a requirement for the fuel gauge to work correctly.

Turn On at Startup: The default power status when powering the device. If set to on, the relay will be turned on automatically when the device is first powered up.

Trigger on Relay Active: If enabled, the device will turn the power on as a response to the RELAY terminal being temporarily pulled to the ground using a push button.

Invert Relay Logic: Enabling this option will invert the behavior of the RELAY terminal: when the power is on, the RELAY terminal will be floating and when the power is off it will be driven to the ground. When this option is enabled "Trigger on Relay Active" is ignored (disabled).

Connect Filter (milliseconds): The duration of time in milliseconds the LVD (Low Voltage Disconnect), HVD, and OCD (Over-Current Disconnect) conditions must be removed for the PowerMon to re-engage the power relay.

MF Terminal Function: Selects the function of the MF terminal: push-button input, data output, or external temperature sensor. The external temperature sensors are only available for hardware revision 2.2 or higher.

Data Logging Mode: Configure the data logging sample rate. Possible values are disabled, every second, 2 seconds, 5 sec, 10 sec, 20 sec, 30 sec, or 1 minute.

Low Voltage Disconnect

LVD Voltage Source: The voltage used by the low voltage disconnect feature. Voltage1 or Voltage2 can be selected.

LVD Disconnect Threshold (V): The voltage in volts below which the power relay will disengage.

LVD Connect Threshold (V): The voltage in volts above which the power relay can re-engage (after the connect filter time has passed). This must be higher than LVD Disconnect Threshold.

LVD Disconnect Filter (milliseconds): The duration of time the voltage must be below the disconnect threshold for the relay to disengage. It is used to filter voltage spikes.

High Voltage Disconnect

HVD Voltage Source: The voltage used by the high voltage disconnect feature. Voltage1 or Voltage2 can be selected.

HVD Disconnect Threshold (V): The voltage in volts above which the power relay will disengage.

HVD Connect Threshold (V): The voltage in volts below which the power relay can re-engage (after the connect filter time has passed). This must be lower than HVD Disconnect Threshold.

HVD Disconnect Filter (milliseconds): The duration of time the voltage must be above the disconnect threshold for the relay to disengage.

Over-Current Disconnect

OCD Disconnect Threshold (A): The current in amperes above which the power relay disengages.

OCD Disconnect Filter (milliseconds): The duration of time the current must be above the disconnect threshold to disengage the relay.

Low Temperature Disconnect

LTD Disconnect Threshold: The temperature below which the power relay will disengage.

LTD Connect Threshold: The temperature above which the power relay can re-engage (after the connect filter time has passed). This must be higher than LTD Disconnect Threshold.

LTD Disconnect Filter (milliseconds): The duration of time the temperature must be below the disconnect threshold for the relay to disengage.

High Temperature Disconnect

HTD Disconnect Threshold: The temperature above which the power relay will disengage.

HTD Connect Threshold: The temperature below which the power relay can re-engage (after the connect filter time has passed). This must be lower than HTD Disconnect Threshold.

HTD Disconnect Filter (milliseconds): The duration of time the temperature must be above the disconnect threshold for the relay to disengage.

Auto-off Timer: If enabled the power will turn off automatically after a specified time since it was turned on has passed. This effectively becomes a turn-off timer.

Auto-on Timer: If enabled the power will turn on automatically after a specified time since it was turned off has passed. This effectively becomes a turn-on timer.

Battery Fuel Gauge

Battery Voltage Source: The voltage used by the battery fuel gauge feature. Voltage1 or Voltage2 can be selected.

Battery Chemistry: The chemistry of the battery used (Lead Acid – Flooded, Lead Acid – AGM, LiFePO4, Li-Ion, Li-Poly).

Battery Voltage: The battery voltage (can be the standard 12V, 24V, 48V, … or custom, in which case the number of cells in the battery can be configured).

Number of Cells: Number of cells in the battery. 12V Lead Acid batteries have 6 cells. 12V $LiFePO_4$ batteries have 4 cells. If you have batteries connected in series, add the number of cells in each of them. If batteries are connected in parallel the number of series cells does not change. This is the number of cells that contribute to the battery nominal voltage.

Total Battery Capacity: Battery capacity in Ah. If batteries are connected in parallel, add their capacities. If batteries are connected in series the capacity does not change.

Disconnect on Battery SoC Threshold (%): The device will disconnect power (turn the relay OFF) when the battery state of charge becomes lower than this threshold (in percentage).

Connect on Battery SoC Threshold (%): The device will re-connect power (turn the relay ON) when the battery state of charge becomes higher than this threshold (in percentage).

Generator Control

Generator Control Voltage Source: The voltage used by the generator control feature. Voltage1 or Voltage2 can be selected.

Turn On Based on Voltage: If enabled the generator will be turned on when the battery voltage drops under a specified threshold.

> Turn On Voltage Threshold (V): The threshold in volts below which the generator will be turned on.
>
> Turn On Voltage Filter (milliseconds): The duration of time the voltage must be below the turn-on threshold for the generator to be turned on.

Turn On Based on SoC: If enabled the generator will be turned on when the battery SoC (State-of-Charge) drops under a specified threshold.

> Turn On SoC Threshold (%): The threshold in percentage below which the generator will be turned on.

Turn Off Based on Voltage: If enabled the generator will be turned off when the battery voltage increases above a specified threshold.

> Turn Off Voltage Threshold (V): The threshold in volts above which the generator will be turned off.

Turn Off Based on SoC: If enabled the generator will be turned off when the battery SoC (State-of-Charge) increases above a specified threshold.

Turn Off SoC Threshold (%): The threshold in percentage above which the generator will be turned off.

Turn Off Delay (minutes): Delay applied between the conditions to turn the generator off become true and turning the generator off. For example, if set to 1 minute, the generator will stay on for an extra minute after the voltage or SoC increases above the turn-off threshold.

LiFePO Charge Manager

Battery Voltage: The battery voltage (can be the standard 12V, 24V, 48V, or custom, in which case the number of cells in the battery can be configured).

Number of Cells: Number of cells of the battery. 12V $LiFePO_4$ batteries have 4 cells. If you have multiple batteries connected in series, add the number of cells in each of them. If batteries are connected in parallel the number of series cells does not change. This is the number of cells that contribute to the battery nominal voltage.

Total Battery Capacity: Battery capacity in Ah. If batteries are connected in parallel, add up their capacities. If batteries are connected in series the capacity does not change (only the number of cells in series does).

Default Factory Settings. The default configuration for PowerMon is to use the integrated current shunt. The device can always be reset to the default configuration using the PowerMonX app. To do this, connect to a device, tap the top right corner menu, and then “Device Information”. Tap on Factory Reset.

WARNING: When resetting to the factory defaults, all custom settings, and timers will be erased, including the device calibration, the battery fuel gauge internal state, and the data log.

Password lock. The device can be locked using a master/user password scheme. Upon connecting, the app will prompt the user to enter the user password if the device is locked. Once the correct password is entered, the device becomes unlocked and will stay unlocked for the duration of the connection.

The master password locks only certain functions that are critical to the correct and safe operation of the device. The manufacturer of a custom system using the PowerMon battery monitor can use the master password to protect those critical areas of the configuration. The critical areas protected by the master password can be unlocked by tapping on “Master Access Unlock” on the Device Information page.

The following features are not available if the device is locked by the master password: resetting the power meter/battery statistics, saving the configuration, resetting to factory settings, zeroing, or calibrating the current reading, clearing the data log, updating the device firmware.

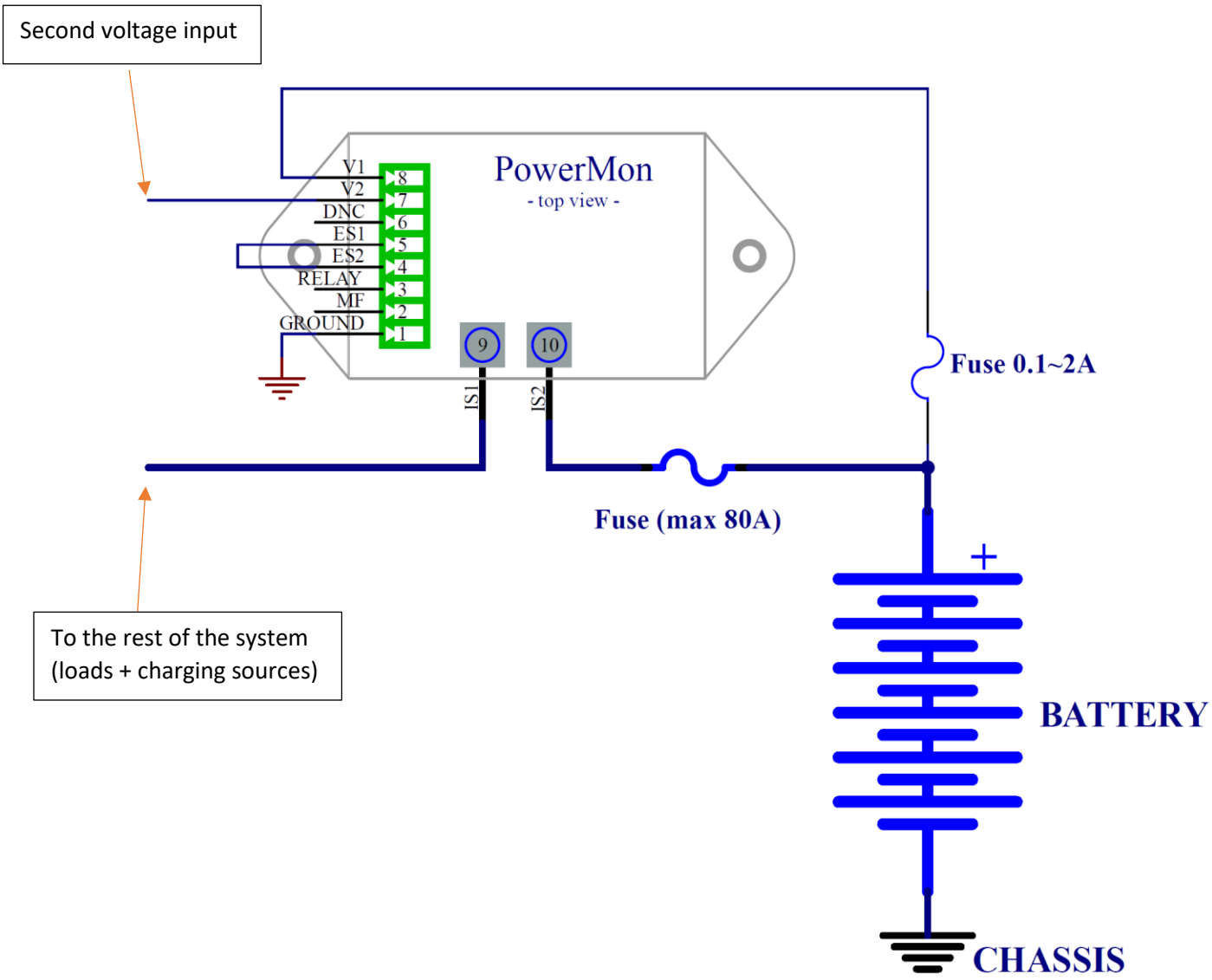
If the device is locked with the user password, entering the master password instead will unlock the entire device.

Operation. PowerMon is continuously advertising its presence over Bluetooth. PowerMonX is the preferred app to use, and it can be found on the App Store / Play Store for both Apple and Android devices. The app allows you to scan for PowerMon devices, connect, view the live data, view the battery statistics, change the configuration, rename the device, configure the password protection, visualize the logged data, and more.

Radio performance. The device contains an internal Bluetooth Low Energy radio operating in the 2.4GHz ISM band and an internal antenna. For best performance, the device should be installed in such a way as to offer a path for radio waves to reach it. Metal walls or enclosures can attenuate or completely shield the device. Installation on non-metallic surfaces is preferred. The mobile device app displays the RSSI value (Received Signal Strength Indication) in real-time.

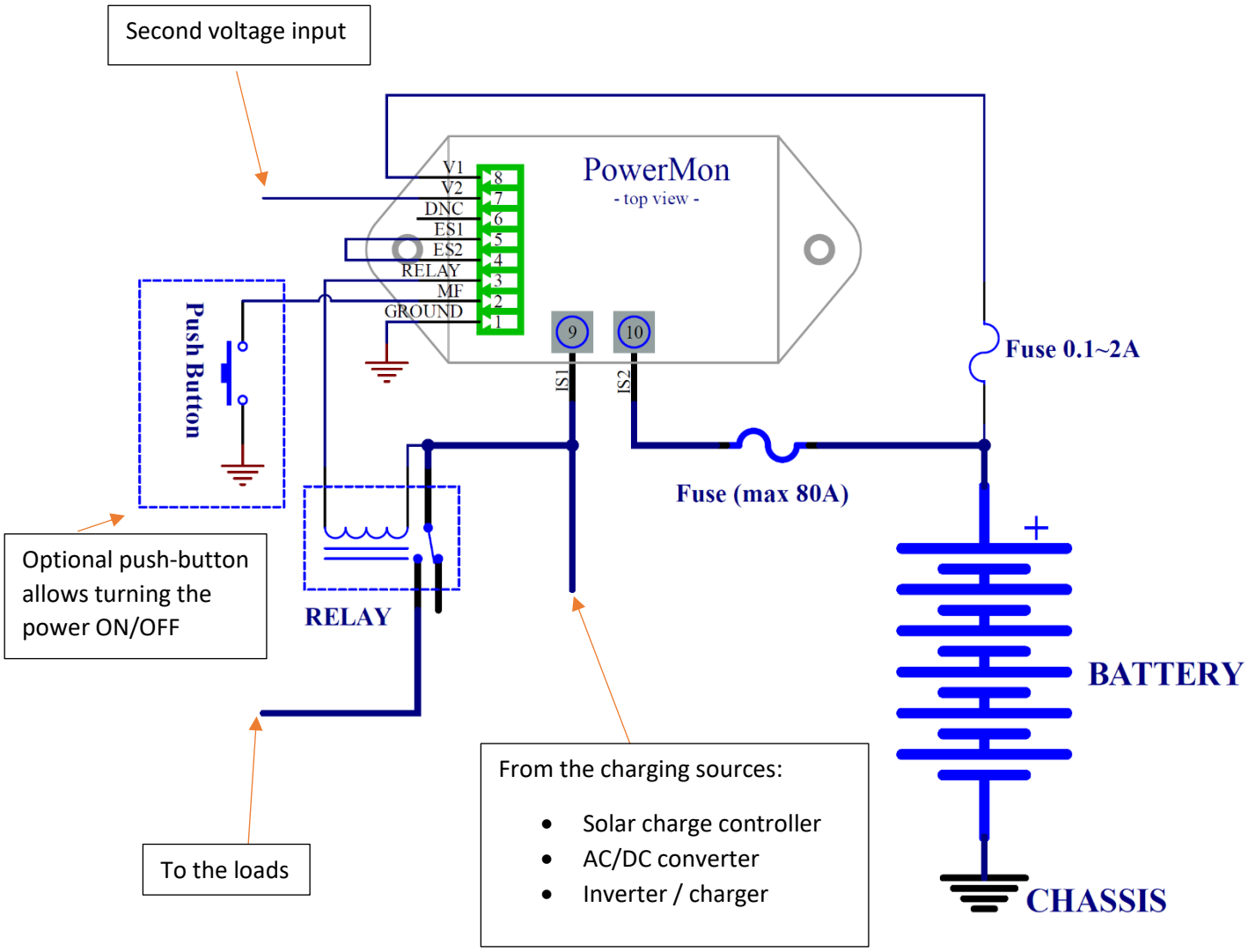
Renaming the device. Renaming the device can be achieved using the top-right menu button and taping on “Device Information”. The maximum name length is 8 characters.

WIRING DIAGRAMS



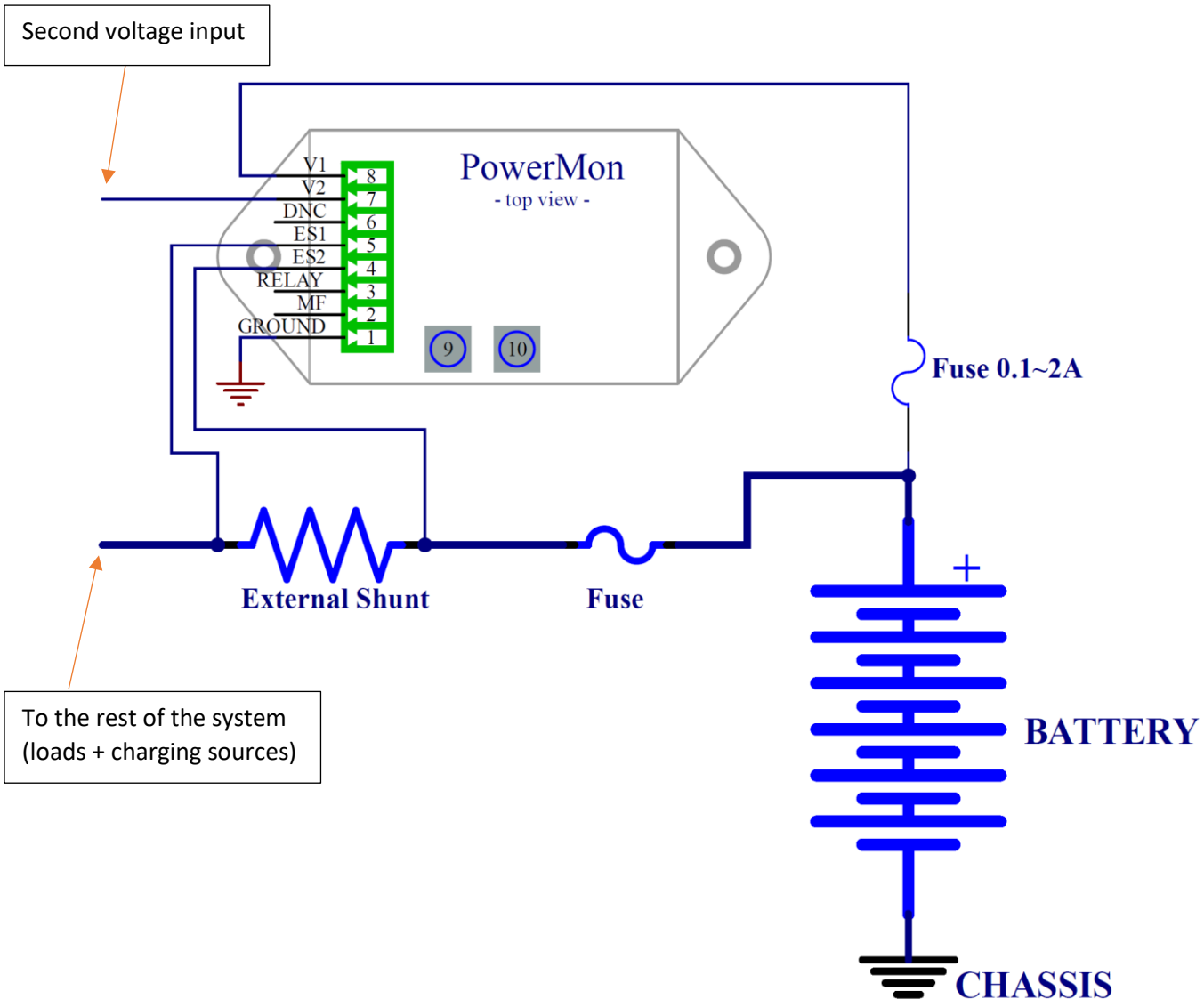
Typical application using the internal shunt, without the relay

- The disconnect functions are not available (there is no relay).
- V2 can be used to monitor a second battery, the midpoint between two batteries in series, or the solar panel input voltage (max. 72V). Leave unconnected if not used.
- Don’t forget to wire ES1 and ES2 together



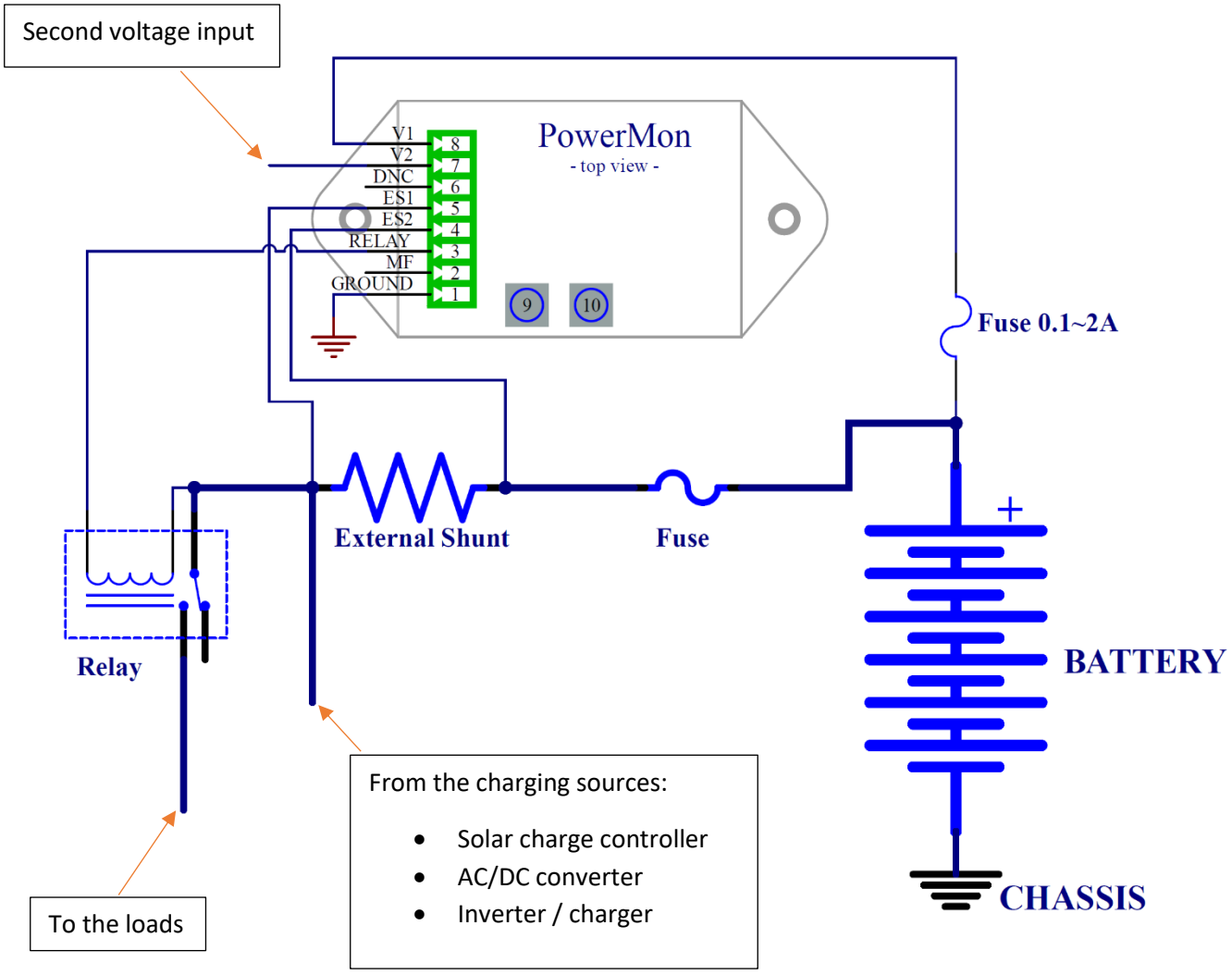
Typical application using the internal shunt and the relay

- The disconnect functions are available
- V2 can be used to monitor a second battery, the midpoint between two batteries in series, or the solar panel input voltage (max. 72V). Leave unconnected if not used.
- The charging sources are connected before the relay. This is done so they cannot be disconnected from the battery during a low voltage or other disconnect events (very important for an MPPT charge controller).
- Don't forget to wire ES1 and ES2 together



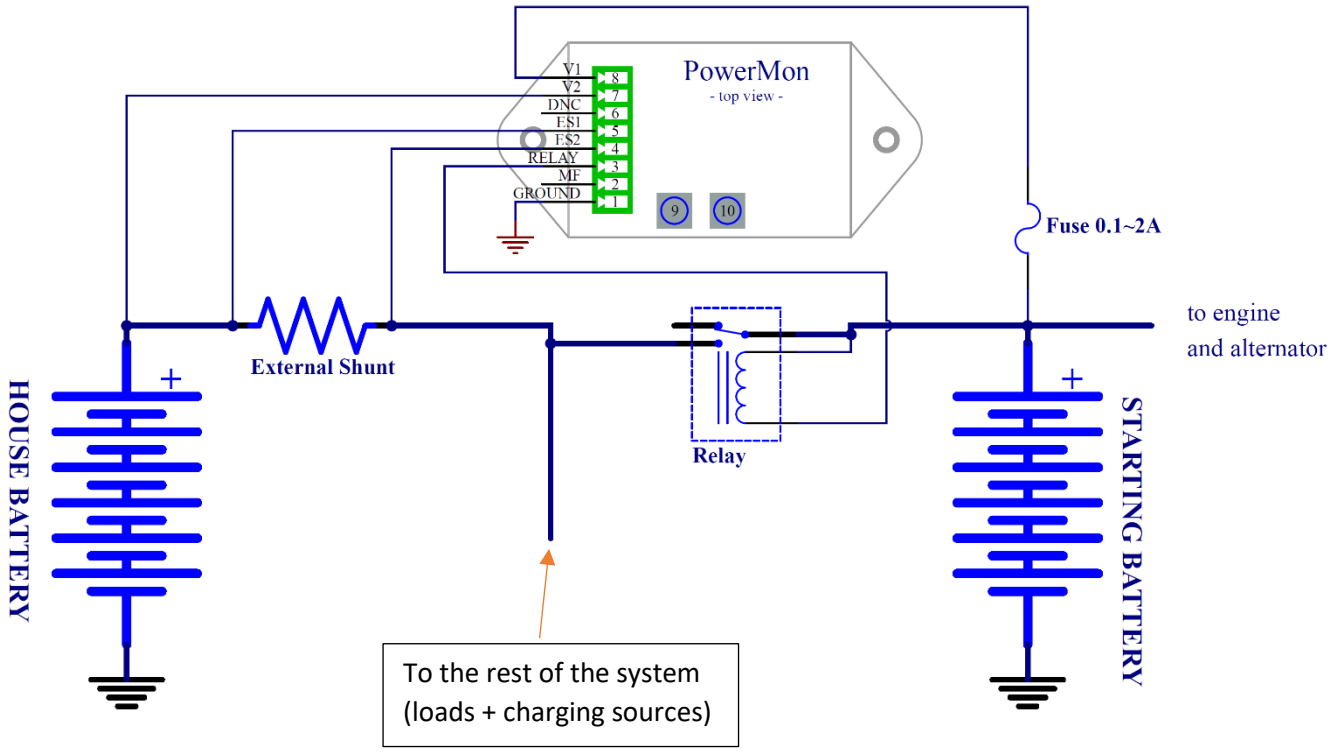
Typical application using an external shunt and no relay

- The disconnect functions are not available (there is no relay).
- V2 can be used to monitor a second battery, the midpoint between two batteries in series, or the solar panel input voltage (max. 72V). Leave unconnected if not used.
- The sense wires from the shunt to ES1 and ES2 should be as short as possible and twisted to minimize noise
- The main fuse should be sized based on the maximum system current and the wire size



Typical application using an external shunt and the relay

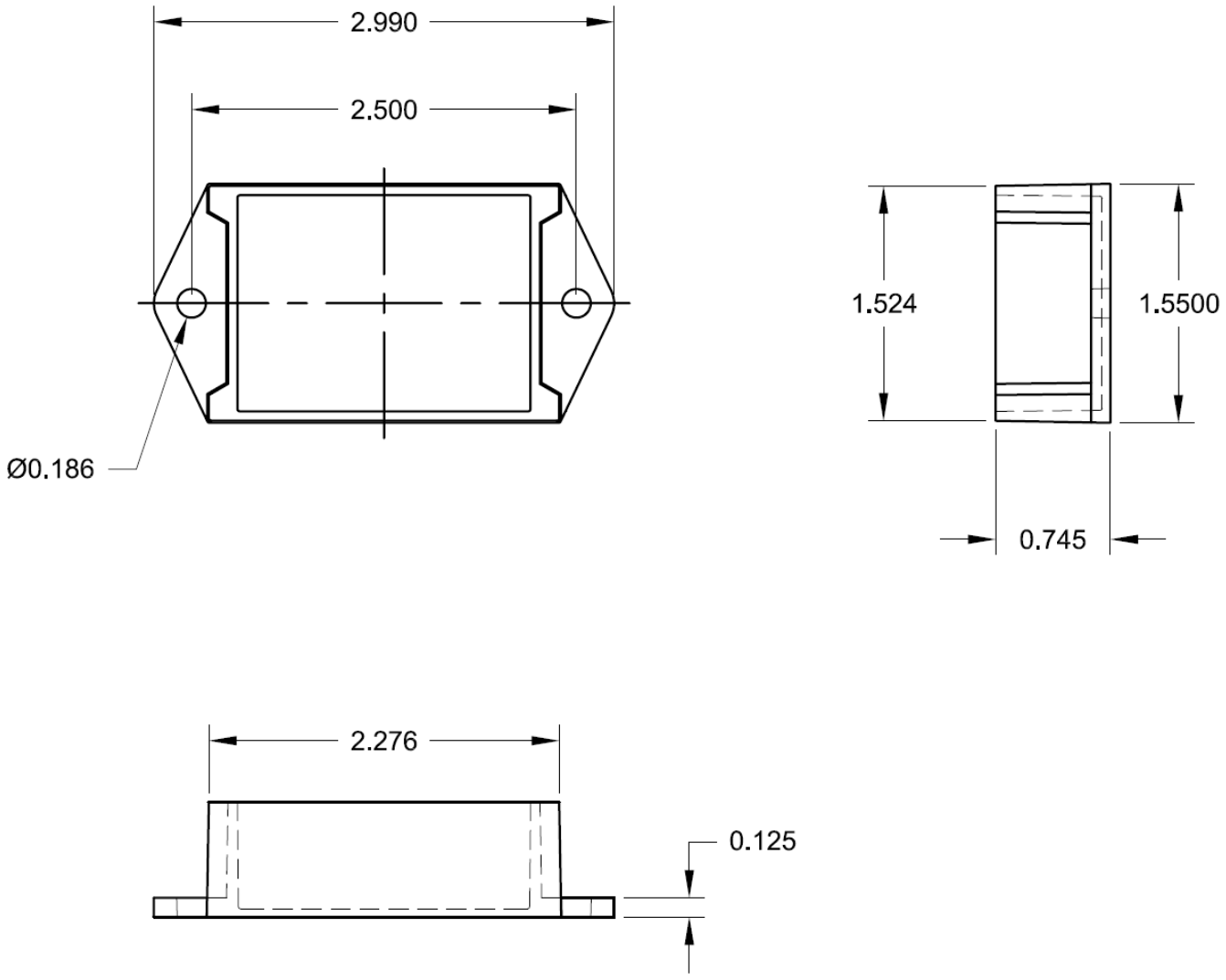
- The disconnect functions are not available (there is no relay).
- V2 can be used to monitor a second battery, the midpoint between two batteries in series, or the solar panel input voltage (max. 72V). Leave unconnected if not used.
- The charging sources are connected before the relay. This is done so they cannot be disconnected from the battery during a low voltage or other disconnect events (very important for an MPPT charge controller).
- The main fuse should be sized based on the maximum system current and the wire size



Typical application of a battery isolator using an external shunt

- The disconnect functions are not available
- V1 is monitoring the starting battery voltage
- V2 is monitoring the house battery voltage
- The house battery SoC is monitored. Set the fuel gauge voltage source to V2 (see device configuration)

DIMENSIONS



Dimensions are in inches.

ORDERING

Part Number	Description
PowerMon	Bluetooth LE Advanced Battery Monitor / DC power meter