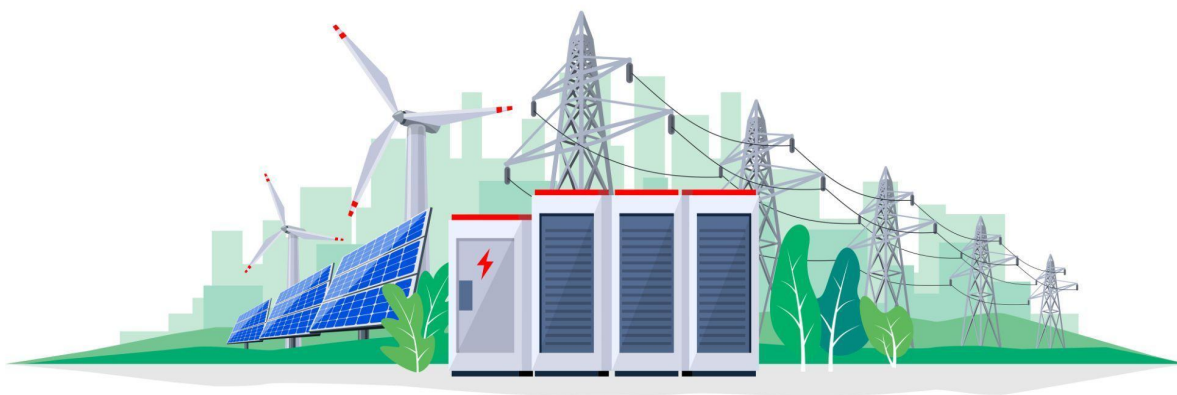


Vulcan

Energy Storage System

Owner's Guide 120V - 240V Models



BATTERY  STORAGE

IMPORTANT PRODUCT SAFETY INSTRUCTIONS

VULCAN GENERATES THE SAME POTENTIALLY LETHAL AC POWER AS A NORMAL HOUSEHOLD WALL OUTLET. PLEASE USE IT CAREFULLY JUST LIKE USING A NORMAL AC OUTLET ON THE WALL.

Read and save this owner's guide for future reference. It contains important safety information and instructions for the Vulcan line of energy products that must be followed during installation, operation, maintenance and troubleshooting. The information included in this guide is accurate at the time of publication. However, this guide is subject to change without prior notice. The illustrations and schematics are meant only to help explain system configuration concepts and installation instructions.

- Read all instructions and cautions carefully before use to avoid personal injury or damage to the unit and any connected products.
- Observe all Input/Output connectors ratings: To avoid fire or electrical shock hazard, observe all ratings on units, and products you intend to use; check manuals for more information.
- Use in a ventilated area: Ensure proper ventilation while in use and do not obstruct fan openings on the unit. Inadequate ventilation may cause damage to the unit. Do not stack anything on top of the unit in storage or in use.
- DO NOT operate in wet conditions: In order to avoid short circuits or electric shock do not allow the unit to get wet. Let the unit dry completely before using. See the section Cold Weather and Outdoor Usage on page 20 for outdoor operation.
- DO NOT insert foreign objects into outputs or ventilation holes.
- Keep the unit clean and dry. Inspect the unit for dirt, dust, or moisture on a regular basis.
- Any manipulation to the unit or its components will void all warranties. Sol Donum™ is not liable for end user misuse of the product, and any injury resulting, as defined in the Limited Liability section of this document.

Glossary of Symbols



The addition of this symbol to a 'Danger' safety label indicates that an electrical hazard exists, which will result in personal injury or death if the instructions are not followed.



This symbol is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

IMPORTANT PRODUCT SAFETY INSTRUCTIONS

The following safety labels are used to alert the reader to conditions that may cause injury or death. Obey all safety messages as posted throughout this document.



DANGER

DANGER indicates a hazardous situation which, if not avoided, will result in serious injury or death.



CAUTION

CAUTION indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

NOTICE

NOTICE is used to address practices not related to physical injury.

PRODUCT SAFETY INFORMATION



DANGER

ELECTRICAL SHOCK AND FIRE HAZARD

Installation must be done by qualified personnel to ensure compliance with all applicable installation and electrical codes and regulations. Recommendations for installing the Vulcan unit are provided here for use by qualified personnel only.

Failure to follow these instructions may result in serious injury or death.



CAUTION

ELECTRICAL SHOCK AND FIRE HAZARD

- Do not open. No serviceable parts inside. Provided with integral protection against overloads. Bonding between conduit connections is not automatic and must be provided as part of the installation.
- Read guide before installing or using.
- Do not cover or obstruct ventilation openings.
- Do not mount in a zero-clearance compartment – overheating may result.
- Do not expose the unit to rain or spray.
- Do not connect AC Output to any other source of power. Unit damage may occur.
- For AC Input and AC Output, use wires suitable for at least 75°C.

Failure to follow these instructions can result in injury or equipment damage.



CAUTION

PHYSICAL INJURY HAZARD

This Vulcan unit is not intended for use by persons (including children) with reduced physical, sensory, or mental capabilities or lack of experience and knowledge, unless they have been given supervision or instruction concerning use of the appliance by a person responsible for their safety. Children should be supervised to ensure that they do not play with the appliance.

Failure to follow these instructions can result in injury or equipment damage.

DECOMMISSIONING

Sol Donum™ energy storage and power generating products contain high-end, industrial purpose electronic components, subassemblies and Grade A Lithium-ion Iron Phosphate batteries. Industrial electronics are used to provide a robust operating platform. Lithium-ion Iron Phosphate batteries are used due to the high energy density and safety of the battery chemistry. ‘Energy density’ means the amount of energy that a system stores in a specific amount of space. Lithium batteries can be smaller and lighter than other types of batteries while holding the same amount of energy. This miniaturization has allowed for the development of products such as the Vulcan system.

The technologies and batteries used in Vulcan units require that they are to be recycled, refurbished or repurposed when they reach their end-of-life (EOL). Vulcan, Energy Store and Smart Store devices are not to be disposed of in household garbage or recycling bins. Do not dismantle Vulcan, Energy Store or Smart Store units. Contact Sol Donum™, support@soldonum.com for guidance.

EPA recommendation for consumers: Contact the manufacturer, automobile dealer or company that installed the Lithium-ion battery for management options; do not put it in the trash or municipal recycling bins.

Because of the size and complexity of these battery systems, medium and large-scale Lithium-ion batteries may not be able to be removed by the consumer. Refer to the manufacturer’s instructions and heed warnings and safety instructions.

- Automobile: Contact the automobile dealer, shop or salvage yard where the battery was purchased.
- Energy Storage: Contact the energy storage equipment manufacturer or company that installed the battery.

EPA recommendation for businesses: EPA recommends that businesses consider managing Lithium-ion batteries under the federal ‘universal waste’ regulations in EPA - Title 40 of the Code of Federal Regulations (CFR) part 273

- Persons who generate wastes that are defined as hazardous under Resource Conservation and Recovery Act (RCRA) are referred to as ‘hazardous waste generators.’
- The universal waste regulations provide a streamlined set of requirements for generators of specific types of common hazardous wastes (e.g., fluorescent lamps containing mercury, batteries) from a wide variety of commercial settings.
- Commercial establishments are responsible for determining whether any waste they produce is hazardous waste, including Lithium-ion batteries at their end of life.

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Purpose

The purpose of this Owner's Guide is to provide explanations, applications and procedures for installing, operating, maintaining, and troubleshooting the Vulcan system.

Scope

The guide provides safety and operating guidelines and information on installing, configuring, troubleshooting, maintaining, and using the Vulcan system.

Audience

The guide is intended for users and operators of the Vulcan Inverter-Charger and Energy Stores. **The section titled Application Notes and Recommendations on page 22 is intended for qualified personnel.** Qualified personnel have training, knowledge, and experience in:

- Installing electrical equipment.
- Applying all applicable installation codes.
- Analyzing and reducing the hazards involved in performing electrical work.

Abbreviations and Acronyms

A	Amperes
Ah	Amp-hours (a unit of battery capacity)
AC	Alternating Current
ATS	Automatic Transfer Switch
AWG	American Wire Gauge
BMS	Battery Management System
°C	Celsius
DC	Direct Current
EMI	Electromagnetic Interference
kVA	Kilovolt-Amps
kW	Kilowatts
kWh	Kilowatt Hours
LCD	Liquid Crystal Display
MC4	Multi-Contact, 4 millimeter
MPPT	Maximum Power Point Tracking
ms	Milliseconds
NEMA	National Electrical Manufacturers Association
RMS	Root Mean Square
SoC	State of Charge
UPS	Uninterruptible Power Supply
Vac	Volts Alternating Current
Vdc	Volts Direct Current

Definitions

Automatic Transfer Switch (ATS) is a device used to switch between two or more sources of electrical power. These can be solid state static or electromechanical devices.

Autotransformer is a magnetic induction device used to step down, step up or convert alternating current (AC) from one voltage to another. For example, utilities use autotransformers/transformers to convert 7100Vac to 120Vac/240Vac that is used within homes.

Battery Management System (BMS) is an advanced microcomputer controlled device that protects the internal Lithium-ion Iron Phosphate (LiFePO₄/LFP) battery from being overly discharged or overly charged, from short circuits, over voltage, extreme temperature, and it keeps the individual battery cells in voltage balance.

EMI Filter is a device that uses a combination of capacitor, inductor and resistor resonant traps to filter out high frequencies. Within an AC voltage circuit, an EMI filter improves power quality by filtering out harmonics, frequencies that are a multiple of the source frequency (60Hz or 50Hz), and other high frequency line noise which can affect sensitive electronics and equipment such as radios.

Grid/Shore Power is the electricity generated and delivered by the utility.

Maximum Power Point Tracking (MPPT) is an algorithm used by solar charge controllers to extract the maximum amount of working power (watts) from solar panels. The algorithm, does this by presenting the lowest resistance load, as closed to zero ohms, to the solar panels until it can reach the highest voltage at the highest current - maximum power point - $W = I * E$

LiFePO₄/LFP or lithium-ion iron phosphate is an advanced battery technology that uses iron phosphate as a key component of its electrochemistry. It is safer than other lithium-ion chemistries such as nickel manganese cobalt oxide (NMC).

ORing Diode is a solid state switch used to control the flow of current without the use of mechanical or electromechanical parts. It is known as a static switch due to the lack of moving parts. It is based upon a MOSFET design for zero voltage drop and very little energy loss as compared to Schottky diode-based switching designs.

Watts (W) is the measure of electrical power used to perform the work from the electricity consumed. For those who use Amperes as a measure, watts can be achieved using the formula $W = I * E$, where "I" is the current in Amperes and "E" is the potential in Volts.

Voltage Sag or a 'brownout' is a short duration reduction in RMS voltage of an AC source, which can be caused by a short circuit, circuit overload, or starting of electric motors. It can affect sensitive electronic loads, computer systems and adjustable motor speed drives.

Introduction



CAUTION

ELECTRICAL SHOCK AND FIRE HAZARD

- Do not open. No serviceable parts inside. Provided with integral protection against overloads. Bonding between conduit connections is not automatic and must be provided as part of the installation.
- Read guide before installing or using.
- Do not cover or obstruct ventilation openings.
- Do not mount in a zero-clearance compartment – overheating may result.
- Do not expose the unit to rain or spray.
- Do not connect AC Output to any other source of power. Unit damage may occur.
- For AC Input and AC Output, use wires suitable for at least 75°C.

Failure to follow these instructions can result in injury or equipment damage.

The Vulcan Inverter-Charger (**Vulcan**) is a high efficiency DC-to-AC power conversion and battery energy storage device that powers 120Vac loads from its internal 1.4kWh lithium-ion iron phosphate (LiFePO₄/LFP) battery or with one or more 2.6kWh or 3.6kWh Energy Stores. Vulcan helps users achieve energy independence and maximizes the return on investment (ROI) of small scale battery energy storage and power systems with a solution that reduces installation time and complexity.

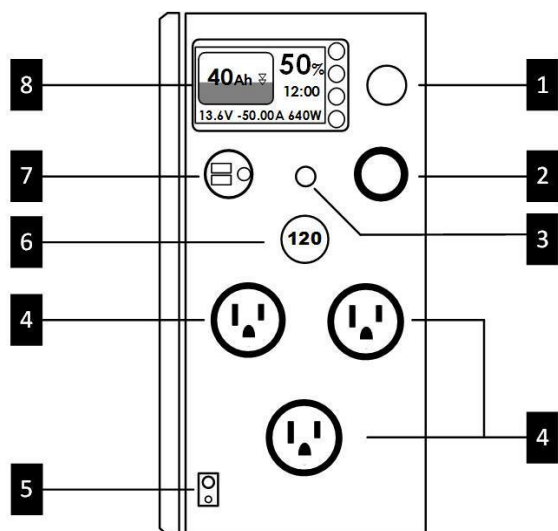
What Vulcan can Do

Vulcan can provide power protection, support energy independence and savings as follows:

- Save electricity/energy costs under time-of-use (TOU) rate plans by running during 'peak' hours and charging during 'off-peak' hours when electricity costs are lower;
- As a standby/backup system to automatically back up critical loads during a power outage;
- Save fuel with a gasoline generator by carrying the load when the generator is switched off - generator firming;
- Collect the sun's energy from solar panels as an off-grid solar energy storage system to store energy and take electrical loads completely off-grid and cut electricity costs;
- Protect your devices and improve electrical power quality by filtering grid/shore power and providing low AC voltage (voltage sag/brown out) protection.

Front Panel

The Vulcan front panel, illustrated in **Figure 1.**, contains the unit controls and outputs.



[1] - AC Power On/Off Button powers the unit inverter on and off. When powered on, the button will illuminate green and the voltage display [6] will indicate the output voltage to the NEMA 5-15 125Vac receptacles [4].

[2] - 12V Accessory Port provides up to 15A of unregulated power from the internal battery.

[3] - 15A DC Fuse Holder protects the 12V Accessory Port [2] and the Dual USB Terminal [7]. It is equipped with a 15A fuse.

[4] - NEMA 5-15, 15A, 125Vac receptacles are UL rated and operate up to 15A at 125V¹.

Figure 1. Vulcan front panel configuration

[5] - Earth Ground Lug is connected to an earth ground stake when additional radio frequency/electromagnetic interference protection is required.

[6] - AC Output Voltage Display indicates the output voltage to the NEMA 5-15 AC voltage output receptacles [4].

[7] - Dual USB Terminal with On/Off provides 2.4A of power through the USB B connector ports. The USB on/off button conserves battery energy when the USB terminal is not in use.

[8] - Battery Capacity and Power is displayed here along with an estimated time to charge or empty the battery (or batteries when Energy Stores are used with the Vulcan Inverter-charger.)

¹ **NOTE:** These are dangerous voltages. Always exercise extreme caution when operating the unit.

Rear Panel

The Vulcan rear panel is illustrated in **Figure 2**. The rear panel contains the inputs for 120VAC, battery expansion connections and the solar panel(s) input connections.

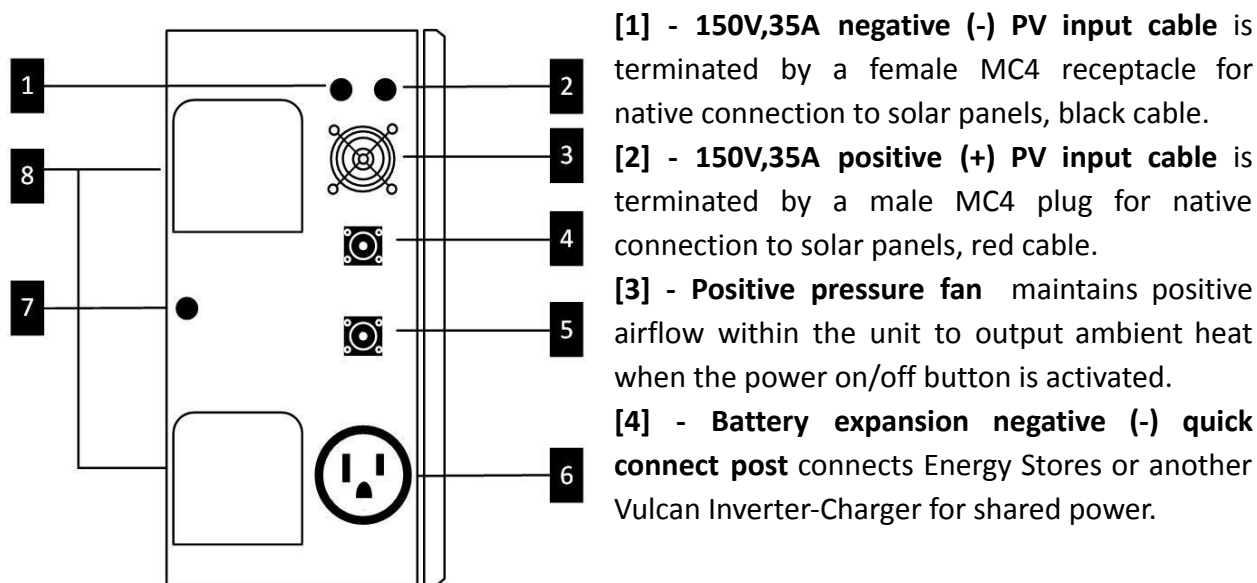


Figure 2. Vulcan rear panel configuration

[5] - Battery expansion Positive (+) quick connect post connects Energy Stores or another Vulcan Inverter-Charger for shared power.

[6] - 120VAC, 15A input plug powers the AC-to-DC battery charger and flows through the automatic transfer switch and EMI filter. When grid/shore power is active, the unit's AC voltage output is grid/shore power from plug [6]. When grid/shore power is inactive, the unit's AC voltage output is generated from battery power.

[7] - 30A AC voltage circuit breaker cover keeps dirt and moisture away from the AC output circuit breaker. In the event of an AC power overload, this port can be checked to view the circuit breaker status.

[8] - Variable speed cooling fans are activated when the AC output load is 250W or above.

How it Works

Vulcan uses battery power to run many types of 120Vac loads to include those with high inrush currents such as microwave ovens, vacuum cleaners, compressors and pump motors. Vulcan contains an internal EMI power filter, pure sine wave inverter and voltage sag protection, which greatly improves AC voltage power quality. It is a single conversion DC-to-AC power converter that uses an Automatic Transfer Switch (ATS) to move from grid/shore power to battery power when the AC voltage drops below a certain threshold. Thus, Vulcan outputs high quality AC power that is capable of running the most demanding and sensitive loads, **Figure 3**.

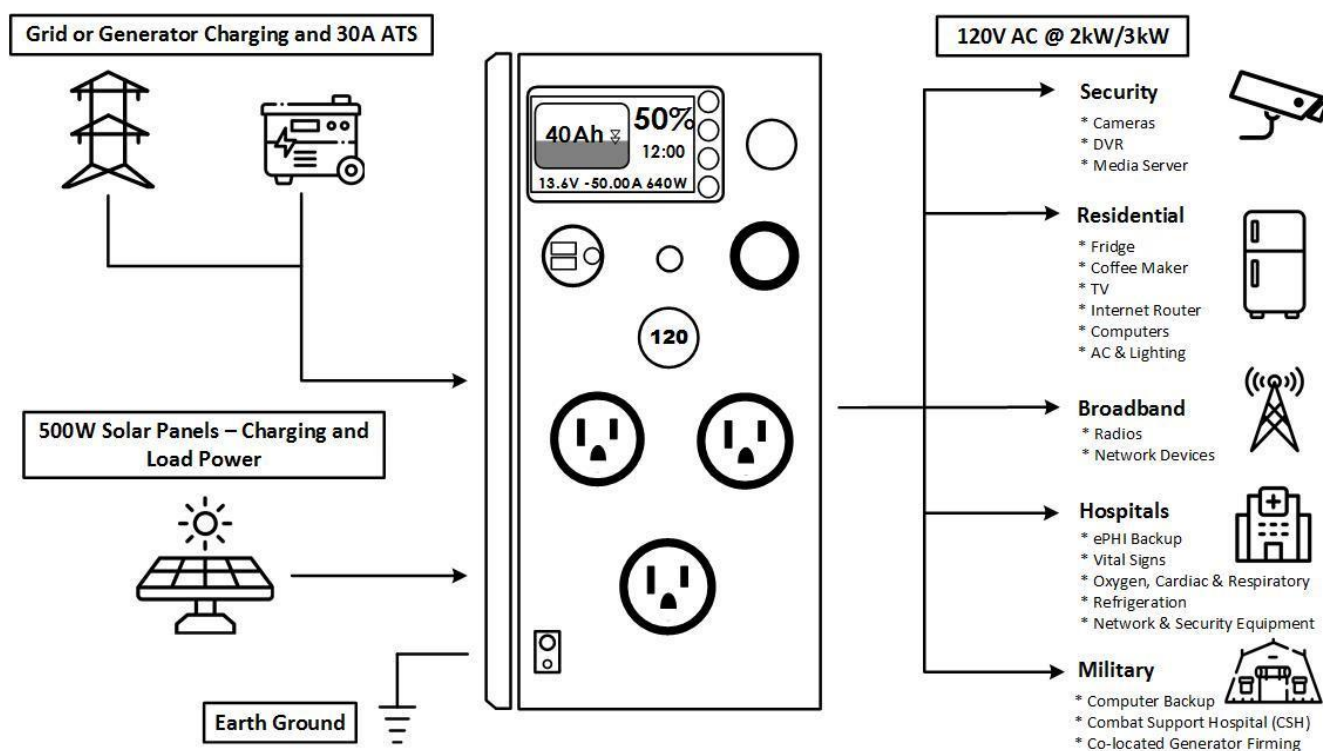


Figure 3. Vulcan input and output options

Vulcan uses an internal ATS to pass through grid/shore power. The ATS allows it to simultaneously charge from several sources - grid, generator and solar panels. Vulcan can charge its battery(s) simultaneously while powering loads at full power.

System Operating Parameters

When operating your system, keep in mind the following operating parameters to ensure sufficient battery and output power capacity to adequately power your loads, **Table 2**.

Operating Parameter	Description
BMS Low Battery Cutoff	Vulcan's battery management system (BMS) protects the internal Lithium Iron Phosphate (LiFePO ₄ /LFP) battery from being overly discharged. The BMS will cut off the battery output when the battery discharges to 10.8V in order to protect the cells. This will power off the display and the on/off power button illumination. In order to reactivate the battery, the Vulcan must be charged from grid/shore power, an Energy Store (page 30) or solar panels (page 23).
Inverter Low Battery Cutoff	In order to preserve battery capacity, the AC output power will shut off when the battery voltage discharges down to 11.2Vdc .
Low AC Voltage Threshold	Vulcan will switch to battery power when the grid/shore voltage drops below 90Vac .
AC Output Voltage	This is the voltage of the grid/shore power when active or the AC output voltage of the Vulcan when running on battery power.
Battery float voltage	This is the resting voltage shown on the Vulcan display. The value is 13.6Vdc and will rest there while Vulcan is running from grid/shore power.
Automatic Transfer Switch Speed	This is the speed at which Vulcan switches from grid/shore to battery and from battery to grid/shore power. The standard Vulcan switching speeds are 10ms and 20ms . This may cause a noticeable flicker in lights but will not affect the operation of TV, computing, medical, and networking equipment.
Inverter Fault Recovery	Automatically retry three (3) times. After which, the load that caused the fault must be removed and the power on/off button Figure 1. [1] must be manually depressed to off then to on to restore the AC output power.
Power Save Time	The AC output will shutdown after 25 hours of no-load/idle. The power on/off button must be cycled to restart.

Table 2. Vulcan system operating parameters.

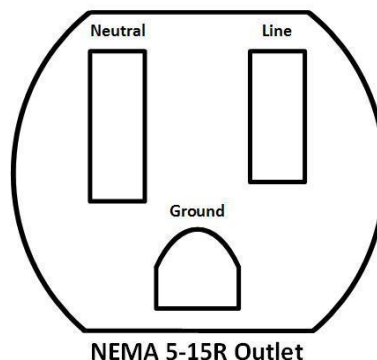
How to Use Vulcan

Before using the Vulcan unit, follow the safety guidelines outlined in the **IMPORTANT PRODUCT SAFETY INSTRUCTIONS** section at the front of this document.

General Usage

Vulcan can be run as a standalone portable AC power source, a grid/shore standby power source or as an energy storage system for renewable solar energy collection to power to 120Vac loads. To use Vulcan directly out of its shipping box:

1. Follow the procedures in section Charging the Vulcan on page 18.
2. Turn on the system power using **AC Power On/Off Button, Figure 1. [1]**. Vulcan will produce AC power after 5 seconds. If the Vulcan has been plugged into grid/shore power as a standby backup, using an extension cord, the AC voltage display will show the grid/shore voltage.
3. Take note of the LCD battery display. When Vulcan is charging, the display backlight will cycle between an on and off state, **Figure 4.**, and the up arrows will display in the battery capacity indicator, **Figure 4. [9]**, the estimated time to full **Figure 4. [10]** or battery empty is displayed here in hours:minutes.
4. Plug devices with a 3-prong 15A or 2-prong 10A plug into the Vulcan NEMA 5-15R power outlets. Extension cords and power strips may be plugged into the Vulcan AC power outlets.
5. If possible, keep your Vulcan plugged into a power source at all times when not in use.
6. Vulcan can charge its battery(s) and run output loads simultaneously. When using solar panels, **Figure 2. [1]** Vulcan will split the available energy between the load and battery(s) with priority given to the load.



CAUTION

Ensure that the combined loads do not exceed the maximum continuous output power rating of the Vulcan unit.

DC Accessories Panel

Some Vulcan units are equipped with an optional DC voltage power panel that provides QC 3.0 USB and 12Vdc accessory power. The USB connections can be used to power and charge 5Vdc devices such as mobile phones. The 12Vdc accessory port can be used to power devices such as radios, food warmers, 12Vdc refrigerators and coolers, air compressors and other devices that may be powered from a car accessory port. This port is unregulated and the output voltage can vary from 11.5Vdc - 14.4Vdc.

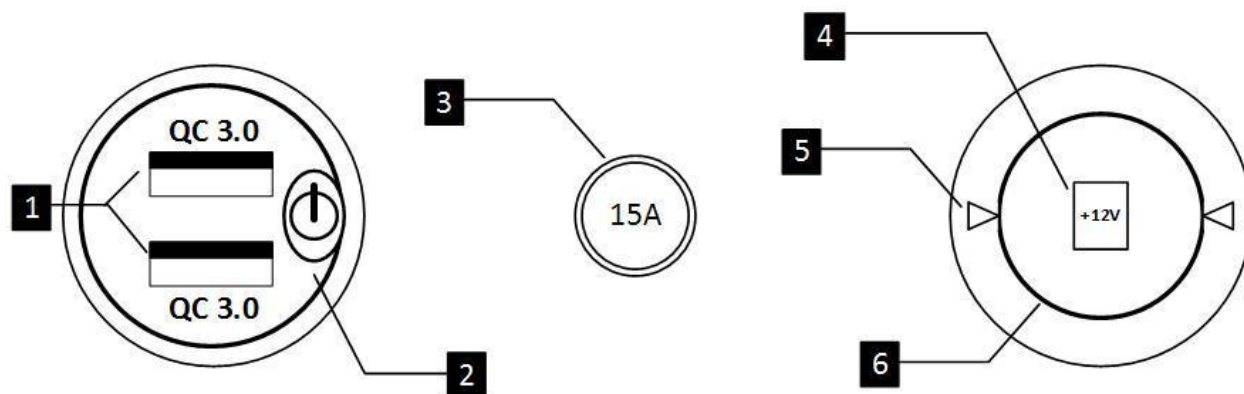


Figure 4. USB and 12Vdc accessory power panel.

- [1] - **36W Quick Charge USB ports** provide 3.6Vdc - 12Vdc at 2A or 3A.
- [2] - **Quick Charge USB power On/Off** activates the quick charge ports. The plug ring will illuminate blue when the Quick Charge ports are active.
- [3] - **15A accessory fuse** protects the USB and 12Vdc accessory ports.
- [4] - **12Vdc accessory port center positive (+) voltage pin.** Ensure that any 12Vdc accessory plug inserted into the accessory port is polarized for a center pin of +12Vdc.
- [5] - **12Vdc accessory port locking point indicator.**
- [6] - **12Vdc accessory port center negative (-) voltage band.** Ensure that any 12Vdc accessory plug inserted into the accessory port is polarized for an outer connection of -12Vdc.



CAUTION

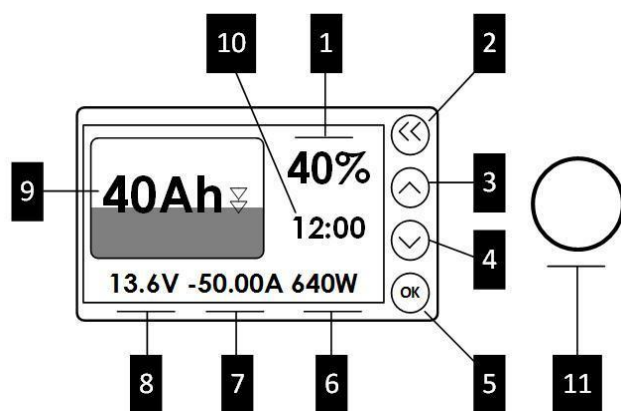
Do not exceed the 15A rating of the DC panel fuse. If the fuse needs replacing, replace it with a fast blow, 250V @ 15A glass fuse.

Grounding Shield Lug

Vulcan contains an RFI shield grounding lug, **Figure 1. [5]**, that is used when additional radio frequency/electromagnetic interference protection is required. Attach this to a ground stake using a minimum copper wire size of 10 AWG.

Front Panel Buttons and LCD Display

The built-in LCD display, **Figure 5.**, indicates six (6) items of information and contains 4 buttons. To the right of the LCD display is the AC power On/Off button.



- [1] - **Battery percentage** indicates the estimated remaining system battery capacity².
- [2] - **Value selection button** updates the total battery capacity displayed.
- [3] - **Up selection button** updates the display settings parameters.
- [4] - **Down selection button** updates the display settings parameters.
- [5] - **Entry OK and backlight button** saves display settings parameters and activates the display backlight.

Figure 5. Front panel display and buttons.

- [6] - **Watts** of energy going into or being pulled from the internal 1.4kWh battery.
- [7] - **Current in amperes** going into or being pulled from the internal 1.4kWh battery.
- [8] - **Battery voltage** indicates the voltage of the system battery(s)
- [9] - **Battery State of Charge (SOC)** in Ampere hours.
- [10] - **Estimated time to empty/full** shows the amount of time in hours:minutes before your Vulcan is completely charged or empty, depending on if the net amount of power going into the Vulcan is positive or negative.
- [11] - **AC power On/Off button** turns the AC power on and off, which is displayed on the AC output voltage display **Figure 1. [6]**, and is used to reset the AC output power in the event of Vulcan shutting down from an AC power fault after the maximum number of automatic retries, three (3).

² **NOTE:** Indicates the Vulcan unit percentage or total combined remaining percentage when used with one or more Energy Stores.

Charging the Vulcan

NOTICE

NOTICE: Perform charging before applying an AC load to your Vulcan system.

CHARGE NOW: Before using or storing, plug your Vulcan into an AC source such as a wall plug using a standard, single receptacle AC power extension cord (not supplied) or solar panels until the unit is fully charged. Try to keep your Vulcan plugged in or on a routine charging source when not in use.

When charging your Vulcan, you will notice the LCD battery display flashing on and off. This indicates the charging state. Once your Vulcan is fully charged, the battery display will indicate 100%. As long as there is more power going into the Vulcan than is being pulled from the output, when charged from solar panels, the display will indicate the estimated time until fully charged. This is estimated based on the power input and output numbers at that time.

Charging and Operating from Solar Panels



DANGER

ELECTRICAL SHOCK AND FIRE HAZARD

Installation must be done by qualified personnel to ensure compliance with all applicable installation and electrical codes and regulations. Recommendations for installing the Vulcan unit are provided here for use by qualified personnel only.

Failure to follow these instructions will result in serious injury or death.

IMPORTANT NOTE: Do not exceed 150VDC/35A or 500W input into the MC4 cables. Doing so will cause damage to the unit and potential bodily injury. For questions about solar charging and the proper way to set up your solar panels, email our solutions team at info@soldonum.com.

Vulcan incorporates a device called a solar charge controller, which uses an algorithm known as maximum power point tracking (MPPT). It actively monitors the energy source you're using to charge the Vulcan LiFePO4/LFP battery by optimizing the source to maximum output power,

resulting in up to 40% faster charge times over pulse width modulated (PWM) charge controllers.

Vulcan accepts power from solar panels into the **RED** and **BLACK** rear panel cables that are terminated with MC4 connectors, **Figure 6**. The connectors are keyed to plug directly into native solar panel cables without special adapters. The input power maximum is 500W. The solar panels must have a minimum open circuit voltage of 22Vdc in order to activate the charge controller.

1. Place the solar panels where they will get as much direct sunlight as possible.

NOTICE

NOTICE: Up to 100 ft of 10 AWG cable may be used between the Vulcan and the source solar panels.

2. Plug the solar panel cables into the MC4, **Figure 6**., connectors at the rear of the Vulcan unit. Vulcan is charging when the LCD display backlight is flashing. The Vulcan is fully charged when the battery percentage indicator, **Figure 4. [1]**, displays 100%.
3. Solar panels should be connected in series for optimal charging performance. **NOTE: Do not exceed 150VDC/35A or 500W of input power to the charge controller.**

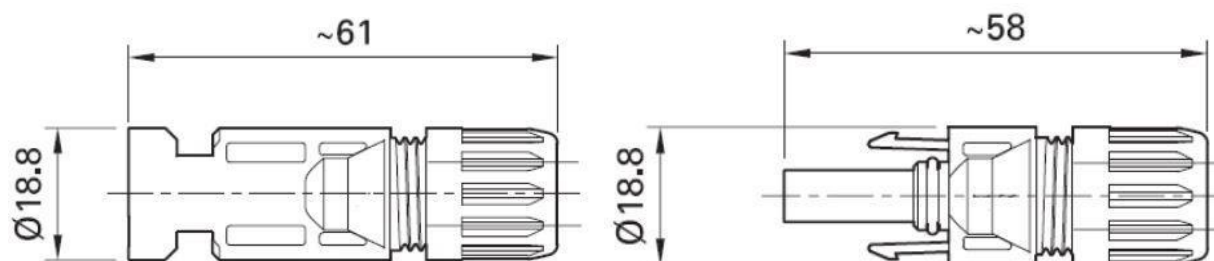


Figure 6. Female and male MC4 solar cable connectors.

Charging and Operating from Grid/Shore Power or Gas Generator

Using an AC power extension cord of 12 AWG or larger gauge (not supplied) plug your Vulcan into any wall or generator outlet that has a 15A or greater service. You will know the Vulcan is charging when the LCD backlight starts to flash and the Watts indicator, **Figure 5. [6]**, displays the amount of energy in watts being placed into the battery.

The Vulcan will recharge from a 120Vac power source such as a wall outlet in approximately 4 hours and is fully charged when the battery percentage indicator, **Figure 5. [1]**, displays 100%. The LCD panel backlight will turn off once the battery reaches its standby voltage of 13.6V.

Overload Conditions

There are two kinds of overload conditions – an overload warning and an overload shutdown.

- Overload Warning occurs when Vulcan's AC load is approximately 100 W below the overload shutdown limit of rated watts, the audible alarm beeps once.
- Overload Shutdown occurs when Vulcan's AC load increases to near ~2100W (Vulcan 2kW) and ~3100W (Vulcan 3kW), the audible alarm beeps every five seconds for one minute prior to the inverter shutting down.
- High Surge Loads occur when induction motors used in freezers, pumps, and other motor operated equipment require high surge currents to start. Vulcan may not be able to start some of these motors even though their rated steady state current draw is within the unit's limits. The unit will indicate an overload and shutdown.

Over-Temperature Conditions

During operation, if Vulcan's internal temperature starts to approach its shutdown limit, the unit will go into an over-temperature protection mode. If the over-temperature condition persists for more than several minutes, the Vulcan will shut down its AC voltage output to prevent damage to the inverter and protect the battery from being over-discharged.

Cold Weather and Outdoor Usage

Cold temperatures (below freezing) can impact the Vulcan's battery capacity. If Vulcan will be operated in sub-zero conditions, without its heating option, we recommend maintaining a constant load to keep current flowing through the battery and BMS system to generate internal heat from the electrochemical reaction within the battery cells. The BMS will shutdown battery charging if the battery core temperature drops below 0°C/32°F.

When using the Vulcan outside, place it under cover and keep moisture from coming in direct contact with the unit. Do not place the unit in standing water. Ensure adequate clearance of at least 1 ft front and rear to guarantee proper ventilation to cool the unit. Following these recommendations will help to maintain optimal unit life, keep the battery at its highest capacity, and ensure the longest battery cycle and calendar life.



CAUTION

When operating in temperatures above 32°C/90°F, ensure there is adequate ventilation to allow for airflow into and exhaust air out of the unit. Do not use it in a confined space that is void of ventilation to the outside air. Refer to section Installation on page 34.

Application Notes and Recommendations

Whether you intend to use your Vulcan to save energy costs to offset a time-of-use energy plan, as a standby/backup system, to save fuel by generator firming, as a solar energy storage system, or a power quality improvement system, there are a few recommendations and specific procedures that must be followed to ensure proper operation and safety.

AC Grid/Shore Power

AC grid/shore power is a source of 120Vac, 60Hz, sine wave alternating current that provides energy to power AC loads. This source is usually the utility grid (power company) or an AC generator. An automatic or manual AC source selector switch can be used to switch between the multiple sources of grid/shore power to the Vulcan. The AC source feeding the Vulcan must have the neutral conductor bonded to ground. When Vulcan passes grid/shore power through, it will lift its internal bonding relay on the output and will rely on the AC input being bonded in order to ensure that the power delivered to a sub panel is properly bonded.

AC Input

The circuit breaker or fuse that is used to supply the Vulcan must be rated at no more than 30A and must be approved for use on 120Vac branch circuits. The wire used between the breaker and the Vulcan input plug must be sized adequately to carry current up to the rating of the input breaker and in accordance with the electrical codes or regulations applicable to your installation.

AC Output

When connecting Vulcan to an AC voltage subpanel, the circuit breaker or fuse must be rated at no more than the rating of the input breaker sourcing the Vulcan AC input and must be approved for use on 120Vac branch circuits. The wire used between the Vulcan and the AC output breaker must be of adequate size to match the AC input circuit breaker's rating. Use a minimum wire size of 12 AWG or 10 AWG. The wiring from each AC output breaker to each of the loads must be adequately sized to carry the current rating of the individual AC output breaker.

Off-Grid Solar Energy Storage

Vulcan may operate using solar panels only to store energy to power AC electrical loads. Depending upon the average AC load measured in watts, a Vulcan system, when combined with adequately sized solar panels that are properly placed and receive the recommended amount of sunlight for storage and load support, can run AC loads perpetually over the lifespan of the Vulcan Inverter-Charger and combined Energy Stores.

1. Determine the 24 hour load requirement = (total load watts * 24)*(inverter efficiency of 0.92) this is the minimum amount of storage required by the Vulcan system. For example, an average AC load of 250W = 6kWh of energy use over 24 hours. Vulcan would need a minimum storage capacity of 6.5kWh to carry the load fully for 24 hours since it is 92% efficient.
2. Determine the solar irradiation period of your location in hours. Maps can be found at the National Renewable Energy Laboratory website³. These are the average representative number of hours that solar panels in any specific region of the Earth can harvest their maximum energy, given ideal conditions. It is recommended that you size your panels appropriately to store 24 hours of energy and run your AC electrical loads over the optimal irradiation time window. With the above example and a winter irradiation period of 4.5 hours, it is recommended that the panels be sized at $((\text{AvLoad} * 4.5) + 6000)/4.5$ or 1,583W.

Figure 7., illustrates a schematic recommendation for an off-grid Vulcan system with power tied into a circuit breaker protected distribution panel. Using one (1) Inverter-Charger and two (2) Energy Stores, the illustrated system in **Figure 7.** will adequately power the example listed above.

³ <https://www.nrel.gov/gis/solar-resource-maps.html>

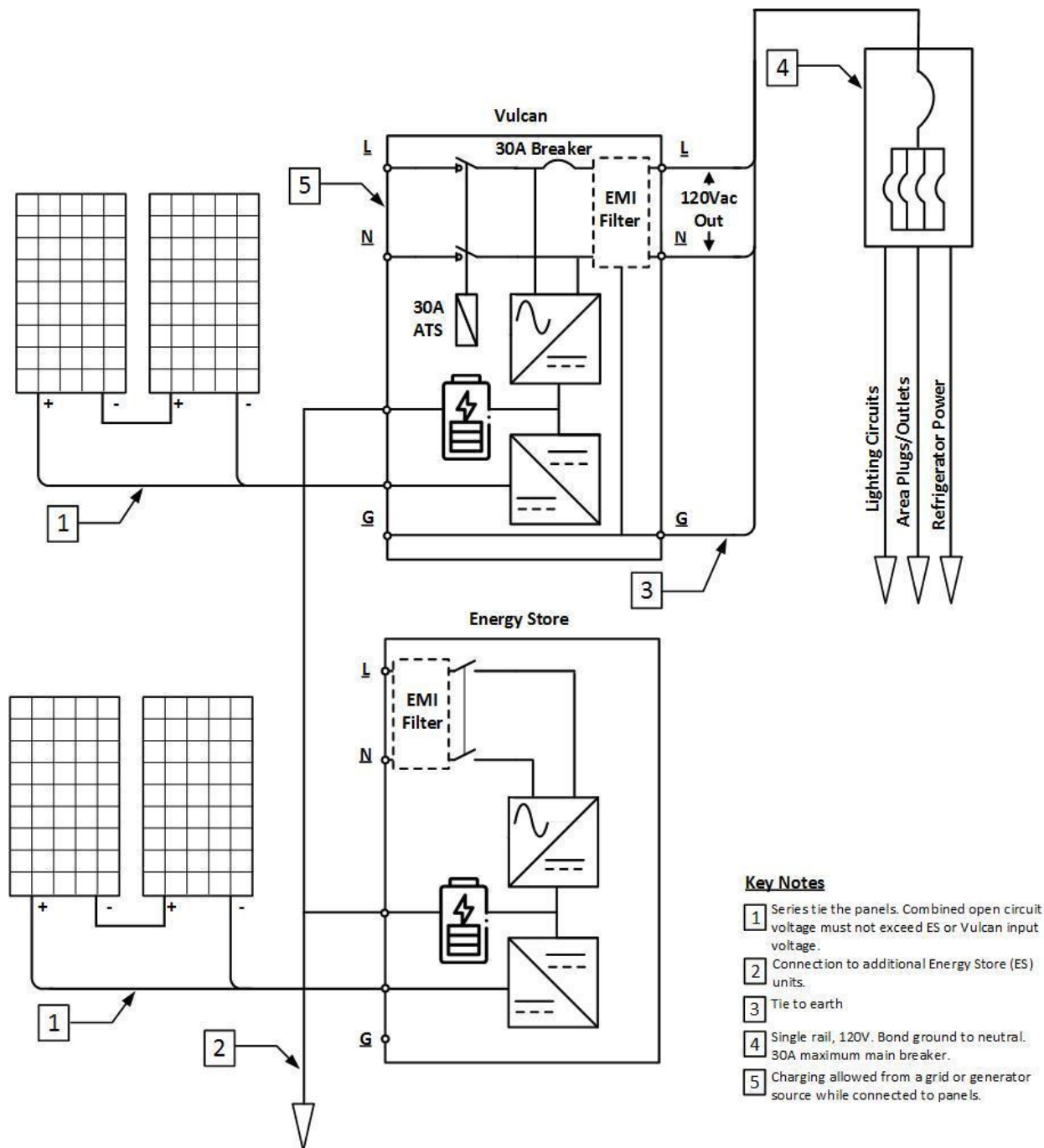


Figure 7. Example solar powered Vulcan system with an electrical panel tie in.

Grid/Shore Standby Power

Most applications of Vulcan units see use as a passive power protection/standby backup to critical loads that run on grid/shore power. In this arrangement, Vulcan can also improve power quality and continuity of operations through EMI filtering and by switching to battery power in the event of a loss or drop of AC voltage. See section General Usage on page 15.

Time-of-Use/On-Peak Electricity Cost Reduction

Under time-of-use (TOU) rate plans, utility customers are charged more for the electricity used during afternoon 'peak' hours when the demand for electricity is higher. The cheapest electricity can be found during 'off-peak' hours when demand is lower. For example, summer off-peak hours might be from 6pm until 2pm the following day because temperatures are lower and fewer people need to cool their living space, creating less demand for electricity.

If you have TOU rates, you can lower your electric bills by waiting for the cheapest time of day to use electricity. For example, using a 7 day digital timer rated at 120V/30A or an outlet timer rated at 120V/15A, **Figure 8.**, you can schedule when to use battery power to run a clothes washer or dishwasher, turn on the lights or charge an electric vehicle. The timer can be set to charge the Vulcan at night during the 'off-peak' hours, depending on your utility's specific rate plan, with an operating life of 10 years or greater. Utilities offer TOU plans to reduce demand on the electric grid by motivating their customers to reduce electricity use during peak hours.

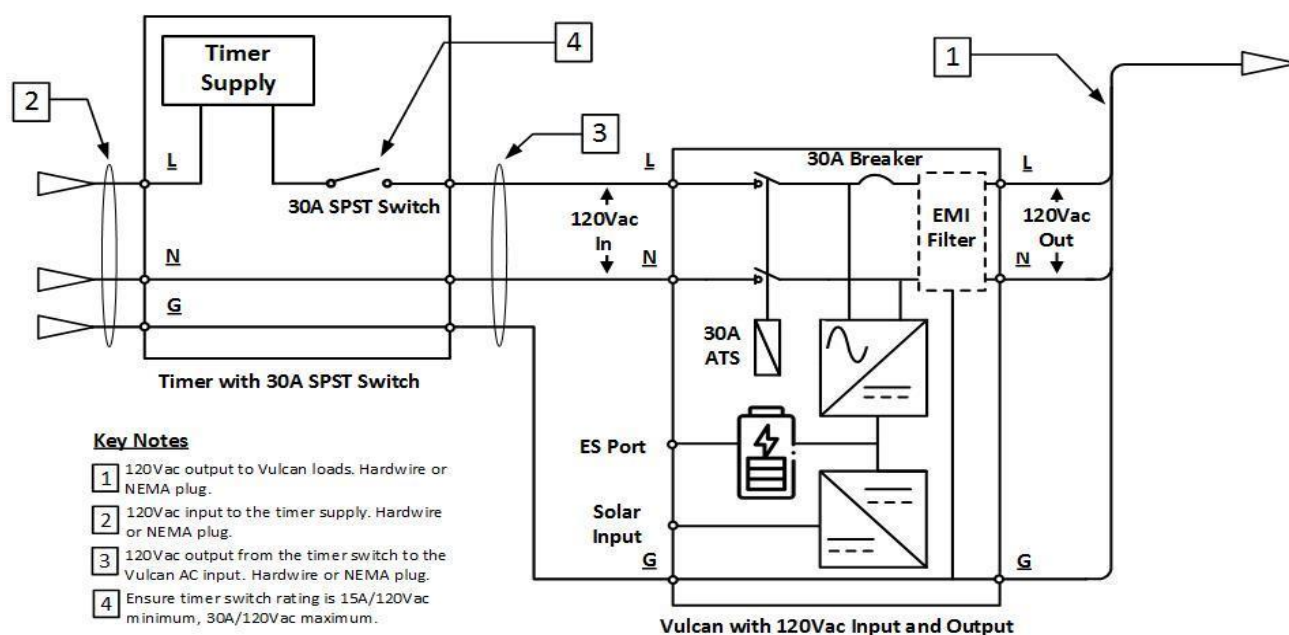


Figure 8. Time-of-Use cost reduction. Add a timer to Vulcan to reduce electricity costs.

Manual/Automatic Transfer Switch Coupling



DANGER

ELECTRICAL SHOCK AND FIRE HAZARD

Installation must be done by qualified personnel to ensure compliance with all applicable installation and electrical codes and regulations. Instructions for installing the Vulcan unit are provided here for use by qualified personnel only.

Failure to follow these instructions will result in serious injury or death.

There are instances where a Vulcan system may be tied into the building infrastructure wiring/circuits that connect to critical loads for backup. When this configuration is desired, Vulcan can be coupled into building circuits using a manual or automatic transfer switch that switches the load between grid/shore power and Vulcan power. The transfer switch has two (2) input connections and one (1) output connection. It connects between the load center/main breaker panel and load wiring, and the Vulcan 120Vac output. **Figure 9.**, illustrates a manual transfer switch configuration schematic suitable for use with the Vulcan system.

In this configuration, a 2kW Vulcan system is connected to a 20A circuit that is fed through its internal 30A automatic transfer switch (ATS). The Vulcan inverter operates in standby mode and will switch to battery power if grid power sags below 90Vac or is lost.

The manual transfer switch has three (3) load power settings:

- **Line:** Feeds grid/shore power to the load circuits
- **Off:** Turns off the load circuits. There is no grid/shore or Vulcan power routed to the circuits in this setting, and;
- **Gen:** Routes power from the Vulcan to the load circuits and energizes them with battery power upon a loss of or drop in AC voltage. This can take place in as little as 10ms.



CAUTION

Do not exceed the maximum continuous load output of the Vulcan unit. Do not exceed the maximum service input breaker rating: 2kW = 20A, 3kW = 30A maximum.



Generator Firming/Fuel Conservation

Firming up a generator fuel supply means guaranteeing energy from other sources to conserve fuel. Vulcan can work in conjunction with a gasoline generator as a hybrid solution to simultaneously pass through AC voltage from the generator to run the generator loads and charge batteries, **Figure 10**. When the battery reaches 100%, the generator is no longer needed and can be shut down to conserve fuel reserves. This configuration provides better power quality through its EMI Filter and voltage sag protection. It can also incorporate solar panels as illustrated in **Figure 7**. for a fully renewables supported hybrid power system.

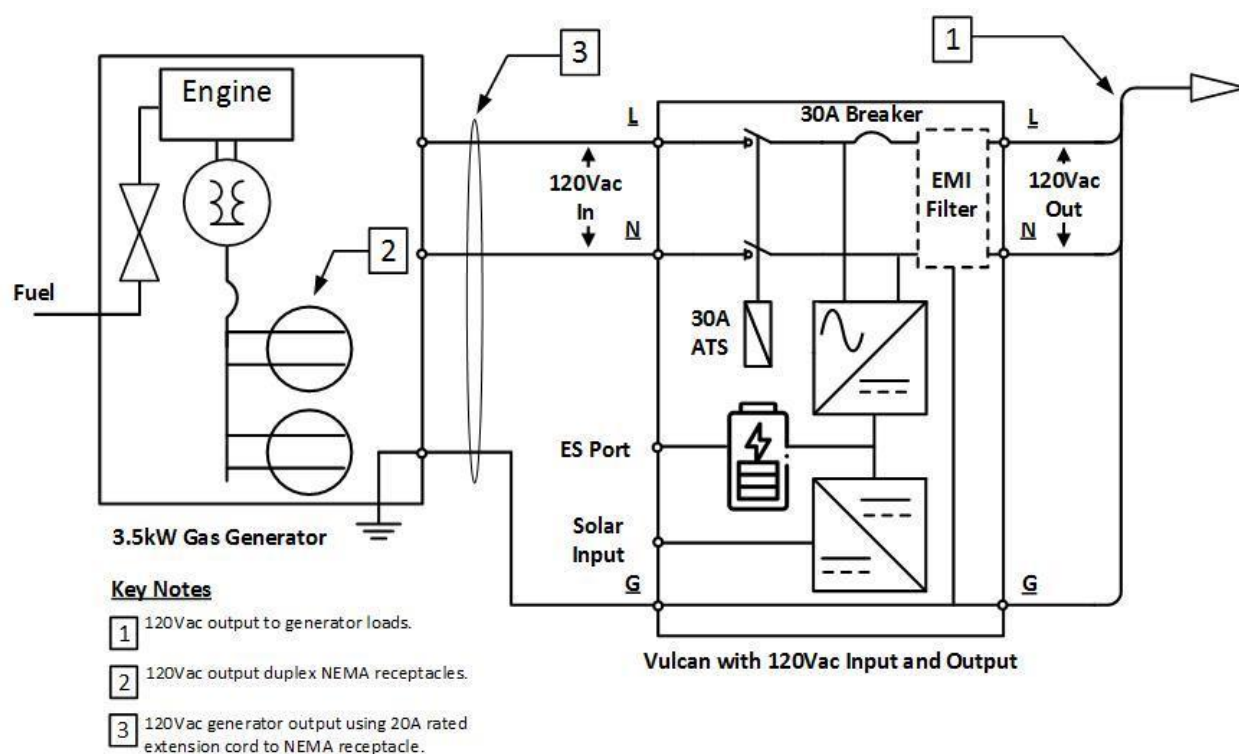


Figure 10. Generator firming to conserve fuel reserves.

UPS Redundant Power Source

Extend UPS power outage runtime reserves from minutes to hours or days by stacking a high capacity Vulcan system in front of a .3kVA - 3kVA UPS. Vulcan systems can be configured up to 100kWh of battery storage, which provides up to 46 hours of battery runtime when coupled with a 2kVA UPS.

Autotransformer Coupling



DANGER

ELECTRICAL SHOCK AND FIRE HAZARD

Installation must be done by qualified personnel to ensure compliance with all applicable installation and electrical codes and regulations. Recommendations for installing the Vulcan unit are provided here for use by qualified personnel only.

Failure to follow these instructions will result in serious injury or death.

Autotransformers are induction devices that can step-up the 120Vac output from Vulcan to a split-phase 120V/240Vac output. A 3 - 5kVA dry-type transformer is recommended if a 4 wire service is needed (2 hot, 1 neutral, 1 ground) to output 240Vac with two 120Vac rails, **Figure 11**.

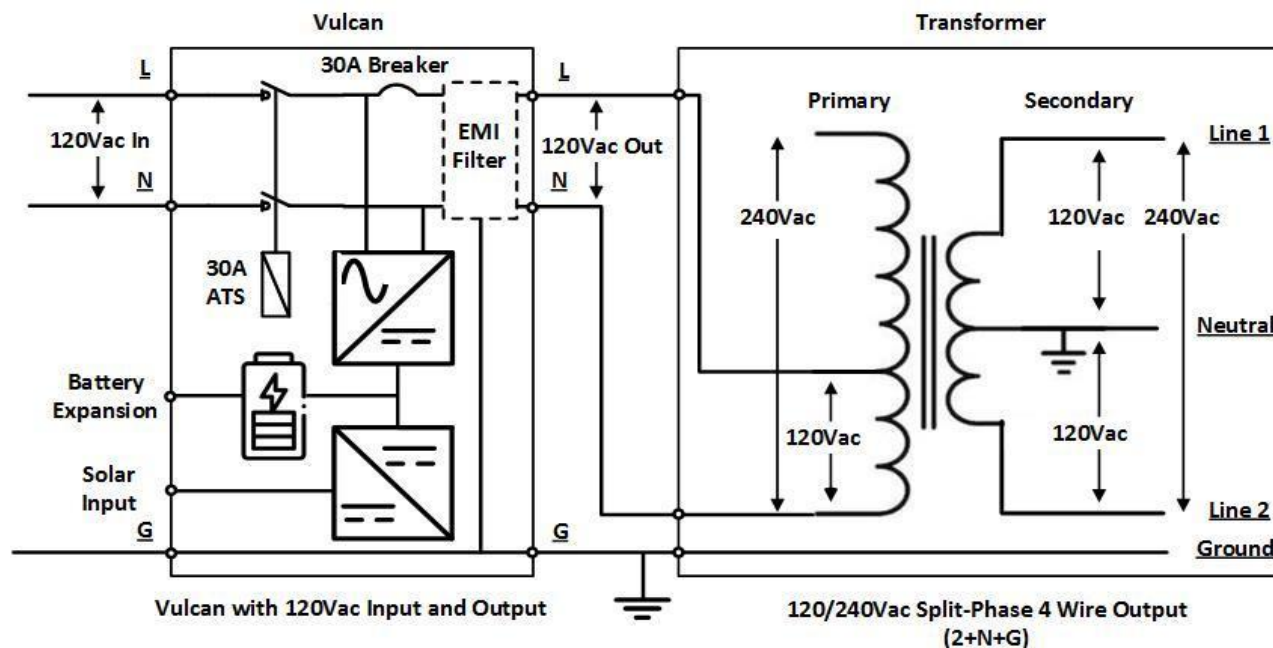


Figure 11. Vulcan step-up transformer connections.



CAUTION

Bond Neutral and Ground at the distribution panel.

External Battery Connections



CAUTION

PHYSICAL INJURY HAZARD

This Vulcan unit is not intended for use by persons (including children) with reduced physical, sensory, or mental capabilities or lack of experience and knowledge, unless they have been given supervision or instruction concerning use of the appliance by a person responsible for their safety. Children should be supervised to ensure that they do not play with the appliance.

Failure to follow these instructions can result in injury or equipment damage.

Vulcan is designed to work with the Sol Donum™ Energy Store and Smart Store expansion batteries. They incorporate short circuit, overvoltage, undervoltage, and temperature protections and an ORing Diode circuit that allow Vulcan systems to scale up to 100kWh of energy capacity.

IMPORTANT NOTE: Vulcan is not compatible with recharging from other 12Vdc sources. This can result in damage to the unit and cables, as well as your vehicle or 12Vdc charging source.

Energy Stores

Energy Stores are batteries that are used to expand Vulcan's battery capacity for greater load runtimes. They are hot-swappable, meaning that they can be plugged into and unplugged from a Vulcan unit at any time while the Vulcan is powered up or powered down. They are connected in a daisy chain using the Sol Donum™ supplied 'Power Bus' expansion cables to provide additional battery power to Vulcan units. The Smart Store can self-charge from solar panels or grid/shore power, which increases overall Vulcan system solar and grid/shore input power to reduce charging times and increase the AC load that can be covered by solar panels energy harvesting.



CAUTION

Always connect Power Bus cables to the appropriate color coded ports between units. Never cross or short circuit the **RED** and **BLACK** cable connections.

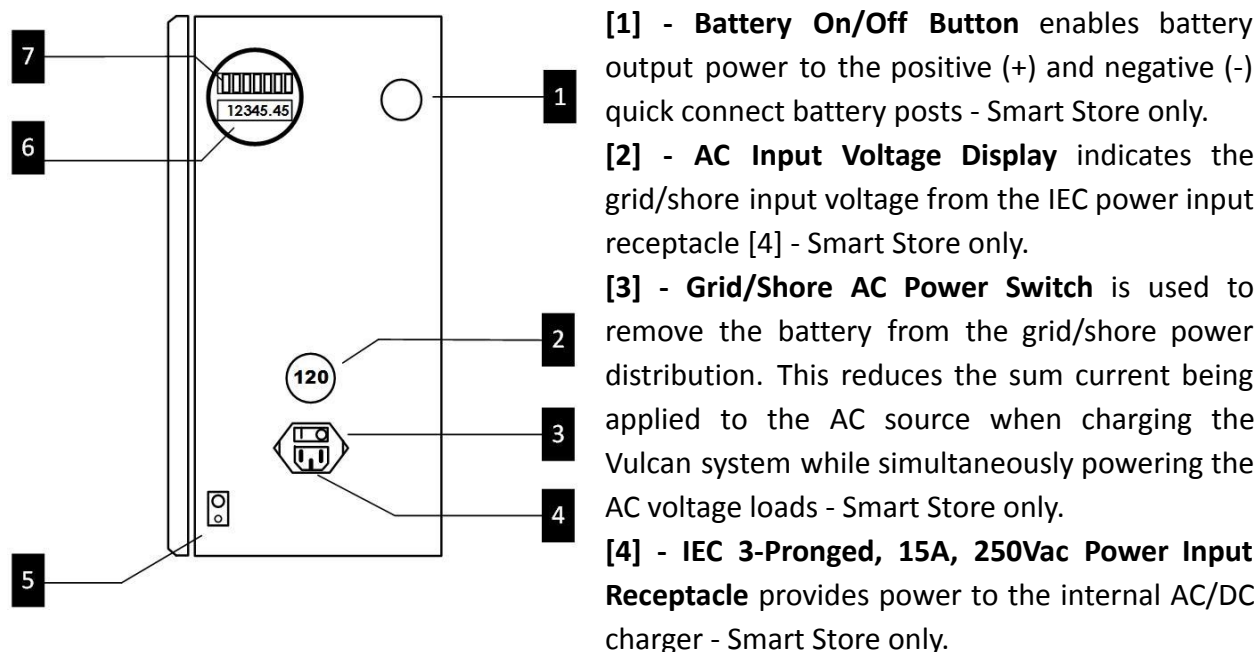


Figure 12. Energy Store front panel configuration.

[5] - **Earth Ground Lug** is connected to an earth ground stake when additional radio frequency/electromagnetic interference protection is required - Smart Store only.

[6] - **Time in Service Display** indicates the number of hours the battery has been in service. The average lifespan to 80% is 87,600 hours (10 years).

[8] - **Battery State of Charge** is an LED bargraph display that shows the state of battery charge. It is updated every six (6) minutes. As the battery's state-of-charge decreases, successive LEDs light up, one at a time from right to left. The right LED (blue) will remain illuminated when the battery is 90% - 100% full. The leftmost 2 LEDs will flash indicating 'empty' (80% depth of discharge).

NOTICE

NOTICE: When the Battery On/Off Button, **Figure 12. [1]**, is switched off, the Energy Store will not provide output power to the battery posts, **Figure 13. [2], [3]**. However, the internal ORing Diode will allow power to flow one way into the battery to charge it.

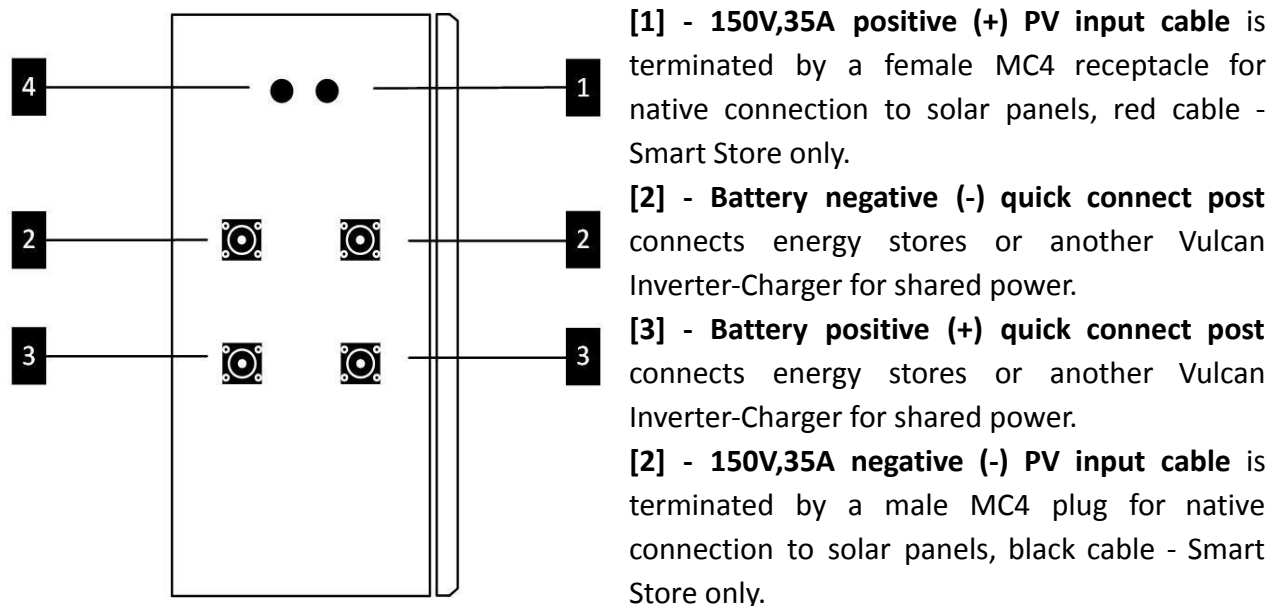


Figure 13. Energy Store rear panel configuration.

Charging

CHARGE NOW: Before using or storing, plug your Energy Store into a Vulcan to charge it. If this is a Smart Store and will not be plugged into a Vulcan system right away, then plug it into an grid/shore power AC voltage source such as a wall outlet using the supplied IEC power cord or solar panels until the unit is fully charged. If using a grid/shore power AC voltage source, ensure that the power switch, **Figure 12. [3]**, is switched on.

NOTICE

NOTICE: Once the Energy Store is fully charged, the battery state-of-charge display will indicate Full.

Charging Smart Stores from Solar Panels



DANGER

ELECTRICAL SHOCK AND FIRE HAZARD

Installation must be done by qualified personnel to ensure compliance with all applicable installation and electrical codes and regulations. Recommendations for installing the Vulcan unit are provided here for use by qualified personnel only.

Failure to follow these instructions will result in serious injury or death.

IMPORTANT NOTE: Do not exceed 150VDC/35A or 500W input into the MC4 cables. Doing so will cause damage to the unit and potential bodily injury. For questions about solar charging and the proper way to set up your solar panels, email our solutions team at info@soldonum.com.

Smart Stores incorporate a device called a solar charge controller, which uses a maximum power point tracking (MPPT) algorithm. It actively monitors the energy source you're using to charge the Smart Store LiFePO4/LFP battery by optimizing the source to maximum output power. Solar panels must have a minimum open circuit voltage of 22Vdc to activate the charge controller.

Smart Stores accept power from solar panels into the **RED** and **BLACK** rear panel cables that are terminated with MC4 connectors, **Figure 6**. The connectors are keyed to plug directly into native solar panel cables without special adapters. The combined input power maximum is 500W.

1. Place the solar panels where they will get as much direct sunlight as possible.

NOTICE

NOTICE: Up to 100 ft of 10 AWG cable may be used between the Vulcan and the source solar panels.

2. Plug the solar panel cables into the MC4 connectors, **Figure 6**., at the rear of the Vulcan unit. Vulcan is charging when the LCD display backlight is flashing. The Vulcan is fully charged when the battery percentage indicator, **Figure 5. [1]**, displays 100%.
3. Solar panels should be connected in series for optimal charging performance. **Do not exceed 150VDC/35A or 500W of input power to the charge controller.**

Considerations for Extending Vulcan Battery Capacity

When mapping out your Vulcan system and the amount of battery capacity required to meet your needs, consider the job that the Vulcan system must accomplish (amount of continuous output power) and the number of hours that your equipment is required to run. Those are the primary considerations for initially sizing, adding more battery capacity and the type of Energy Store(s) to consider.

Battery Runtime Calculations

When running on battery power, the Vulcan Inverter-Charger uses a small amount of battery energy to convert DC voltage to an AC voltage sine wave. The energy cost is 8% - 8.5% of the battery energy used for the power conversion. This is used to calculate the number of hours the Vulcan system can run loads from its AC voltage output.

EXAMPLE: A 21 cu. ft. Energy Star refrigerator uses an average of 71 watts every hour (71Wh or 0.071kWh). The formula to derive the number of hours that a 5kWh Vulcan system can run the refrigerator until the battery is depleted is:

1. Divide the Vulcan system capacity (5kWh) by the load watts = $5000/71 = 70.4$ hours
2. Multiply total hours (70.4) by the lowest Vulcan efficiency of 92% (100% - 8%)
3. Actual runtime hours = $70.4 * 0.92$ for a total of 64.7 hours

This formula can be used to calculate the number of hours that a Vulcan configuration can run devices plugged into its AC voltage output: $(\text{system size}/\text{total watts of load}) * 0.92$

Battery Discharge Graph

The rate-of-discharge graph, **Figure 14.**, illustrates the amount of runtime hours until the Vulcan battery state-of-charge reaches the cutoff point. The graph illustrates load runtimes using a standalone Inverter-Charger (1.4kWh) compared to 5kWh and 8.6kWh system configurations. Use the graph to gain a visual understanding of the number of runtime hours by load watts that can be achieved when battery capacity is increased. Additional runtime hours can be achieved by adding more Energy Stores to your system.

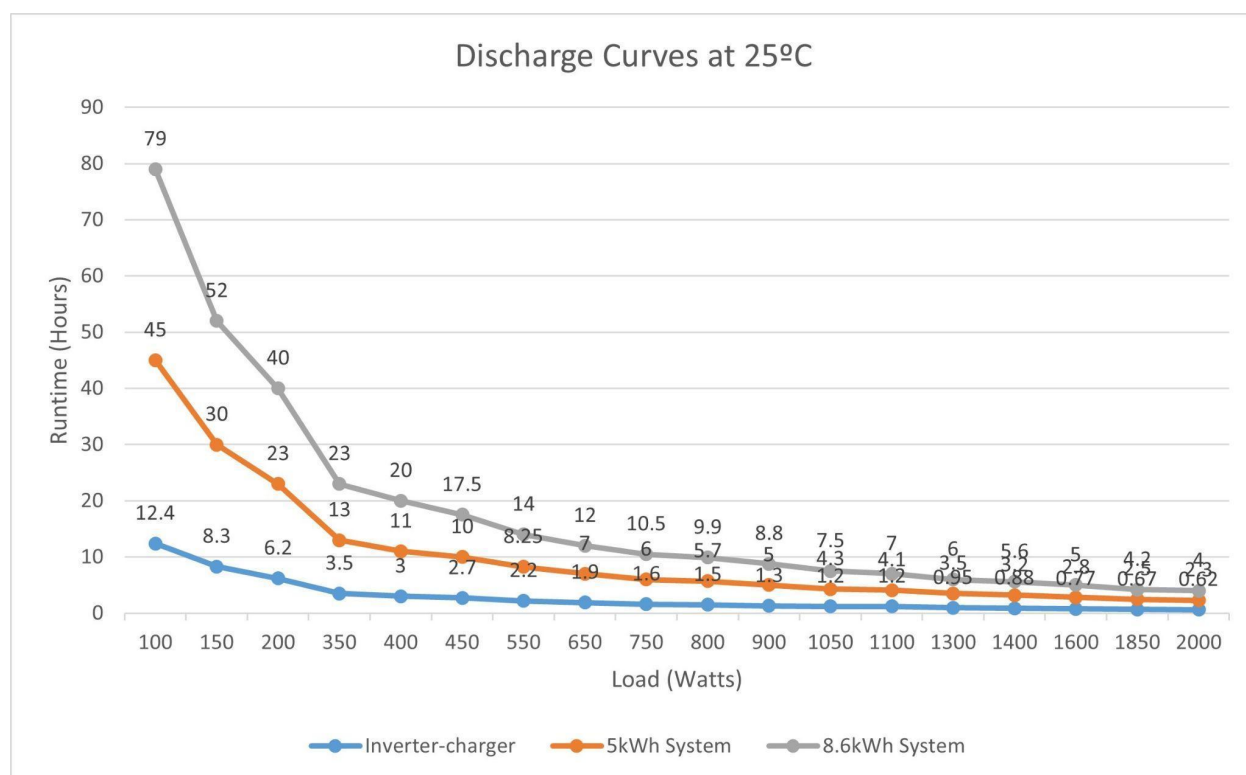


Figure 14. Example battery discharge times.

NOTICE

NOTICE: Calculate system runtimes by multiplying Vulcan system kilowatt hour (kWh) capacity by its inverter efficiency (0.92) and dividing by the load wattage requirement (W).

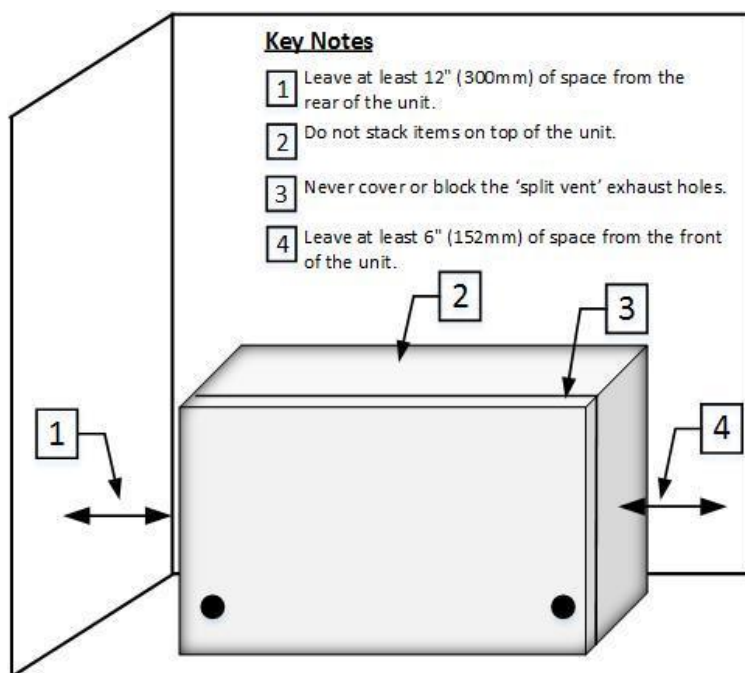
Installation

NOTICE

NOTICE: No tools are required to install, wire or configure the Vulcan units.

General Guidelines

The following criteria applies to the installation of Vulcan units within an open or confined space, **Figure 15.**:



[1], [4] - Leave adequate area around the front, top and rear of the unit to maintain proper ventilation.

[2] - Do not stack or cover the unit with another object.

[3] - Do not tape, cover, or block the 'split vent' exhaust holes.

Refer to section Cold Weather and Outdoor Usage on page 20 for further guidance.

Figure 15. Vulcan physical space considerations.

Rack Mounting

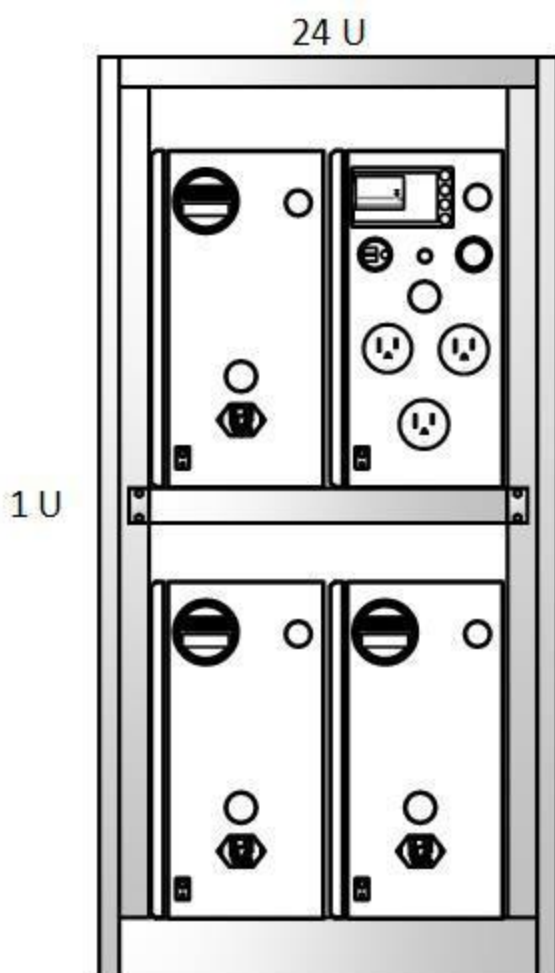


CAUTION

PHYSICAL INJURY HAZARD

This Vulcan unit is not intended for use by persons (including children) with reduced physical, sensory, or mental capabilities or lack of experience and knowledge, unless they have been given supervision or instruction concerning use of the appliance by a person responsible for their safety. Children should be supervised to ensure that they do not play with the appliance.

Failure to follow these instructions can result in injury or equipment damage.



Vulcan and energy Store units feature a narrow design that is suitable for rack mounting. **Figure 15.** illustrates a 12.2kWh Vulcan system placed into a 42', 24U equipment rack using a 1U mounting tray. Connections can be made front and back for all input and output power.

Specific Cautions

1. Ensure proper ventilation when doors are attached to the rack, allowing for air to be exhausted at the top of the rack or top of the front door.
2. Properly secure the rack to mitigate any tipping hazard.
3. Use a 1U mounting shelf that has a load capacity of at least 150 lbs and secure it firmly to the rack mounting rails.
4. Leave adequate maintenance loops on all cables into and out of the Vulcan unit.

Figure 15. Example rack mounting configuration.

Storage and Downtime Maintenance

Having your Vulcan connected to a power source, such as solar panels or wall plug while in storage keeps its battery healthy and topped off. This prolongs battery life and will ensure your Vulcan is charged and ready to power loads at any time.

NOTICE

NOTICE: If you cannot keep your Vulcan plugged into a power source during storage, fully-charge your Vulcan every 3 months and store it in a cool, dry place. Failure to maintain your Vulcan by following these steps can result in battery damage which will void the product warranty.

Inverter-Charger Technical Data

Parameter	Vulcan 120	Vulcan 120 PRO	Vulcan 240
AC Output Power Rating	Single-Phase 120Vac, 2kW/3kW, 50Hz/60Hz, 4kW/6kW Peak		Single-Phase 240Vac, 2kW, 50Hz/60Hz, 4kW Peak
Inverter Efficiency	92%		91%
Power Factor	0.9 - 1.0		
Transfer Switch Rating	30A		
Transfer Switch Speed	10ms/20ms		
Inverter DC Cutoff	11.2V		
Low AC Voltage Cutover	80Vac - 108Vac		170Vac - 220Vac
MPPT Charge Controller ⁴	150Vdc @ 35A (500W)		
AC-to-DC Charger	Power Factor Corrected 120Vac/250Vac @ 360W		
Advanced BMS Type	200A, 10.8V Cutoff, Hi/Lo Temp, Overcurrent & Short Circuit Protection		
Internal Battery Type	1.4kWh Lithium Iron Phosphate (LiFePo4)		
Useful Battery Capacity	97Ah/1.236kWh		96Ah/1.223kWh
Scalable Battery Capacity	5kWh - >100kWh		
AC Output Receptacle Type	3 - NEMA 5-15R/5-20R/ 4 - Cooper Red, NEMA 5-20R Hospital Grade ⁵	1 - NEMA L5-30R, 3 - NEMA 5-20R	1 - NEMA L6-30R
AC Input Plug Type	1 - NEMA 5-15P/5-20P	1 - NEMA L5-30	1 - NEMA L6-30P
Solar Input Connection	2 - MC4 Terminated, 8' 10 AWG Cables		
Battery Expansion	Yes. Hot swappable with 180A Quick Connectors.		
Optional Voltage Configurations	108, 110 & 120V @ 50Hz/60Hz		5kVA Transformer 120V/240V, 50Hz/60Hz
Expansion Connector	Amphenol 180A/1000V Heavy Duty Power Connector, ATHP041P08NN-50		
Cooling	2 - Variable and 2 - Fixed Speed DC Fans		
Operating Temperature	-20°C/-4°F to 122°F/50°C, with output derated above 104°F (40°C)		
Heating Option	20W Heating Element: On @ 5°C/41°F, Off @ 15°C/60°F		
Design Life	10 Years		
Ingress Protection	IP50		
Dimensions	25'D x 15.75'H x 8.27'W (635mm x 400mm x 210mm)		
Weight	55lbs		

⁴ 650W (150V/45A) Charge controller upgrade or charge controller delete is available upon request.

⁵ Heavy duty Cooper, red, hospital grade 20A receptacles with 20A inlet plug available upon request.

Energy Store Technical Data

Parameter	ES & SES 2.6	ES & SES 3.6
Internal Battery Type	Lithium Iron Phosphate (LiFePo4)	
Battery Capacity	206Ah/2.6kWh	280Ah/3.6kWh
Advanced BMS Type	200A with Cell Balancing and Overcurrent, Short Circuit, Charging and Temperature Protections	
Nominal Voltage	12.8V	
Max Charge Current	200A (1C)	200A (0.7C)
Max Discharge Current	200A (1C)	200A (0.7C)
BMS Low Voltage Cutoff	10.8V	
Design Life	10 Years	
Charge/Discharge Cycles	5000	
Charging Temperature	0°C/32°F to 50°C/122°F, -12°C/10°F with Heating Option	
Ingress Protection	IP54	
Strap Configuration	Series or Parallel Tied	
Terminal Type	Amphenol 180A/1000V Heavy Duty Power Connector, ATHP041P08NN-50	
Hot Swappable	Yes	
MPPT Charge Controller ⁶	SES - 150Vdc @ 35A (500W)	
AC-to-DC Charger ⁷	SES - Power Factor Corrected 120Vac/250Vac @ 360W	
Solar Input Connection ⁸	SES - 2 - MC4 Terminated 8' 10 AWG Cables	
Cooling	ES - Passive, SES - Fixed Speed DC Fan, On @ 32°C/90°F	
Operating Temperature	-20°C/-4°F to 122°F/50°C	
Heating	Optional 20W Heating Element: On @ 5°C/41°F, Off @ 15°C/60°F	
Dimensions	25'D x 15.75'H x 8.27'W (635mm x 400mm x 210mm)	
Weight	50lbs	60lbs
Mounting Options	Rack Tray/Standalone	

⁶ 650W, 860W & 1000W (150V/70A) Charge Controller upgrades or charge controller delete are available upon request.

⁷ Available on Smart Store models only.

⁸ Available on Smart Store models only.

Troubleshooting

Issue	Procedure/Remedy
Vulcan - Blank LCD display, no AC output power and power button light not illuminated.	<p>Vulcan's battery management system (BMS) has shutdown Vulcan due to a low battery voltage from discharge. The battery needs to be recharged.</p> <ol style="list-style-type: none"> 1. Plug the Vulcan into an AC power source at the AC input plug located at the back of the unit or, 2. Attach solar panels with a <u>minimum open circuit voltage of 22Vdc</u> to the MC4 connector plugs, Figure 5. 3. If the system does not recharge, contact support@soldonum.com
Vulcan - No AC voltage output displayed and no voltage at the output receptacles.	<p>Turn on the power on/off button located at the upper left of the enclosure. The button will illuminate with a green glow and the voltage display will activate after 10 seconds. If this does not solve the issue proceed to the following segment.</p> <p>The Vulcan system is experiencing one of the following conditions:</p> <ul style="list-style-type: none"> ● Inverter Low Battery Cutoff condition. In order to preserve battery capacity, the <u>AC output power will shut off when the battery voltage discharges down to 11.2Vdc</u>. Recharge the system to clear the condition. ● Inverter overload condition. Vulcan has a built-in automatic restart on an output overload. However, If the inverter is shutdown and does not restart, remove the load and cycle the power on/off button. The output power will be restored. ● Power save mode. The AC output will shutdown after 25 hours of no-load/idle. The power on/off button must be cycled to restart.
System not charging from solar panels.	<ul style="list-style-type: none"> ● Check the connections and cabling between the solar panels and the Vulcan/Smart Store MC4 connectors. ● Ensure the Vulcan is not fully charged. If the battery is fully charged then the charge controllers will not harvest energy from the solar panels. A load must be added in order to activate charge controller energy harvesting. ● Ensure the solar panels have a <u>minimum open circuit</u>

	<p><u>voltage of at least 22Vdc to activate the charge controller.</u></p> <ul style="list-style-type: none"> • Ensure the total open circuit voltage of the panel array does not exceed 150Vdc. <u>Excessive voltage will place the charge controller into an overvoltage fault condition.</u> This can be cleared by unplugging the solar panels and reducing the number of panels tied together. • Ensure that the AC load on the Vulcan does not exceed the power output of the solar panels while they are producing DC power from the sun. If the system load exceeds the panel output at any given time, all panel energy will be used to produce power for the AC loads.
System not charging from the grid/shore power source.	<ul style="list-style-type: none"> • Check the grid/shore power supply circuit and breakers to ensure 120Vac is being provided to the Vulcan/Smart Store. • If the supply breaker trips when the power restores and loads are present, turn off the power switch at the front of the Smart Store(s) to reduce the load circuit current. • If grid/shore power is present, check the plug connection at the rear of the Vulcan unit and the plug connection at the front of the Smart Store. Ensure the Smart Store AC power switch is on.
Smart Store power share not being seen by the Vulcan.	<ul style="list-style-type: none"> • Ensure that the Smart Store battery power on/off button is depressed and illuminated. This will parallel balance the Smart Store battery with the Vulcan system.
Low battery percentage on the Vulcan unit.	<ul style="list-style-type: none"> • The Vulcan unit needs to be charged from a grid/shore power source, Solar panels or a fully charged Energy Store or Smart Store.
Low state-of-charge on the Energy Store and/or Smart Store units.	<p>The state-of-charge display is flashing a red or yellow LED to indicate that the state-of-charge is 20% or less:</p> <ul style="list-style-type: none"> • Connect the Smart Store to a grid/shore AC power source. • Connect the Smart Store to solar panels with adequate sun and placement. • Connect the Energy Store and/or Smart Store to a Vulcan unit. Ensure that the Vulcan power on/off button is depressed and illuminated. This will charge the Energy Store and/or Smart Store.

General Information

Batteries

Vulcan utilizes the latest Lithium-ion Iron Phosphate battery technology. These batteries are safer than NMC chemistries and have a 10 year lifespan at 5000 cycles. However, following the recommendations listed below will ensure the longest battery life from your Vulcan system.

- Batteries need to be used. The best thing for any battery is to use it. Do not leave the battery sitting without being charged for extended periods of time. If the Vulcan unit will be stored without a charger, make sure it's fully charged before you put it away.
- A lithium battery's operating voltage and charging capacity can decrease at temperatures below 0°C/32°F. Avoid storing the Vulcan units in cold temperature when the unit is not in use, refer to section Cold Weather and Outdoor Usage on page 20.
- Read this manual. It's a long read, but this manual is the best place to find the dos and don'ts for the Vulcan battery. Reading your manual will ensure you're taking steps to keep your batteries in top operating condition.

Solar Panels

Vulcan makes it easy to recharge your system from the sun. Keep in mind the following information when recharging your system with solar power.

- Solar panels do not store power from the sun, they collect it. Use solar panels to collect/harvest the sun's energy. Store the energy in a Vulcan battery. Use the stored energy to power your devices, day or night.
- Not all solar charge times are created equal. Most solar panel manufacturers calculate their recharge times with the following equation: Device Watt Hours/Solar Panel Watts = Solar Recharge Times. So theoretically, a 150 watt solar panel would recharge a 600 watt-hour battery in 4.0 hours ($600/150 = 4$). However, on a good sunny day you'll receive approximately 50-75% of your solar panel's rated wattage.
- Solar panels work even in overcast conditions. Solar panels use Infrared, Ultraviolet, and visible rays from the sun that can penetrate through clouds. Although the efficiency of the solar panel will decrease in cloudy conditions, the panels will still harvest energy from the sun.

- Keep solar panels away from shade and windows. Solar panels are more efficient and will harvest more energy when fully exposed to sunlight. Windows will also decrease solar panel efficiency.
- Proper solar panel alignment harvests the greatest amount of energy from the sun. Keeping your solar panel angled toward the sun can dramatically increase solar efficiency.
- Solar panels are more efficient when they are kept cool. Solar panels should always be elevated to allow airflow underneath them for the greatest efficiency. The exceptions are flexible panels but they should be mounted to a surface that will allow for the greatest amount of heat transfer.

Warranty & Contact

LIMITED WARRANTY

Sol Donum™ warrants to the original consumer purchaser that this Vulcan product will be free from defects in workmanship and material under normal consumer use during the applicable warranty period identified in Paragraph 2, below, subject to the exclusions set forth in Paragraph 5, below. This warranty statement sets forth Vulcan's total and exclusive warranty obligation. We will not assume, nor authorize any person to assume for us, any other liability in connection with the sales of our products.

WARRANTY PERIOD

The warranty period for Sol Donum™ products (whether purchased on a stand-alone basis or as part of another system) is three years from the date of the original purchase; and the Vulcan products will retain energy capacity of 80% at 10 years following the date of the original purchase. In each case, the warranty period is measured starting on the date of purchase by the original consumer purchaser. The sales receipt from the first consumer purchase, or other reasonable documentary proof, is required in order to establish the start date of the warranty period.

REMEDY

Sol Donum™ will repair or replace (at Sol Donum's option and expense) any Vulcan product that fails to operate during the applicable warranty period due to a defect in workmanship or material. If the product fails to comply with the Warranty, Seller will, in its sole discretion, either (1) repair the product at no charge, using new or refurbished replacement parts, or (2) exchange the Products with equivalent products (new or refurbished). If the product is repaired or replaced under the Warranty, the remainder of the original warranty period will apply to the repaired or replacement product. When a product or part is exchanged, any replacement item becomes property of the consumer and the replaced item becomes property of Sol Donum™. This warranty is not transferable to any subsequent owner of the product.

LIMITED TO ORIGINAL CONSUMER BUYER

The warranty on Vulcan products is limited to the original consumer purchaser and is not transferable to any subsequent owner.

EXCLUSIONS

This warranty does not apply to: (i) to damage caused by accident, abuse, misuse, misapplication, negligence, force majeure events, or non-Seller products; (ii) to damage caused

by service performed by anyone other than the Seller; (iii) to a product or a part that has been modified without the written permission of the Seller; (iv) to a product where any Seller serial number has been removed or defaced, or (v) to any product purchased through an online auction house. Sol Doum's warranty does not apply to any battery cell or product containing a battery cell unless the battery cell is fully charged by you within seven (7) days after you purchase the product and at least once every 6 months thereafter.

HOW TO RECEIVE SERVICE

To obtain warranty service, you must contact our customer service team via email at **support@soldonum.com**. If our customer service team determines that further assistance is required, they will give you a Return Material Authorization ('RMA') number and will provide you with a prepaid return shipping label that you can use to mail back your non-functioning item(s). You must properly package the product, clearly marking the RMA number on the package and including proof of your purchase date with the product. We will process your return and send your repaired or replacement product to you at our expense for product being shipped to locations in North America. For products purchased or being shipped outside of North America, please contact the local distributor from whom you purchased the product or email **support@soldonum.com** to obtain further distributor information.

IMPLIED WARRANTIES

THE LIMITED WARRANTY STATED HEREIN IS IN LIEU OF ALL OTHER EXPRESS WARRANTIES. IN NO EVENT SHALL ANY IMPLIED WARRANTIES, INCLUDING BUT NOT LIMITED TO ANY WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT, EXTEND BEYOND THE APPLICABLE WARRANTY PERIOD IDENTIFIED IN PARAGRAPH 2, ABOVE. Some states do not allow limitations on how long an implied warranty lasts, so the above limitation may not apply to you. This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

EXCLUSIVE REMEDY; LIMITATION OF LIABILITY

The foregoing provisions state Sol Donum's entire liability, and your exclusive remedy, for any breach of warranty, express or implied. IN NO EVENT WILL Vulcan BE LIABLE FOR ANY CONSEQUENTIAL OR INCIDENTAL DAMAGES ARISING FROM ANY USE OR MALFUNCTION OF ANY Vulcan PRODUCT, OR FROM ANY BREACH OF WARRANTY, INCLUDING DAMAGE TO OTHER DEVICES. IN NO EVENT WILL Vulcan's LIABILITY FOR ANY CLAIM, WHETHER IN CONTRACT, WARRANTY, TORT (INCLUDING NEGLIGENCE AND STRICT LIABILITY) OR UNDER ANY OTHER THEORY OF LIABILITY, EXCEED THE AMOUNT PAID BY YOU FOR THE Vulcan PRODUCT. Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.