Thornwave Labs Inc

PowerMon-E

Ethernet / IoT

**Advanced Battery Monitor / DC Power Meter**

– USER MANUAL –

BRIEF

PowerMon-E is an advanced, Ethernet enabled IoT battery monitor and DC power meter designed for comprehensive monitoring, analysis, and logging of battery and DC-powered systems. It measures two independent voltage inputs (0-64V), current over 1,000A using an external shunt, and temperature. From these measurements, PowerMon computes a wide range of derived parameters, including power (W), energy (Wh), coulombs (Ah), battery state of charge (% SoC), estimated remaining runtime at current load, and extensive battery and DC power statistics.

The device logs data internally to flash memory for up to three years, enabling long-term performance analysis and advanced troubleshooting. PowerMon can control either a mechanical or solid-state relay, allowing it to operate as a low- and high- voltage disconnect, overcurrent disconnect, low- and high- temperature disconnect, battery isolator for multi-battery systems, remote on/off switch, timer, or generator controller.

Configuration, monitoring, and data access are performed using the PowerMonX mobile app, available free of charge for Android and iOS devices. PC software is also available for Windows and Linux.

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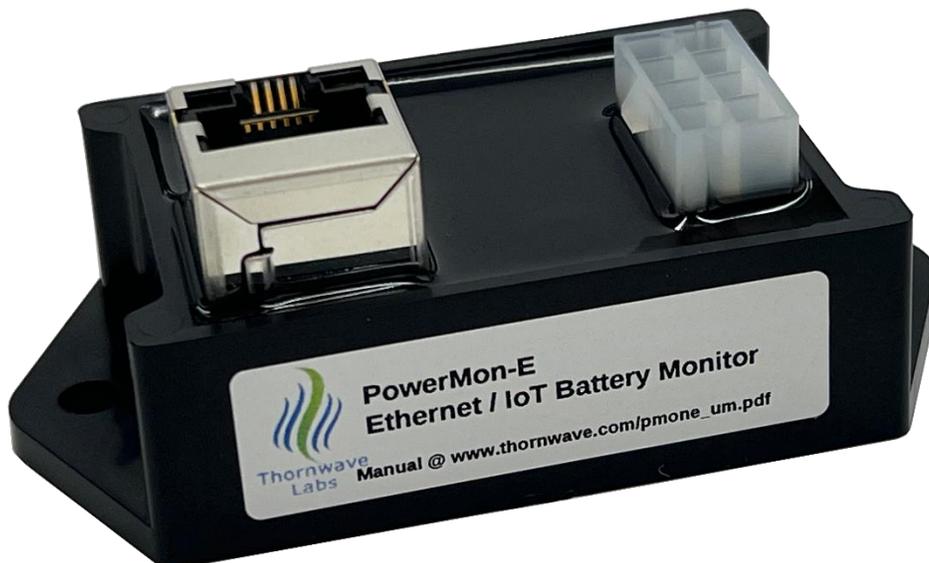
FEATURES

- Measures two voltage inputs, current, power (W), coulombs (Ah), energy (Wh), and temperature
- Operates at up to 64V
- Can sense up to 160mV of voltage drop across an external current shunt, allowing over 1,000A to be measured
- Fully differential input for the current shunt, allowing it to be mounted on either the positive or negative side of the battery
- Data logging up to 3 years
- Can drive one mechanical or solid-state relay
- Low- and high- voltage disconnect
- Overcurrent disconnect
- Low- and high- temperature disconnect
- Generator control
- Battery isolator for multi-battery systems
- Battery monitor (battery fuel gauge) that displays the state of charge (%) and the estimated remaining time on battery at the current load
- Compatible with all types of batteries
- Lithium iron phosphate battery charge manager

- Can control the relay based on schedules
- Supports an external temperature sensor (DS18B20-based, or an NTC thermistor on a dedicated input)
- Password protection
- Very low power consumption (see Performance Parameters)
- 100MBit/s Ethernet RJ-45 interface
- 8-pole connector and 3 ft wiring harness included
- ABS plastic enclosure with mounting flanges, fully encapsulated in epoxy potting compound
- Compact size: 3.0" x 1.55" x 0.75" (76mm x 39mm x 19mm) including the mounting flanges.
- Weatherproof
- PowerMonX app is available free for Android and iOS. PowerMon-Manager is available free for PCs (Windows and Linux).
- Highly configurable, optimized for top performance with a wide range of shunts

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 timer

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TERMINAL DESCRIPTION / INTERNAL DIAGRAM
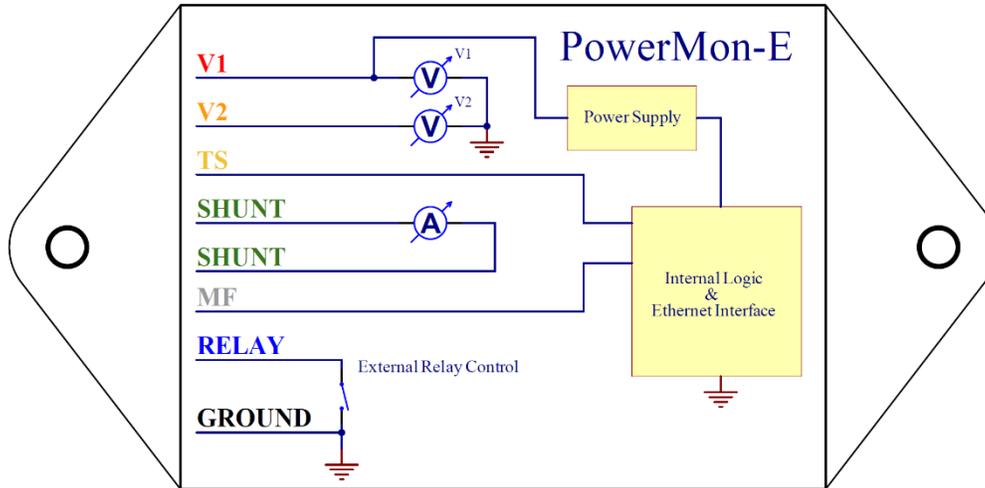
Color	Terminal	Name	Description
BLACK	8mm ring	GROUND	System ground. Connect directly to the battery negative.
WHITE	Insulated	MF	Multi-Function signal. Supports either a push button input or an external DS18B20-based temperature sensor. DO NOT CONNECT TO ANY VOLTAGE HIGHER THAN 3.3V. DAMAGE WILL OCCUR.
BLUE	1/4" female spade	RELAY	Relay output. It drives a mechanical or solid-state relay. To turn the relay on, the device grounds this terminal internally.
GREEN	5mm ring	SHUNT	External shunt connection.
GREEN	5mm ring	SHUNT	External shunt connection.
YELLOW	1/4" female spade	TS	External temperature sensor. Use a 10k NTC (3950 curve) connected between TS and GROUND.
ORANGE	8mm ring	V2	Second monitored voltage. Can measure the voltage of a second battery or DC source.
RED	8mm ring	V1	This is the main voltage that will be monitored. The device also draws its own power from this terminal. Connect to the battery positive.

Terminal Description (when using the supplied wiring harness)

SPECIFICATIONS

Absolute Maximum Ratings [1,2]	
Maximum voltage at the V1 and V2 terminals	**+64V**
Maximum voltage at the RELAY terminal	**+64V**
Maximum current through the RELAY terminal (maximum mechanical relay coil current)	**2A**
Maximum measured current	**depends on the external shunt (can be over 1,000A)**
Maximum differential voltage between the shunt inputs	**-64V to +64V**
Maximum voltage at any shunt input	**-0.6V to +64V**
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 (BLACK wire) unless otherwise specified.

Performance Parameter	Value
Measured voltage (V1, V2)	**0 to 64V**
Measured voltage accuracy	**max 0.2%, typ. 0.15%**
Measured differential voltage at shunt inputs	**-160mV to +160mV**
Current monitoring accuracy	**depends on the current shunt accuracy, typically 0.25% (with calibration)**
Temperature resolution	**1°C / 1°F**
Data logging sample rate	**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 consumed by the device (using the latest firmware version, Ethernet cable connected, link LED off)	
at 12V	**31.6mA**
at 24V	**15.8mA**
at 36V	**11.0mA**
at 48V	**8.6mA**
at 60V	**7.3mA**

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. Son fonctionnement est soumis aux deux conditions suivantes: (1) cet appareil ne doit pas provoquer d'interférences nuisibles, et (2) cet appareil doit accepter toute interférence reçue, y compris les interférences susceptibles de provoquer un fonctionnement indésirable.

IC RSS-102 RF Exemption

This device 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 de cet appareil aux radiofréquences a été évaluée conformément à la norme RSS-102 et est conforme aux limites établies par le Code de sécurité 6 de Santé Canada.

IC RSS-Gen 8.4

This device complies with Innovation, Science and Economic Development Canada's 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'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. Son fonctionnement est soumis aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) 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. Do not work on a live electrical system. Disconnect the power sources first (battery, shore power, solar panels, generator)!

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 device! Do not disassemble or attempt to repair! The unit operates with voltages up to 64V which can be lethal or cause serious and permanent injury.

Warning!

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

Warning!

The device is to be connected to DC circuits only, not exceeding 64V. Failure to do so will result in equipment damage. 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. Although PowerMon, coupled with a relay, can disconnect power if an overcurrent condition occurs, it should not be used to replace fuses or circuit-breakers. A properly rated fuse or circuit breaker should be used to protect the load and the wiring!

Warning!

Batteries are dangerous! Do not short-circuit a battery or the battery monitor terminals. 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 properly sized fuses or circuit breakers.

CONNECTIVITY

PowerMon-E requires a client device running either the PowerMonX mobile app, or the PowerMon-Manager PC software. The client can connect to the PowerMon-E device using one of the following two connection methods.

- **Local connection** – The client connects to the PowerMon-E device over the local network, enabling significantly higher throughput and lower latency than remote connections. This makes it the preferred method for tasks such as downloading data logs. To use a local connection, the client must be connected to the same network as the PowerMon-E. The device automatically advertises its presence and current measurement data on the local network every three seconds, allowing clients to discover it without manual configuration.

- **Remote connection** – The client connects to the PowerMon-E device over the Internet. This connection method allows access when the client is not on the same local network, but higher latency and lower data throughput should be expected. Both the client and the PowerMon-E device must have active Internet connectivity.

Local Connection
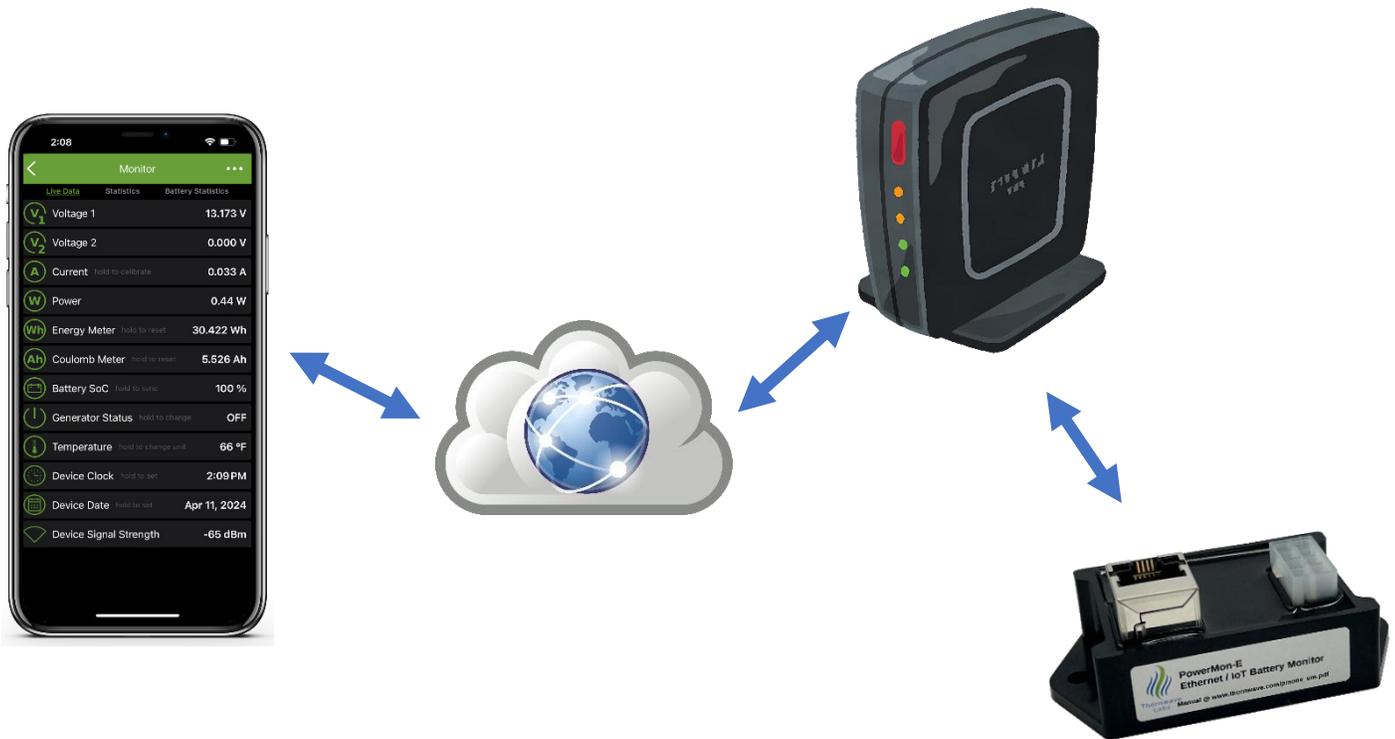
Remote Connection

OVERVIEW

Installation. PowerMon was designed to be installed inside an equipment bay or enclosure where it will be protected from water, high humidity, condensation, and battery or other corrosive gases. Although the device is encapsulated in epoxy, making it resistant to humidity, occasional splashing or corrosive battery gases, the connectors are not. Use the supplied wiring harness to make all the connections.

Device power. The PowerMon device is drawing its supply power from the V1 terminal. Ensure that V1 is always present. If the device loses power, it will lose the internal clock. Connect GROUND to the battery negative terminal and V1 to the battery positive terminal.

External current shunt. To measure current, an external current shunt is used. This method allows monitoring of over 1,000A. The external shunt must be connected to the SHUNT inputs. Twisting the shunt wires helps to reduce electrical noise. The voltage at the SHUNT inputs can be between -0.6V and +64V relative to ground, allowing the current shunt to be placed on either the positive or the negative side of the battery. The current reading should be positive when charging the battery and negative when discharging. If the current

polarity is reversed, swap the SHUNT wires, or simply change the <u>Flip Current Sign</u> switch in the device general configuration.

Current offset. Due to the high sensitivity of the PowerMon current measurement circuitry, a small offset may be present (measurement is different than zero even when the actual current is zero). This offset is typically less than 0.1A. In applications where the measurement accuracy is critical, this offset can be eliminated. To zero the offset, 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). Tap and hold on the "*Current*" tab and then "*Zero Current*". The operation will take 3 seconds to complete during which no current must flow through the shunt. Do not perform the zeroing of the current offset if there is current flowing through the shunt. Doing so will introduce a large offset. Any current that is flowing through the shunt when the zeroing operation is performed will become the new indicated zero. There is no way of removing an offset correction without doing a factory reset. You can, however, re-zero the offset at any time.

Current calibration. Under typical conditions, PowerMon can measure current with better than 1% accuracy. If higher accuracy is required, the current measurement can be calibrated. To calibrate the current reading, an ammeter capable of measuring current with an accuracy better than 0.25% is required. Connect the ammeter leads in series with the shunt and read the actual value of the current. Tap and hold on the "*Current*" tab, tap on "*Calibrate Current*" and enter the value measured by the ammeter. 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. When the relay is active, the RELAY terminal is internally grounded by PowerMon. The relay coil should be connected between the power supply (typically battery positive) and the RELAY terminal. The low/high voltage disconnect, low/high temperature disconnect, overcurrent disconnect, and generator control functions require the use of a mechanical relay / SSR (solid-state Relay).

Low voltage disconnect. When enabled, this feature turns the relay off when the voltage drops below a specified threshold, disconnecting the loads, protecting the battery from over-discharge. The voltage must be below the configurable threshold for a configurable amount of time before disconnection occurs. This prevents nuisance disconnecting after a high current event such as cranking an engine could cause the voltage to momentarily drop. The relay will re-engage a configurable amount of time after the voltage goes back above the connect threshold.

This feature also allows PowerMon to function as a battery isolator. In this configuration 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 both 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 changed to fit the application.

High voltage disconnect. This function, similarly to the low voltage disconnect, disconnects the load when the voltage exceeds a specified disconnect threshold and will reconnect the load when the voltage stays below the reconnect threshold for a configurable amount of time. This feature can be used simultaneously with the low voltage disconnect.

Overcurrent disconnect. When enabled, this feature disconnects the load when the measured current exceeds a user-specified trip value, protecting the batteries and load from overcurrent. The relay will re-engage a configurable amount of time after the current drops below the trip threshold.

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

Small measurement errors and current integration over long periods of time will introduce errors in the state-of-charge estimation. This is normal and expected behavior. For this reason, the device will re-synchronize its SoC counter to 100% 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 and charge efficiency of the battery. The next table lists 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 simultaneously with the other disconnect functions. When enabled, the mobile app will automatically disable the other disconnect functions. The relay must be installed between the battery and the charger, or power source used for charging (the vehicle alternator for example). The purpose 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 battery capacity (Ah) should be properly configured. At least one disconnect condition must be true for at least 2 seconds before the disconnect occurs. The connect conditions must be true for the time specified in Connect Filter for the connect to take place (default is 10 seconds).

The following table lists the conditions used by PowerMon to determine 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, and "C" refers to the battery capacity in Ah. Care must 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 1A, whichever is greater
-	full charge is detected: battery voltage (V1) greater than 3.5V /cell **AND** charging current (I) less than C/20

External DS18B20 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 GROUND (system ground) and connect DATA to the MF terminal. Configure the MF function to temperature sensor in the device general configuration. If the sensor is recognized by PowerMon, the temperature reading in the Live Data page will change to "*Ext. Temperature*".

External NTC temperature sensor: Connect a 10k ohm NTC thermistor (3950 curve) between GROUND and TS. The system will automatically recognize the thermistor and the temperature reading in the "*Live Data*" page will change to "*Ext. Temperature*".

Internal clock. PowerMon maintains time using an internal clock. If the internal clock is not set the device is not logging data. The device can also automatically acquire the clock from the Internet. The time zone should be set correctly for the clock to display the correct value. The device keeps track of daylight-saving time automatically, based on the configured time zone.

Data logging. PowerMon logs the following parameters for up to 3 years: V1, V2, current, power, temperature, battery state of charge and power status. Data is logged inside a flash memory and survives power cycles. The device supports logging with the following sample rates: once a second, every 2, 5, 10, 20, 30, and 60 seconds. PowerMon accumulates about 500 samples before storing them in flash memory. This means that the logged data can be delayed from the real time measurements by up to 500 samples. If the sample rate is

once a second, this translates to about 500 seconds, or about 8 minutes. This delay can grow to about 8 hours if the sample rate is set to once a minute.

Schedules. The device supports controlling the relay using a set of up to 16 schedules. Each schedule consists of 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 schedule does not need to have both the start and stop times. One of them can be disabled. This kind of schedule should be used in pairs: one turns the relay on, and the second one turns it off. Repetition controls the days when a schedule will trigger. This can be either DoW (Day of Week) where the schedule repeats on specific days of the week or DoM (Day of Month) where the schedule repeats on specific days of the month.

Using multiple schedules, users can create very complex on/off patterns.

Examples:

Schedule 1: START 4:50PM, STOP 5:10PM, REPETITION DOW Mon Tue Wed Thr Fri Sat Sun

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

Schedule 2: START 8:00PM. STOP: disabled, REPETITION DOW Mon Tue Wed Thr Fri Sat Sun

Schedule 3: START disabled, STOP: 7:00AM, REPETITION DOW Mon Tue Wed Thr Fri Sat Sun

This set of schedules 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 schedule. This is just an example.

Schedule 4: START 12:00AM. STOP: disabled, REPETITION DOM: 1

Schedule 5: START disabled, STOP: 12:00AM, REPETITION DOM: 8

This set of schedules 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, once a second, except when connected remotely, via the Internet, in which case the data is updated once every 2 seconds.

Monitor Item	Description
Voltage 1	Voltage measured at the V1 terminal (referenced to the terminal GROUND)
Voltage 2	Voltage measured at the V2 terminal (referenced to the terminal GROUND). This value will not show up if V2 is disabled from the device general configuration.
Current	Current flowing through the external shunt. 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 polarity is inverted, it can be flipped using the Flip Current Sign switch in the device 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.
Energy Meter	This value is the electrical energy that flowed through the shunt. It counts in Wh (Watt-hour), and it can be reset to zero. This measurement is purely informational. It is not used for any other purpose by the device.
Coulomb Meter	This value is the accumulated coulombs. It counts in Ah (Ampere-hour), and it can be reset to zero. This measurement is purely informational. It is not used for any other purpose by the device.
Battery SoC	The battery state-of-charge is displayed as a percentage, from 0% to 100%. If the value displays "*unknown*", it is because the battery fuel gauge 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 polarity is correct, and the battery fuel gauge is configured correctly (battery chemistry, battery voltage, and battery capacity). For lithium batteries, a small discharge may be required (about 10%) before applying a full charge to initially synchronize the SoC reading. If it is known that the battery is fully charged, the SoC can be forcefully set to 100% by long tapping.
Battery Remaining	The estimated time left before the battery is completely discharged, based on the current rate of discharge. This value is only shown when the magnitude of the discharge current is higher than -0.1A. (more negative 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) – the relay is off due to an LVD condition HVD (High Voltage Disconnect) OCD (OverCurrent Disconnect) LTD (Low Temperature Disconnect) HTD (High Temperature Disconnect)

	NCH (Not CHarging) – only in LiFePO charge manager mode – the relay is off, and the battery is not being charged). The power can be manually turned on/off. For all disconnect functions to operate, the power must be manually set to on. When there are any schedules configured in the device, they take control of the power state.
Generator Status	This is shown only when the generator control feature is enabled in the device general configuration. It displays the generator control 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"*.
Device Clock	The internal time and date of the device. It can be set manually or automatically, from the Internet. The device time zone must be configured correctly for the clock to display correctly.

Configuration. The device configuration can be changed using the PowerMonX app. Configuration parameters are grouped into categories based on the function they affect.

General

Configuration Item	Description
Keep Link LED On	If enabled, the PowerMon-E will keep the RJ-45 port link LED on as long as the Ethernet link is up. If disabled, PowerMon-E will turn the LED off 5 minutes after plugging the cable, to save power. If the link is lost, the LED timeout will reset.
Set Time Automatically	When enabled, the device will acquire the date/time from the Internet.
Device Timezone	The time zone the device will use to compute the local time.
Shunt Specifications	The characteristics of the shunt used.
Maximum Shunt Current	The maximum current (in Amperes) that the shunt is expected to measure. Typically, this value is set to the maximum rated current of the shunt. It can be set lower to increase the measurement resolution. To do this, the value must 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 flowing 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 measurement range.
Disable Voltage 2	Disable the V2 voltage input. Use this option if you don't use the V2 voltage input and desire not to have it displayed at all. In some models this also reduces the current consumption of the device.
Power Meter Voltage Source	Selects the voltage used to calculate power and energy. Voltage1 or Voltage2 can be selected.

	Allows the current polarity to be inverted by software. This can be used to correct the shunt being wired backward. The setting 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.
Flip Current Sign	Allows the current polarity to be inverted by software. This can be used to correct the shunt being wired backward. The setting 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 enabled, the relay will turn on automatically when the device is first powered up.
Latch Relay On	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	When enabled, this option will invert the behavior of the RELAY terminal. When the power is on, the RELAY terminal will be floating; when the power is off it will be grounded. When this option is enabled Latch Relay On is ignored (disabled).
Connect Filter	The duration of time, in milliseconds, the LVD (Low Voltage Disconnect), HVD, OCD (Overcurrent Disconnect), LTD and HTD conditions must be removed before PowerMon turns on the relay.
MF Terminal Function	Selects the function of the MF terminal: push-button input, data output, or external temperature sensor.
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

Configuration Item	Description
LVD Voltage Source	Selects the voltage input used by the low voltage disconnect feature. Voltage1 or Voltage2 can be selected.
LVD Disconnect Threshold	The voltage (in Volts) below which the power relay will turn off.
LVD Connect Threshold	The voltage (in Volts) above which the power relay can turn on (after the Connect Filter time has passed). This must be higher than LVD Disconnect Threshold.
LVD Disconnect Filter	The duration of time the voltage must remain below the disconnect threshold for the power relay to turn off. It is used to filter voltage transients.

High Voltage Disconnect

Configuration Item	Description
HVD Voltage Source	Selects the voltage input used by the high voltage disconnect feature. Voltage1 or Voltage2 can be selected.
HVD Disconnect Threshold	The voltage (in Volts) above which the power relay will turn off.
HVD Connect Threshold	The voltage (in Volts) below which the power relay can turn on (after the Connect Filter time has passed). This must be lower than HVD Disconnect Threshold.
HVD Disconnect Filter	The duration of time the voltage must remain above the disconnect threshold for the power relay to turn off.

Overcurrent Disconnect

Configuration Item	Description
OCD Disconnect Threshold	The current (in Amperes) above which the power relay will turn off. The current must stay below this value before the power relay can turn on (after the Connect Filter time has passed).
OCD Disconnect Filter	The duration of time the current must be above the disconnect threshold for the power relay to turn off.

Low Temperature Disconnect

Configuration Item	Description
LTD Disconnect Threshold	The temperature below which the power relay will turn off.
LTD Connect Threshold	The temperature above which the power relay can turn on (after the Connect Filter time has passed). This value must be higher than LTD Disconnect Threshold.
LTD Disconnect Filter	The duration of time the temperature must be below the disconnect threshold for the power relay to turn off.

High Temperature Disconnect

Configuration Item	Description
HTD Disconnect Threshold	The temperature above which the power relay will turn off.
HTD Connect Threshold	The temperature below which the power relay can turn on (after the Connect Filter time has passed). This value must be lower than HTD Disconnect Threshold.
HTD Disconnect Filter	The duration of time the temperature must be above the disconnect threshold for the power relay to turn off.

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

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

Battery Fuel Gauge

Configuration Item	Description
Battery Voltage Source	Selects the voltage input used by the battery fuel gauge feature. Voltage1 or Voltage2 can be selected.
Battery Chemistry	Specifies the chemistry of the battery: Lead Acid – Flooded, Lead Acid – AGM, LiFePO4, Li-Ion, or Li-Poly.

Battery Voltage	Specifies the battery voltage. This 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	Specifies the number of cells in the battery. A 12V lead acid battery has 6 cells while a 12V LiFePO$_4$ battery has 4 cells. If batteries are 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 nominal voltage of the battery.
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.
Full Charge Detection	Selects the full charge detection algorithm. Default or custom can be selected.
Full Charge Detection Voltage	The voltage must be above this threshold to detect full charge.
Full Charge Detection Current	The current must be below this threshold to detect full charge.
Full Charge Detection Delay	The voltage must be above the configured threshold and the current below the configured threshold for this amount of time before the battery is considered fully charged.
Disconnect on Battery SoC Threshold	The device will turn the power relay off when the battery state of charge becomes lower than this threshold expressed in percentage.
Connect on Battery SoC Threshold	The device will turn the power relay on when the battery state of charge becomes higher than this threshold expressed in percentage.

Generator Control

Configuration Item	Description
Generator Control Voltage Source	Selects the voltage input used by the generator control feature. Voltage1 or Voltage2 can be selected.
Turn On Based on Voltage	When enabled, the generator will be turned on when the battery voltage drops below a specified threshold.
Turn On Voltage Threshold	The threshold (in Volts) below which the generator will be turned on.
Turn On Voltage Filter	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	When enabled, the generator will be turned on when the battery SoC (State-of-Charge) drops below 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	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	Specifies the 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 increase above the turn-off threshold.

LiFePO Charge Manager

Configuration Item	Description
Battery Voltage	Specifies the battery voltage. This 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	Specifies the number of cells in the battery. A 12V lead acid battery has 6 cells while a 12V LiFePO$_4$ battery has 4 cells. If batteries are 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 nominal voltage of the battery.
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. PowerMon can be reset to the default configuration using the PowerMonX app. To do this, connect to a device, tap on top right corner menu, and then "*Device Information*". Tap on "*Factory Reset*".

WARNING: When resetting the device to factory defaults, all custom settings, schedules, current calibration, the battery fuel gauge internal state, statistics, and the logged data will be lost.

Renaming the device. The device can be renamed using the top-right menu button and tapping on "*Device Information*". The maximum name length is 32 characters.

Device Pairing. Pairing a device allows it to be accessed remotely over the Internet. When a device is paired with the app it shows up in "Remote Device" on the "Discover Devices" screen. To pair with a device, go to "*Device Information*" page and tap on "*Pair*". The latest app versions pair automatically when connecting to a device from "*Local Devices*". Only devices listed under "*Local Devices*" can be paired with. Once paired on one mobile device, the device link can be shared with other mobile devices by swiping the device in "*Remote Devices*".

Password lock. The device supports a dual-level security model using user and master passwords. When a device is locked with the user password, the app will prompt for the password upon connection. After the correct password is entered, the device is unlocked and remains unlocked for the duration of that connection. The master password is intended to protect functions that are critical to the safe and correct operation of the device. Manufacturers integrating the PowerMon battery monitor into a custom system can use the master password to restrict access to these critical configuration areas. Access to master-protected functions can be requested by tapping on "*Master Access - Unlock*" on the "*Device Information*" screen. While the device is locked by the master password, the following functions are unavailable:

- Resetting general or battery statistics
- Changing the device configuration
- Restoring factory settings
- Zeroing or calibrating the current measurement
- Re-synchronizing the battery fuel gauge
- Clearing the data log
- Updating the device firmware

If the device is locked with a user password, entering the master password will also unlock the user portion of the device.

WIRING DIAGRAMS
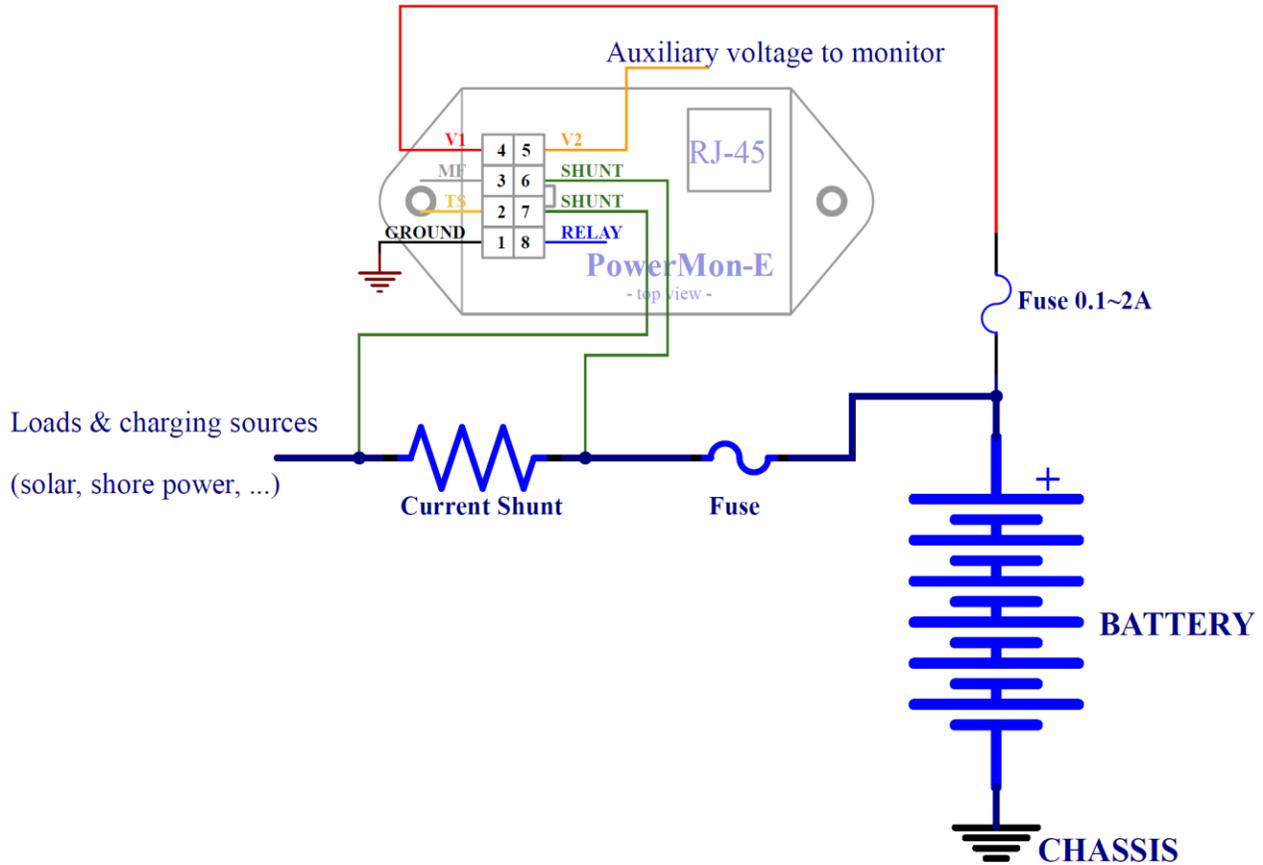
Typical application without a relay

- 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 (see performance tables for the maximum voltage). Leave unconnected if not used.
- The wires from the shunt to the SHUNT inputs should be as short as possible and twisted to minimize electrical noise
- The main fuse should be sized based on the maximum system current and the wire size
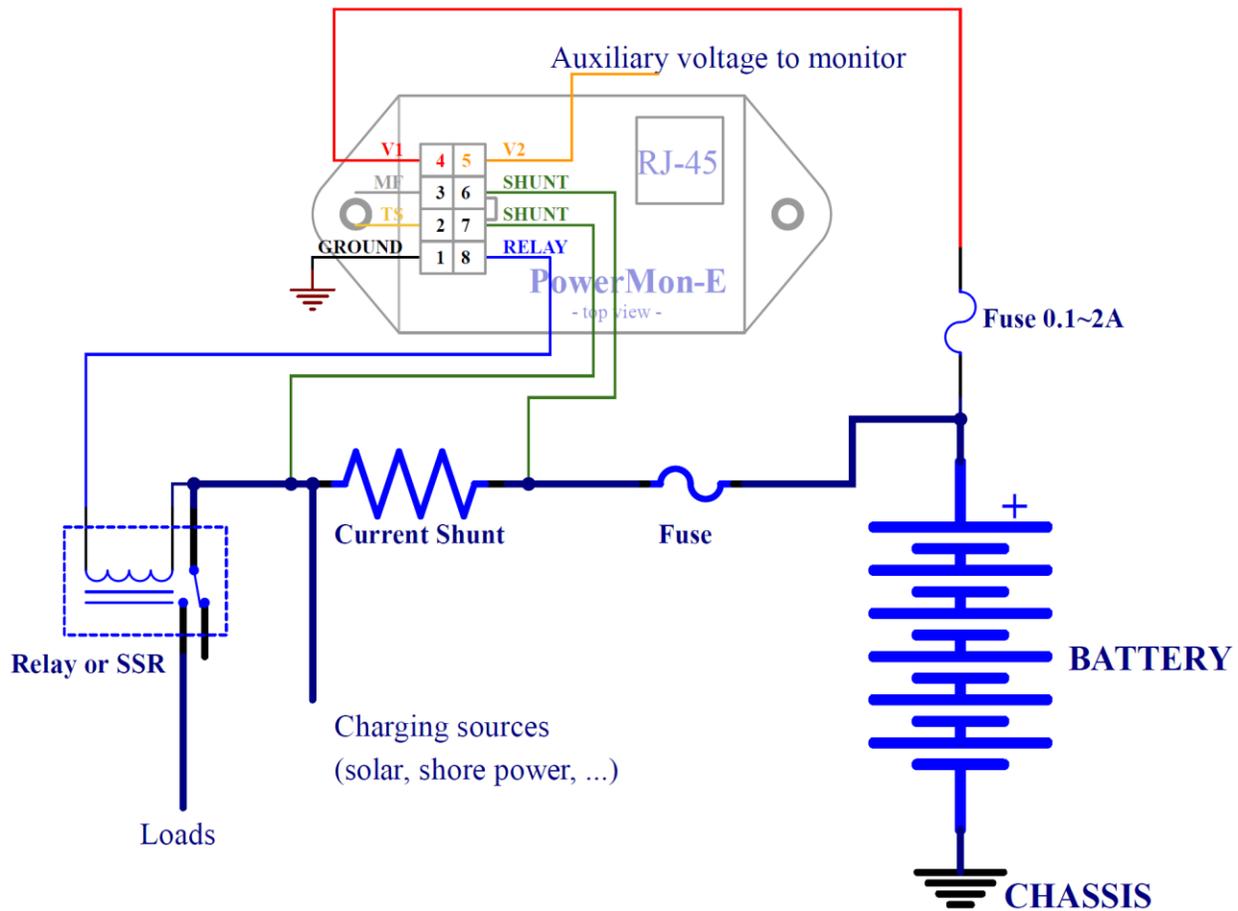
Typical application using a relay

- V2 can be used to monitor a second battery, the midpoint between two batteries in series, or the solar panel input voltage (see performance tables for the maximum voltage). 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
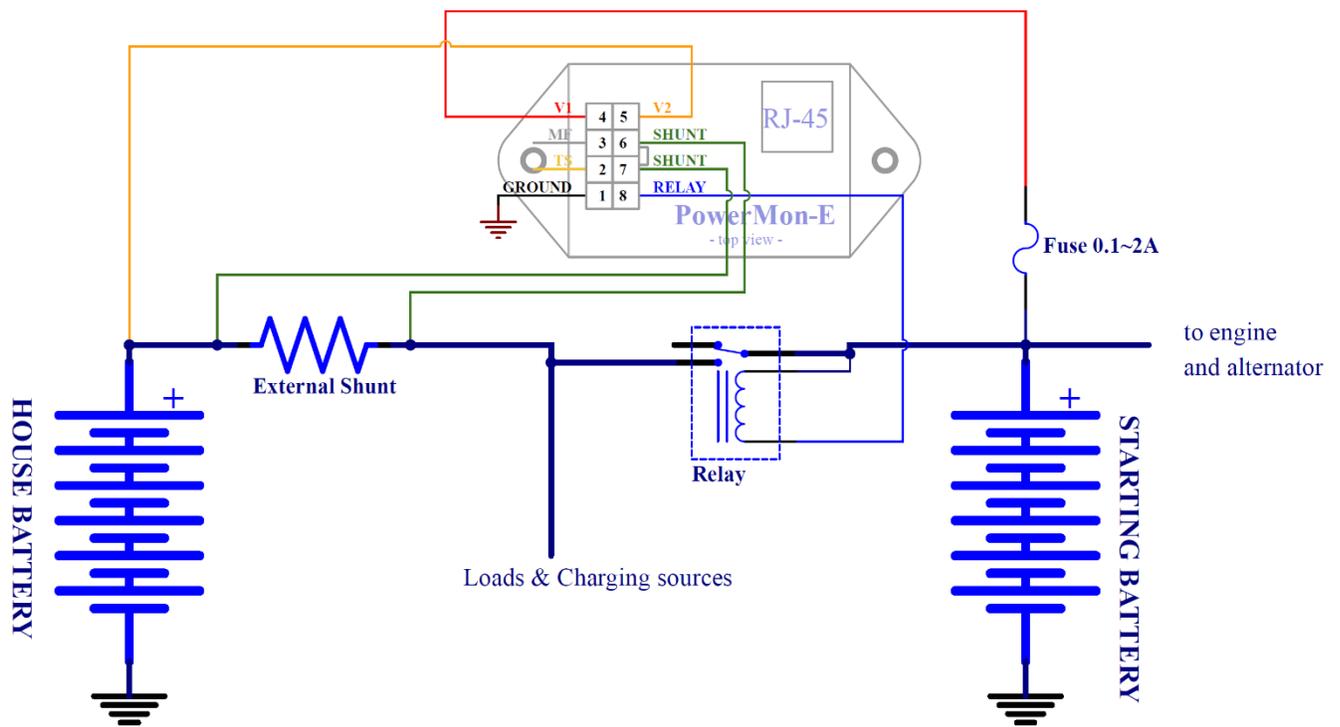
Typical application of a battery isolator

- 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)

![Thornwave Labs Inc]
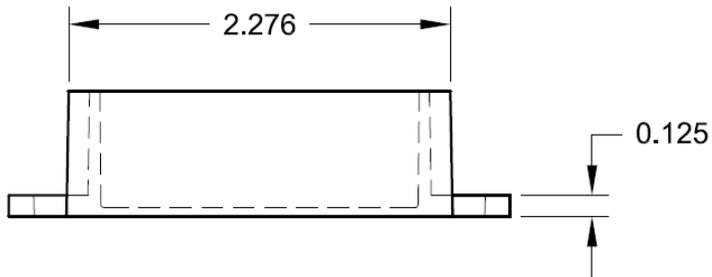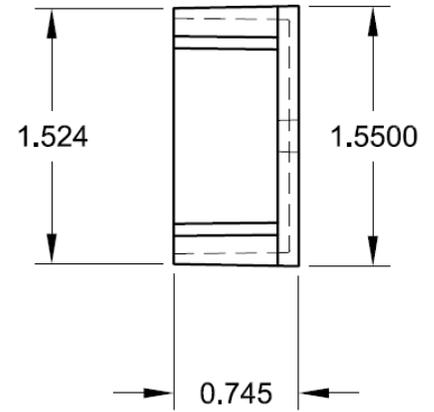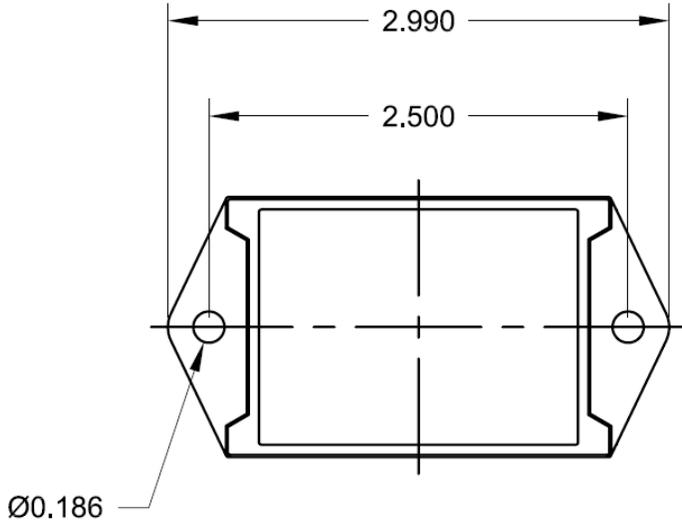
DIMENSIONS

Dimensions are in inches.

ORDERING

Part Number	Description
PowerMon-E	Ethernet / IoT Advanced Battery Monitor / DC Power Meter