samlexpower®

Evolution® Series Inverter/Charger
Pure Sine Wave

Models:
EVO-2212E
EVO-3012E
EVO-2224E
EVO-4024E

For use with 230 VAC Models

Owner's Manual

Please read this manual BEFORE operating your device.

Firmware:
Rev 0.82

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SECTION 1 | Safety Instructions & General Information

1.1 IMPORTANT SAFETY INSTRUCTIONS

SAVE THESE INSTRUCTIONS. THIS MANUAL CONTAINS IMPORTANT INSTRUCTIONS FOR MODELS: EVO-2212E, EVO-2224E, EVO-3012E, EVO-4024E THAT SHALL BE FOLLOWED DURING INSTALLATION & MAINTENANCE OF THE INVERTER/CHARGER.

THE FOLLOWING SYMBOLS WILL BE USED IN THIS MANUAL TO HIGHLIGHT SAFETY AND IMPORTANT INFORMATION:



WARNING!
Indicates possibility of physical harm to the user in case of non-compliance.



CAUTION!
Indicates possibility of damage to the equipment in case of non-compliance.



INFO
Indicates useful supplemental information.



AVERTISSEMENT !
Il y a une possibilité de faire du mal physique à l'utilisateur si les consignes de sécurités sont pas suivies.



ATTENTION !
Il y a une risque de faire des dégâts à l'équipement si l'utilisateur ne suit pas les instructions.

Please read these instructions BEFORE installing or operating the unit to prevent personal injury or damage to the unit

---

 **WARNING! /**  **CAUTION!**

1. **WARNING!** To reduce risk of explosion, do not install in machinery space or in area in which ignition-protected equipment is required to be used.

2 **CAUTION!** (a) To prevent damage due to excessive vibration/shock, use on marine vessels with lengths more than 65 ft. (19.8M). (b) This unit is NOT designed for weather-deck installation. To reduce risk of electrical shock, do not expose to rain or spray.

3.1 **CAUTION!** EVO® Inverter/Charger with fully automatic charging circuit charges properly rated 12 V / 24 V Lead Acid, Nickel Zinc (Ni-Zn) and Lithium Ion Batteries. When EVO® Inverter/Charger is in Charge Mode, Green LED marked "ON" will be blinking.

3.2 **WARNING! Lithium Ion Battery Hazard**. Option is available to use 12 V / 24 V nominal Lithium Ion batteries. The user/installer should ensure that charging voltages, currents and profiles are programmed appropriately to meet all operating and safety requirements of the battery being used. Make sure that the Lithium Ion Battery includes Battery Management System (*BMS*) with built-in safety protocols. Follow the instructions specified by the Lithium Ion Battery manufacturer. When the EVO® Inverter/Charger is in Charge Mode, Green LED marked "ON" will be blinking.

4. **CAUTION!** For indoors use only.
5. **CAUTION!** Hot Surfaces! To prevent burns, do not touch.
6. **CAUTION!** The AC input/output wiring terminals are intended for field connection using Copper conductors that are to be sized based on 70 °C / 158 °F . See Tables 3.2.1, 3.2.2 and 3.2.3 for sizing of conductors for AC INPUT circuits and Table 3.3 for sizing of conductors for AC OUTPUT circuits.
7. **WARNING!** Over current protection (*AC Breakers*) for the AC input/output circuits has NOT been provided and has to be provided by the installer/user. See guidelines at Tables 3.2.1, 3.2.2 and 3.3.3 for sizing of breakers for AC INPUT circuits and Table 3.3 for sizing of breakers for AC OUTPUT circuits. National and Local Electrical Codes will supersede these guidelines.
8. **CAUTION!** The battery terminals are intended for field connection using Copper conductors that are sized based on 90°C. See Table 3.1 for recommended sizes for installation.
9. **WARNING!** Over current protection (*Fuse*) for battery and External Charger circuits has NOT been provided and has to provided by the installer/user. See guidelines at Table 3.1 for recommended sizes for installation. National and Local Electrical Codes will supersede these guidelines.
10. Tightening torques to be applied to the wiring terminals are given in Section 3.7.2.
11. This unit has been provided with integral protections against overloads.
12. **WARNING!** To reduce risk of electric shock and fire:
    - Installation should be carried out by certified installer and as per Local and National Electrical Codes.
    - Do not connect to circuit operating at more than 280 Volts to Ground.
    - Both AC and DC voltage sources are terminated inside this equipment. Each circuit must be individually disconnected before servicing.
    - Do not remove cover. No user serviceable part inside. Refer servicing to qualified servicing personnel.
    - Do not mount in zero clearance compartment.
    - Do not cover or obstruct ventilation openings.
    - Fuse(s) should be replaced with the same type and rating as of the original installed fuse(s).
13. **GROUNDING:** The Grounding symbol shown below is used for identifying only the field wiring equipment-grounding terminal. However, this symbol is usable with the circle omitted for identifying various points within the unit that are bonded to Ground.

     Grounding Symbol/Défaut à la terre

14. **WARNING!** Precautions When Working With Batteries.

Lead Acid Batteries

- Batteries contain very corrosive diluted Sulphuric Acid as electrolyte. Precautions should be taken to prevent contact with skin, eyes or clothing. Wear eye protection.
- Batteries generate Hydrogen and Oxygen during charging resulting in evolution of explosive gas mixture. Care should be taken to ventilate the battery area and follow the battery manufacturer's recommendations.
- Never smoke or allow a spark or flame near the batteries.
- Use caution to reduce the risk of dropping a metal tool on the battery. It could spark or short circuit the battery or other electrical parts and could cause an explosion. Always use insulated tools.

- Remove metal items like rings, bracelets and watches when working with batteries. Batteries can produce a short circuit current high enough to weld a ring or the like to metal and thus cause a severe burn.
- If you need to remove a battery, always remove the Ground terminal from the battery first. Make sure that all the accessories are off so that you do not cause a spark.

Lithium Ion Batteries

- Ensure that the battery includes Battery Management System (*BMS*) with built-in safety protocol.
- Ensure that voltage, current and charging profile settings of the charger are correct
- Ensure that the Battery Management System (*BMS*) of the battery is able to provide contact closure signal to the EVO® Inverter/Charger under conditions of (i) over voltage / over heating (*to stop charging*) and (ii) deep discharge (*to stop inverting*) *[Refer to Section 5.11.2]*.

AVERTISSEMENT ! / ATTENTION !

1. ***AVERTISSEMENT !*** *Pour réduire le risque d'explosion, ne pas installer dans la salle des machines ou dans une zone dans laquelle un équipement ignifuge doit être utilisé.*
2. ***ATTENTION !*** *(a) Pour éviter tout dommage dû à des vibrations / chocs excessifs, utilisez-le sur des navires d'une longueur supérieure à 65 pieds. (19,8 M). (b) Cet appareil n'est PAS conçu pour une installation sur une terrasse. Pour réduire le risque de choc électrique, ne pas exposer à la pluie ou aux embruns.*

3.1 ATTENTION ! *L'onduleur/chargeur EVO^{MC} avec circuit de charge entièrement automatique charge correctement les batteries au plomb-acide de 12 V / 24 V, au nickel-zinc (Ni-Zn) et au lithium-ion. Lorsque l'onduleur / chargeur EVO^{MC} est en mode de charge, la LED verte marquée «ON» (12, Fig 2.1) clignote.*

3.2 AVERTISSEMENT ! Risque de batterie au lithium-ion. *L'option est disponible pour utiliser des batteries lithium-ion nominales 12 V / 24 V. L'utilisateur / l'installateur doit s'assurer que les tensions, courants et profils de charge sont programmés de manière appropriée pour répondre à toutes les exigences de fonctionnement et de sécurité de la batterie utilisée. Assurez-vous que la batterie au lithium-ion comprend un système de gestion de batterie (BMS) avec des protocoles de sécurité intégrés. Suivez les instructions spécifiées par le fabricant de la batterie au lithium-ion. Lorsque l'onduleur/chargeur EVO^{MC} est en mode de charge, la LED verte marquée «ON» (12, Fig 2.1) clignote.*

4. ***ATTENTION !*** *Pour une utilisation en intérieur uniquement.*
5. ***ATTENTION !*** *Surfaces chaudes! Pour éviter les brûlures, ne touchez pas.*
6. ***ATTENTION !*** *Les bornes de câblage d'entrée / sortie CA sont destinées à une connexion sur site à l'aide de conducteurs en cuivre dont la taille doit être de 70 °C / 185 °F . Voir les tableaux 3.2.1, 3.2.2 et 3.2.3 pour le dimensionnement des conducteurs pour les circuits d'ENTREE AC et le tableau 3.3 pour le dimensionnement des conducteurs pour les circuits de sortie AC.*
7. ***AVERTISSEMENT !*** *La protection contre les surintensités (disjoncteurs CA) pour les circuits d'entrée/sortie CA n'a PAS été fournie et doit être fournie par l'installateur / l'utilisateur. Voir les directives aux tableaux 3.2.1, 3.2.2 et 3.3.3 pour le dimensionnement des disjoncteurs pour les circuits d'ENTRÉE CA et au tableau 3.3 pour le dimensionnement des disjoncteurs pour les circuits de sortie CA. Les codes électriques nationaux et locaux remplaceront ces directives.*
8. ***ATTENTION !*** *Les bornes de la batterie sont destinées au raccordement sur site à l'aide de conducteurs en cuivre dimensionnés à 90 °C / 194 °F. Voir le tableau 3.1 pour les tailles recommandées pour l'installation.*

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9. AVERTISSEMENT ! *La protection contre les surintensités (fusible) pour les circuits de batterie et de chargeur externe n'a PAS été fournie et doit être fournie par l'installateur / l'utilisateur. Voir les directives du tableau 3.1 pour les tailles recommandées pour l'installation. Les codes électriques nationaux et locaux remplaceront ces directives.*

10. Les couples de serrage à appliquer aux bornes de câblage sont indiqués dans la section 3.7.2.

11. Cet appareil est doté de protections intégrales contre les surcharges.

12. AVERTISSEMENT ! *Pour réduire les risques d'électrocution et d'incendie:*

- *L'installation doit être effectuée par un installateur certifié et conformément aux codes électriques locaux et nationaux.*
- *Ne pas connecter à un circuit fonctionnant à plus de 280 volts par rapport à la terre.*
- *Les sources de tension CA et CC sont terminées à l'intérieur de cet équipement. Chaque circuit doit être déconnecté individuellement avant l'entretien.*
- *Ne retirez pas le couvercle. Aucune pièce réparable par l'utilisateur à l'intérieur. Confiez l'entretien à un personnel d'entretien qualifié.*
- *Ne pas monter dans un compartiment à dégagement nul.*
- *Ne couvrez pas et n'obstruez pas les ouvertures de ventilation.*
- *Le (s) fusible (s) doit (doivent) être remplacé (s) par le même type et le même calibre que le (s) fusible (s) d'origine installé (s).*

13. MISE À LA TERRE : *Le symbole de mise à la terre illustré ci-dessous est utilisé pour identifier uniquement la borne de mise à la terre de l'équipement de câblage sur site. Cependant, ce symbole est utilisable avec le cercle omis pour identifier divers points dans l'unité qui sont liés à la terre.*

⏚ *Grounding Symbol/Défaut à la terre.*

14. MISE EN GARDE ! *Précautions lorsque vous travaillez avec des piles.*

Batteries au plomb

- *Les piles contiennent très corrosif acide sulfurique dilué comme électrolyte. Des précautions doivent être prises pour empêcher tout contact avec la peau, les yeux ou les vêtements. Porter des lunettes de protection*
- *Les batteries produisent de l'hydrogène et de l'oxygène lors de la charge résultant de l'évolution du mélange de gaz explosif. Il faut prendre soin de ventiler la zone de la batterie et de suivre les recommandations du fabricant de la batterie.*
- *Ne jamais fumer ou permettre une étincelle ou une flamme près des batteries.*
- *Faites preuve de prudence afin de réduire le risque de chute d'un outil métallique sur la batterie. Il pourrait provoquer un court-circuit ou la batterie ou d'autres pièces électriques et pourrait causer une explosion. Toujours utiliser des outils isolés*
- *Retirez les articles métalliques tels que des bagues, des bracelets et des montres lorsque vous travaillez avec des batteries. Les batteries peuvent produire un court-circuit suffisamment élevé pour souder une bague ou autre métal et ainsi causer de graves brûlures.*
- *Si vous devez retirer la batterie, retirez toujours la borne de terre de la batterie. Assurez-vous que tous les accessoires sont hors de sorte que vous ne causent pas une étincelle.*

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Batteries lithium-ion

- *Assurez-vous que la batterie comprend un système de gestion de batterie (BMS) avec protocole de sécurité intégré.*
- *Assurez-vous que les paramètres de tension, de courant et de profil de charge du chargeur sont corrects*
- *Assurez-vous que le système de gestion de batterie (BMS) de la batterie est en mesure de fournir un signal de fermeture de contact à l'onduleur / chargeur EVO^{MC} dans des conditions de (i) surtension / surchauffe (pour arrêter la charge) et (ii) décharge profonde (pour arrêter inversion) [Reportez-vous à la section 5.11.2].*

1.2 DEFINITIONS

The following definitions are used in this manual for explaining various electrical concepts, specifications and operations:

Peak Value: It is the maximum value of electrical parameter like voltage/current.

RMS (Root Mean Square) Value: It is a statistical average value of a quantity that varies in value with respect to time. For example, a pure sine wave that alternates between peak values of Positive 325.22 V and Negative 325.22 V has an RMS value of 230 VAC. Also, for a pure sine wave, the RMS value = Peak value ÷ 1.414.

Voltage (V), Volts: It is denoted by "V" and the unit is "Volts". It is the electrical force that drives electrical current (I) when connected to a load. It can be DC (Direct Current – flow in one direction only) or AC (Alternating Current – direction of flow changes periodically). The AC value shown in the specifications is the RMS (Root Mean Square) value.

Current (I), Amps, A: It is denoted by "I" and the unit is Amperes – shown as "A". It is the flow of electrons through a conductor when a voltage (V) is applied across it.

Frequency (F), Hz: It is a measure of the number of occurrences of a repeating event per unit time. For example, cycles per second (or Hertz) in a sinusoidal voltage.

Efficiency, (η): This is the ratio of Power Output ÷ Power Input.

Phase Angle, (φ): It is denoted by "φ" and specifies the angle in degrees by which the current vector leads or lags the voltage vector in a sinusoidal voltage. In a purely inductive load, the current vector lags the voltage vector by Phase Angle (φ) = 90°. In a purely capacitive load, the current vector leads the voltage vector by Phase Angle, (φ) = 90°. In a purely resistive load, the current vector is in phase with the voltage vector and hence, the Phase Angle, (φ) = 0°. In a load consisting of a combination of resistances, inductances and capacitances, the Phase Angle (φ) of the net current vector will be > 0° < 90° and may lag or lead the voltage vector.

Resistance (R), Ohm, Ω: It is the property of a conductor that opposes the flow of current when a voltage is applied across it. In a resistance, the current is in phase with the voltage. It is denoted by "R" and its unit is "Ohm" - also denoted as "Ω".

Inductive Reactance (X_L), Capacitive Reactance (X_C) and Reactance (X): Reactance is the opposition of a circuit element to a change of electric current or voltage due to that element's inductance or capacitance. Inductive Reactance ($\mathbf{X_L}$) is the property of a coil of wire in resisting any change of electric current through the coil. It is proportional to frequency and inductance and causes the current vector to lag the voltage vector by Phase Angle (φ) = 90°. Capacitive reactance ($\mathbf{X_C}$) is the property of capacitive elements to oppose changes in voltage. $\mathbf{X_C}$ is inversely proportional to the frequency and capacitance and causes the current vector to lead the voltage vector by Phase Angle (φ) = 90°. The unit

of both $\mathbf{X_L}$ and $\mathbf{X_C}$ is "Ohm" - also denoted as "Ω". The effects of inductive reactance $\mathbf{X_L}$ to cause the current to lag the voltage by 90° and that of the capacitive reactance $\mathbf{X_C}$ to cause the current to lead the voltage by 90° are exactly opposite and the net effect is a tendency to cancel each other. Hence, in a circuit containing both inductances and capacitances, the net **Reactance (X)** will be equal to the difference between the values of the inductive and capacitive reactances. The net **Reactance (X)** will be inductive if $\mathbf{X_L} > \mathbf{X_C}$ and capacitive if $\mathbf{X_C} > \mathbf{X_L}$.

Impedance, Z: It is the vectorial sum of Resistance and Reactance vectors in a circuit.

Active Power (P), Watts: It is denoted as "**P**" and the unit is "**Watt**". It is the power that is consumed in the resistive elements of the load. A load will require additional Reactive Power for powering the inductive and capacitive elements. The effective power required would be the Apparent Power that is a vectorial sum of the Active and Reactive Powers.

Reactive Power (Q), VAR: Is denoted as "**Q**" and the unit is **VAR**. Over a cycle, this power is alternatively stored and returned by the inductive and capacitive elements of the load. It is not consumed by the inductive and capacitive elements in the load but a certain value travels from the AC source to these elements in the (+) half cycle of the sinusoidal voltage (Positive value) and the same value is returned back to the AC source in the (-) half cycle of the sinusoidal voltage (Negative value). Hence, when averaged over a span of one cycle, the net value of this power is 0. However, on an instantaneous basis, this power has to be provided by the AC source. *Hence, the inverter, AC wiring and over current protection devices have to be sized based on the combined effect of the Active and Reactive Powers that is called the Apparent Power.*

Apparent Power (S), VA: This power, denoted by "S", is the vectorial sum of the Active Power in Watts and the Reactive Power in "VAR". In magnitude, it is equal to the RMS value of voltage "V" X the RMS value of current "A". The Unit is VA. *Please note that Apparent Power VA is more than the Active Power in Watts. Hence, the inverter, AC wiring and over current protection devices have to be sized based on the Apparent Power.*

Maximum Continuous Running AC Power Rating: This rating may be specified as "Active Power" in Watts (W) or "Apparent Power" in Volt Amps (VA). It is normally specified in "Active Power (P)" in Watts for Resistive type of loads that have Power Factor =1. Reactive types of loads will draw higher value of "Apparent Power" that is the sum of "Active and Reactive Powers". *Thus, AC power source should be sized based on the higher "Apparent Power" Rating in (VA) for all Reactive Types of AC loads. If the AC power source is sized based on the lower "Active Power" Rating in Watts (W), the AC power source may be subjected to overload conditions when powering Reactive Type of loads*.

Starting Surge Power Rating: Certain loads require considerably higher Starting Surge Power for short duration (lasting from tens of millisecs to few seconds) as compared to their Maximum Continuous Running Power Rating. Some examples of such loads are given on below:

- **Electric Motors:** At the moment when an electric motor is powered ON, the rotor is stationary (*equivalent to being "Locked"*), there is no "Back EMF" and the windings draw a very heavy starting current (*Amperes*) called "Locked Rotor Amperes" (*LRA*) due to low DC resistance of the windings. For example, in motor driven loads like Air-conditioning and Refrigeration Compressors and in Well Pumps (*using Pressure Tank*), LRA may be as high as 10 times its rated Full Load Amps (*FLA*) / Maximum Continuous Running Power Rating. The value and duration of LRA of the motor depends upon the winding design of the motor and the inertia/resistance to movement of mechanical load being driven by the motor. As the motor speed rises to its rated RPM, "Back EMF" proportional to the RPM is generated in the windings and the current draw reduces proportionately till it draws the running FLA/Maximum Continuous Running Power Rating at the rated RPM.

- **Transformers (e.g. Isolation Transformers, Step-up/Step-down Transformers, Power Transformer in Microwave Oven etc.):** At the moment when AC power is supplied to a transformer, the transformer draws very heavy "Magnetization Inrush Current" for a few millisecs that can reach up to 10 times the Maximum Continuous Rating of the Transformer.
- **Devices like (i) Infrared Quartz Halogen Heaters (*also used in Laser Printers*)/Quartz Halogen Lights/ Incandescent Light Bulbs using Tungsten heating elements and (ii) PTC Ceramic Heaters:** Tungsten and PTC Ceramic have a very high Positive Temperature Coefficient of Resistance i.e. they have lower resistance when cold and higher resistance when hot. As Tungsten/PTC Ceramic heating element will be cold at the time of powering ON, its resistance will be low and hence, the device will draw very heavy Starting Surge Current with consequent very heavy Starting Surge Power with a value of up to 8 times the Maximum Continuous Running AC Power.
- **AC to DC Switched Mode Power Supplies (*SMPS*):** This type of power supply is used as stand-alone power supply or as front end in all electronic devices powered from Utility/Grid e.g. in audio/video/computing devices and battery chargers (*Please see Section 4 for more details on SMPS*). When this power supply is switched ON, its internal input side capacitors start charging resulting in very high Inrush Current for a few millisecs (*Please see Fig 4.1*). This inrush current/power may reach up to 15 times the Continuous Maximum Running Power Rating. The inrush current/power will, however, be limited by the Starting Surge Power Rating of the AC source.

Power Factor, (PF): It is denoted by "PF" and is equal to the ratio of the Active Power (P) in Watts to the Apparent Power (S) in VA. The maximum value is 1 for resistive types of loads where the Active Power (P) in Watts = the Apparent Power (S) in VA. It is 0 for purely inductive or purely capacitive loads. Practically, the loads will be a combination of resistive, inductive and capacitive elements and hence, its value will be > 0 <1. Normally it ranges from 0.5 to 0.8.

Load: Electrical appliance or device to which an electrical voltage is fed.

Linear Load: A load that draws sinusoidal current when a sinusoidal voltage is fed to it. Examples are, incandescent lamp, heater, electric motor, etc.

Non-Linear Load: A load that does not draw a sinusoidal current when a sinusoidal voltage is fed to it. For example, non-power factor corrected Switched Mode Power Supplies (*SMPS*) used in computers, audio video equipment, battery chargers, etc.

Resistive Load: A device or appliance that consists of pure resistance (*like filament lamps, cook tops, toaster, coffee maker etc.*) and draws only Active Power (Watts) from the inverter. The inverter can be sized based on the Active Power rating (Watts) of the Resistive Load without creating overload (*except for resistive loads with Tungsten based heating element like filament lamps, Quartz/Halogen lamps and Quartz / Halogen Infrared heaters or, ceramic/PTC of heaters. These require higher starting surge power due to lower resistance value when the heating elements are cold*).

Reactive Load: A device or appliance that consists of a combination of resistive, inductive and capacitive elements (*like motor driven tools, refrigeration compressors, microwaves, computers, audio/ video etc.*). The Power Factor (PF) of this type of load is < 1 e.g. AC Motors (*PF = 0.4 to 0.8*), AC to DC Switch Mode Power Supplies (*PF = 0.5 to 0.6*), Transformers (*PF = 0.8*) etc. These devices require Apparent Power (VA) from the inverter to operate. The Apparent Power is a vectorial sum of Active Power (Watts) and Reactive Power (VAR). *The inverter has to be sized based on the higher Apparent Power (VA) and also based on the Starting Surge Power.*

1.3 GENERAL INFORMATION - INVERTER RELATED

General information related to operation and sizing of inverters is given in succeeding sub-sections.

1.3.1 AC Voltage Waveforms

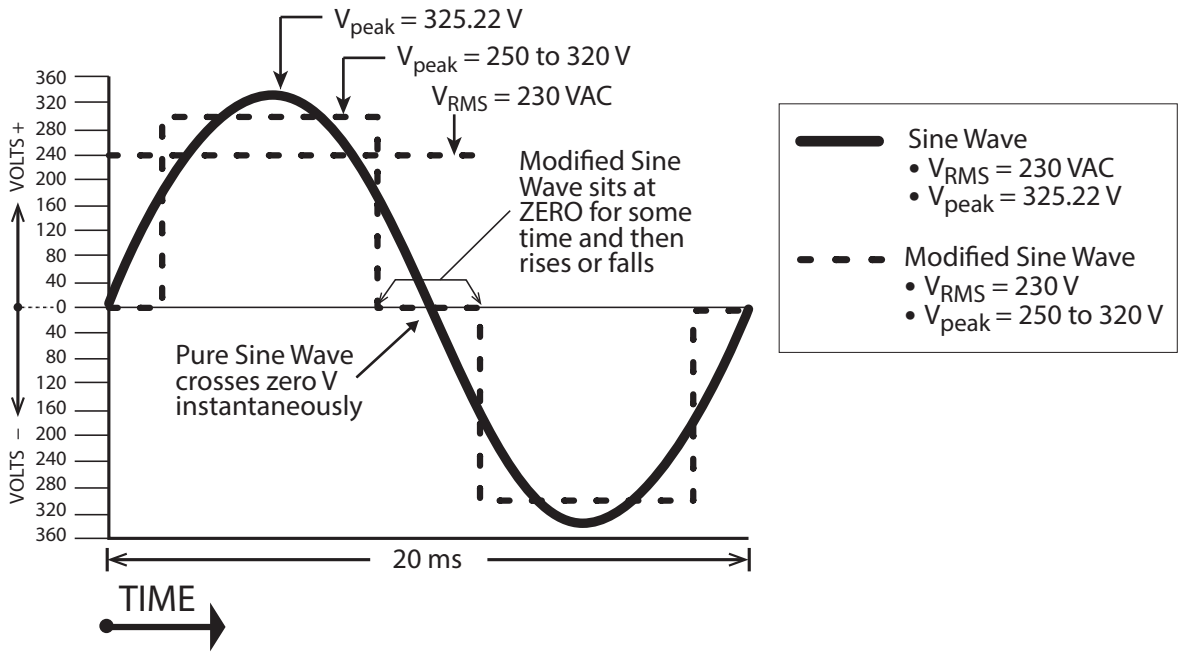


Fig 1.3.1 Pure and Modified Sine Waveforms for 230 VAC, 50 Hz

The 230 VAC output waveform of the Evolution® series inverters is a Pure Sine Wave like the waveform of Utility/ Grid power. Please see Sine Waveform represented in the Fig. 1.3.1 that also shows equivalent Modified Waveform for comparison.

In a Sine Wave, the voltage rises and falls smoothly with a smoothly changing phase angle and also changes its polarity instantly when it crosses 0 Volts. In a Modified Sine Wave, the voltage rises and falls abruptly, the phase angle also changes abruptly and it sits at 0 V for some time before changing its polarity. Thus, any device that uses a control circuitry that senses the phase (*for voltage/speed control*) or instantaneous zero voltage crossing (for timing control) will not work properly from a voltage that has a Modified Sine Waveform.

Also, as the Modified Sine Wave is a form of Square Wave, it is comprised of multiple Sine Waves of odd harmonics (*multiples*) of the fundamental frequency of the Modified Sine Wave. For example, a 50 Hz Modified Sine Wave will consist of Sine Waves with odd harmonic frequencies of 3rd (*150 Hz*), 5th (*250 Hz*), 7th (*350 Hz*) and so on. The high frequency harmonic content in a Modified Sine Wave produces enhanced radio interference, higher heating effect in inductive loads like microwaves and motor driven devices like hand tools, refrigeration/air-conditioning compressors, pumps etc. The higher frequency harmonics also produce overloading effect in low frequency capacitors due to lowering of their capacitive reactance by the higher harmonic frequencies. These capacitors are used in ballasts for fluorescent lighting for Power Factor improvement and in single-phase induction motors as start and run capacitors. Thus, Modified and Square Wave Inverters may shut down due to overload when powering these devices.

1.3.2 Advantages of Pure Sine Wave Inverters

- The output waveform is a Sine Wave with very low harmonic distortion and cleaner power like Grid/Utility supplied electricity.
- Inductive loads like microwaves, motors, transformers etc. run faster, quieter and cooler.
- More suitable for powering fluorescent lighting fixtures containing Power Factor Improvement Capacitors and single phase motors containing Start and Run Capacitors.
- Reduces audible and electrical noise in fans, fluorescent lights, audio amplifiers, TV, fax and answering machines.
- Does not contribute to the possibility of crashes in computers, weird print outs and glitches in monitors.

Some examples of devices that may not work properly with Modified Sine Wave and may also get damaged are given below:

- Laser printers, photocopiers, and magneto-optical hard drives.
- Built-in clocks in devices such as clock radios, alarm clocks, coffee makers, bread-makers, VCR, microwave ovens etc. may not keep time correctly.
- Output voltage control devices like dimmers, ceiling fan/motor speed control may not work properly (*dimming/ speed control may not function*).
- Sewing machines with speed/microprocessor control.
- Transformer-less capacitive input powered devices like (i) Razors, flashlights, night-lights, smoke detectors etc. (ii) Some re-chargers for battery packs used in hand power tools. *These may get damaged. Please check with the manufacturer of these types of devices for suitability.*
- Devices that use radio frequency signals carried by the AC distribution wiring.
- Some new furnaces with microprocessor control/Oil burner primary controls.
- High intensity discharge (*HID*) lamps like Metal Halide lamps. *These may get damaged. Please check with the manufacturer of these types of devices for suitability.*
- Some fluorescent lamps/light fixtures that have Power Factor Correction Capacitors. *The inverter may shut down indicating overload.*
- Induction Cooktops.

1.3.3 Power Rating of Inverters

INFO

For proper understanding of explanations given below, please refer to definitions of Active, Reactive, Apparent, Continuous, Surge Powers, Power Factor, and Resistive, Reactive Loads at Section 1.2 under "DEFINITIONS"

The power rating of inverters is specified as follows:

- Maximum Continuous Running Power Rating
- Starting Surge Power Rating

Please read details of the above two types of power ratings in Section 1.2 under "DEFINITIONS"

INFO

The manufacturers' specification for power rating of AC appliances and devices indicates only the Maximum Continuous Running Power Rating. The Starting Surge Power required by some specific types of devices as explained above has to be determined by actual testing or by checking with the manufacturer. This may not be possible in all cases and hence, can be guessed at best, based on some general Rules of Thumb.

Table 1.6 provides a list of some common AC appliances/devices that require high Starting Surge Power. An "Inverter Sizing Factor" has been recommended against each which is a Multiplication Factor to be applied to the Maximum Continuous Running Power Rating (Active Power Rating in Watts) of the AC appliance/device to arrive at the Maximum Continuous Running Power Rating of the inverter (Multiply the Maximum Continuous Running Power Rating (Active Power Rating in Watts) of the appliance/device by recommended Sizing Factor to arrive at the Maximum Continuous Running Power Rating of the inverter.

TABLE 1.3.1 INVERTER SIZING FACTOR

Type of Device or Appliance	Inverter Sizing Factor (See Note 1)
Air Conditioner, Refrigerator, Freezer (Compressor based)	5
Air Compressor	4
Sump Pump, Well Pump, Submersible Pump	3
Dishwasher, Clothes Washer	3
Microwave (where rated output power is the Cooking Power)	2
Furnace Fan	3
Industrial Motor	3
Portable Kerosene, Diesel Fuel Heater	3
Circular Saw, Bench Grinder	3
Incandescent, Halogen, Quartz Lamps	3
Ceramic, PTC (*Postive Temperature Coefficient*) type of heaters	5
Laser Printer, Other Devices using Infrared, Quartz Halogen Heaters	4
Switch Mode Power Supplies (SMPS): no Power Factor correction	2
Photographic Strobe, Flash Lights	4 (See Note 2)

NOTES FOR TABLE 1.3.1:

1 Multiply the Maximum Continuous Power Rating (Active Power Rating in Watts) of the appliance/device by the recommended sizing factor to arrive at the Maximum Continuous Running Power Rating of the Inverter.

2 For photographic strobe/flash unit, the Surge Power of the inverter should be > 4 times the Watt Sec rating of photographic strobe/flash unit.

1.3.4 Electro-Magnetic Interference (EMI) and EMC Compliance

These inverters contain internal switching devices that generate conducted and radiated electromagnetic interference (*EMI*). The EMI is unintentional and cannot be entirely eliminated. The magnitude of EMI is, however, limited by circuit design to acceptable levels as per limits laid down in the European EMC Directive 2014/30/EU for Class A limits. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated

in a residential environment. These inverters can conduct and radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. The effects of EMI will also depend upon a number of factors external to the inverter like proximity of the inverter to the EMI receptors, types and quality of connecting wires and cables etc. EMI due to factors external to the inverter may be reduced as follows:

- Ensure that the inverter is firmly grounded to the Ground System of the building or the vehicle.
- Locate the inverter as far away from the EMI receptors like radio, audio and video devices as possible.
- Keep the DC side wires between the battery and the inverter as short as possible.
- Do NOT keep the battery wires far apart. Keep them taped together to reduce their inductance and induced voltages. This reduces ripple in the battery wires and improves performance and efficiency.
- Shield the DC side wires with metal sheathing/copper foil/braiding.
- Use coaxial shielded cable for all antenna inputs (instead of 300 ohm twin leads).
- Use high quality shielded cables to attach audio and video devices to one another.
- Limit operation of other high power loads when operating audio/video equipment.

1.3.5 Characteristics of Switch Mode Power Supplies (SMPS)

Switch Mode Power Supplies (*SMPS*) are extensively used to convert the incoming AC power into various voltages like 3.3 V, 5 V, 12 V, 24 V etc. that are used to power various devices and circuits used in electronic equipment like battery chargers, computers, audio and video devices, radios etc. These power supplies use large capacitors in their input section for filtration. When the power supply is first turned on, there is a very large inrush current drawn by the power supply as the input capacitors are charged (*The capacitors act almost like a short circuit at the instant the power is turned on*). The inrush current at turn-on is several to tens of times larger than the rated RMS input current and lasts for a few milliseconds. An example of the input voltage versus input current waveforms is given in Fig. 1.3.2. It will be seen that the initial input current pulse just after turn-on is > 15 times larger than the steady state RMS current. The inrush dissipates in around 2 or 3 cycles i.e. in around 40 to 60 milliseconds for 50 Hz sine wave.

Further, due to the presence of high value of input filter capacitors, the current drawn by an SMPS (*With no Power Factor correction*) is not sinusoidal but non-linear as shown in Fig 1.3.3. The steady state input current of SMPS is a train of non-linear pulses instead of a sinusoidal wave. These pulses are two to four milliseconds duration each with a very high Crest Factor of around 3. Crest Factor is defined by the following equation: **CREST FACTOR = PEAK VALUE ÷ RMS VALUE**

Many SMPS units incorporate "Inrush Current Limiting". The most common method is the NTC (*Negative Temperature Coefficient*) resistor. The NTC resistor has a high resistance when cold and a low resistance when hot. The NTC resistor is placed in series with the input to the power supply. The higher cold resistance limits the input current as the input capacitors charge up. The input current heats up the NTC and the resistance drops during normal operation. However, if the power supply is quickly turned OFF and back ON, the NTC resistor will be hot so its low resistance state will not prevent an inrush current event.

The inverter should, therefore, be sized adequately to withstand the high inrush current and the high Crest Factor of the current drawn by the SMPS. Normally, inverters have short duration Surge Power Rating of 2 times their Maximum Continuous Power Rating. Hence, it is recommended that for purposes of sizing the inverter, to accommodate Crest Factor of 3, the Maximum Continuous Power Rating of the inverter should be > 2 times the Maximum Continuous Rated Power of the SMPS. For example, an SMPS rated at 100 Watts should be powered from an inverter that has Maximum Continuous Power Rating of > 200 Watts.

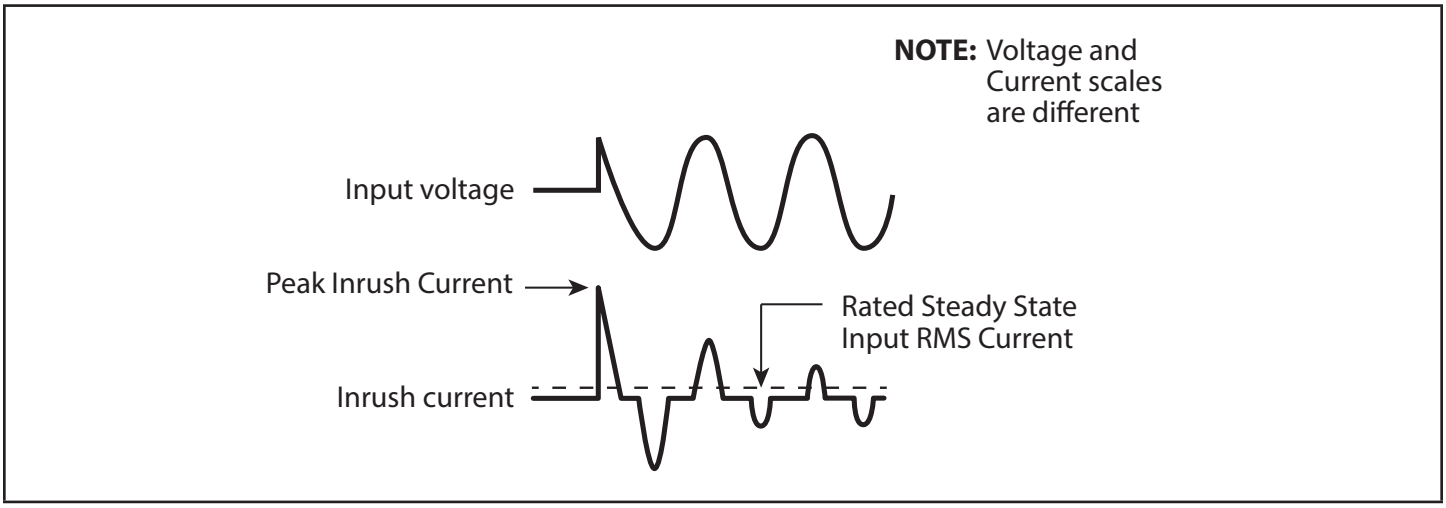


Fig 1.3.2 Inrush Current in an SMPS

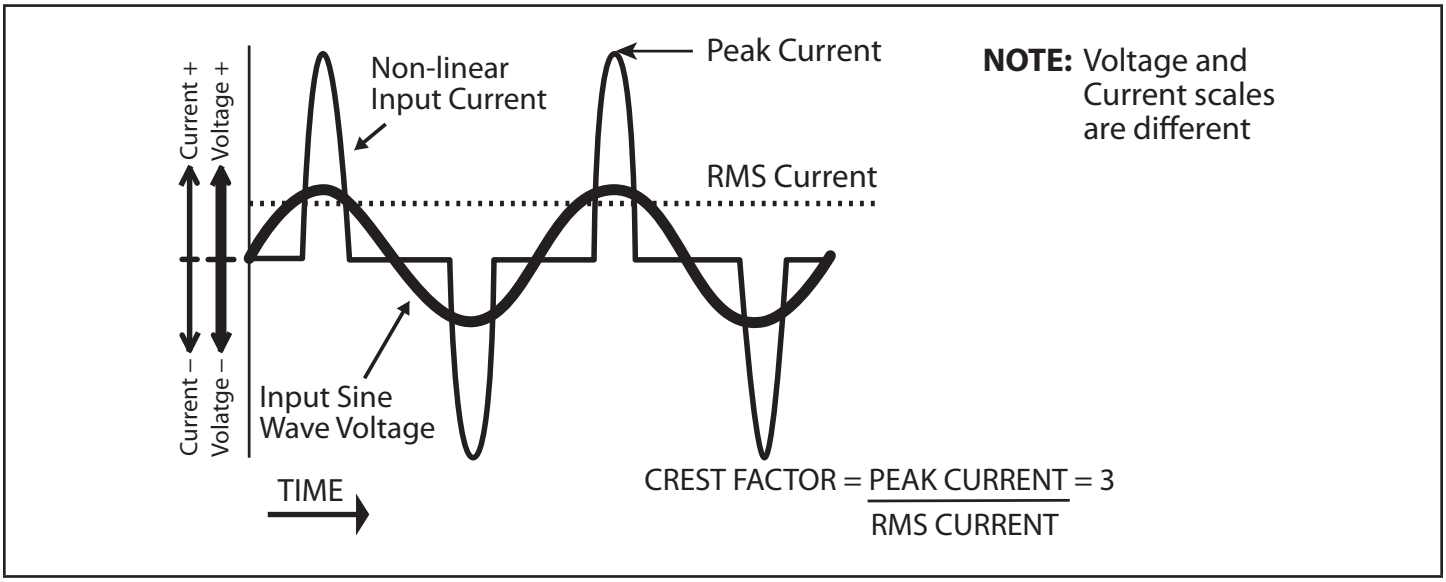


Fig 1.3.3 High Crest Factor of Current Drawn by SMPS

1.4 GENERAL INFORMATION – BATTERY RELATED

INFO

For complete information on Lead Acid Batteries and Charging Process, please visit www.samlexamerica.com > Support > White Papers > White Paper – Batteries, Chargers and Alternators.

1.4.1 Lead Acid Battery – Basic Description And Electro-Chemical Reactions

1.4.1.1 A Lead Acid Battery Pack consists of a number of 2 V nominal cells (*actual voltage of the cell is around 2.105 V*) that are connected in series e.g. a 12 V nominal Battery Pack will have six, 2 V nominal cells in series (*actual*

approximate voltage of the 6 cells will be 2.105 x 6 = 12.63 V). Each 2 V nominal cell in this battery consists of an independent enclosed compartment that has Positive and Negative Plates (*also called Electrodes*) dipped in electrolyte that is composed of diluted Sulphuric Acid. Battery Packs are available with nominal voltages of 2 V, 4 V, 6 V, 8 V and 12 V.

1.4.1.2 A fully charged Lead Acid Battery comprises of (i) **Positive Plates**: Lead Dioxide (PbO_2), (ii) **Negative Plates**: Sponge Lead (Pb) and (iii) **Electrolyte**: Mixture of 65% water and 35% Sulfuric Acid (H_2SO_4) with Specific Gravity = 1.265 at Standard Room Temperature of 77 °F / 25°C (Fully charged condition). During discharging, electro-chemical reactions lead to: (i) **At Positive Plates**: Conversion of Lead Dioxide (PbO_2) to soft Lead Sulfate ($PbSO_4$) crystals, (ii) **At Negative Plates**: Conversion of Sponge Lead (Pb) to soft Lead Sulfate ($PbSO_4$) crystals and (iii) **In Electrolyte**: Conversion of portion of Sulfuric Acid (H_2SO_4) to water leading to reduction in Specific Gravity (*1.120 for fully discharged condition*).

1.4.2 Types Of Lead Acid Batteries

1.4.2.1 Sealed Lead Acid (*SLA*) Or Valve Regulated Lead Acid (*VRLA*) Batteries: These can either be Gel Cell or AGM (Absorbed Glass Mat). In a Gel Cell battery, the electrolyte is in the form of a gel. In AGM (*Absorbed Glass Mat*) battery, the electrolyte is soaked in Glass Mat. In both these types, the electrolyte is immobile. There are no refill caps and the battery is totally sealed. Hydrogen and Oxygen released during the charging process is not allowed to escape and is recombined inside the battery through use of Recombinant Catalyst (s). Hence, there is no water loss and the batteries are maintenance free. These batteries have safety valves on each cell to release excessive pressure that may be built up inside the cell. The Gel Cell is the least affected by temperature extremes, storage at low state of charge and has a low rate of self-discharge. An AGM battery will handle overcharging slightly better than the Gel Cell.

1.4.2.2 Non Sealed (*Vented/Flooded/Wet Cell*) Lead acid Batteries: In these batteries, each individual cell compartment has a refill cap that is used to top up the cell with distilled water and to measure the specific gravity of the electrolyte using a hydrometer. When fully charged, each individual cell has a voltage of approximately 2.105 V and electrolyte specific gravity of 1.265. As the cell discharges, its voltage and specific gravity drop. Thus, a healthy, fully charged, 12 V nominal battery with each of the 6 cells fully charged to 2.105 V will measure a standing voltage of 12.63 V at Standard Room Temperature of 77 ºF / 25 ºC. Also, in a healthy battery, all the individual cells will have the same voltage and same specific gravity. If there is a substantial difference in the voltages (*0.2 V or higher*) and specific gravities of the individual cells (0.015 or more), the cells will have to be "equalized" (*Refer to Sections 1.4.3.4 and 1.4.4 regarding further details on equalization*).

1.4.2.3 SLI (*Starting, Lighting, and Ignition*) Batteries: Everybody is familiar with the SLI batteries that are used for automotive starting, lighting, ignition and powering vehicular accessories. SLI batteries are designed to produce high current in short bursts for cranking. This current is also called also called "Cranking Amps". SLI batteries use lots of thin plates to maximize the surface area of the plates for providing very large Cranking Amps. This allows very high starting current but causes the plates to warp when the battery is cycled. Vehicle starting typically discharges 1%-3% of a healthy SLI battery's capacity. The automotive SLI battery is not designed for repeated deep discharge where up to 80 % of the battery capacity is discharged and then recharged. If an SLI battery is used for this type of deep discharge application, its useful service life will be drastically reduced. This type of battery is not recommended for the storage of energy for inverter backup applications.

1.4.2.4 Deep Cycle Lead Acid Batteries: These batteries are designed with thick-plate electrodes to serve as primary power sources, to have a constant discharge rate, to have the capability to be deeply discharged up to 80% capacity and to repeatedly accept recharging. They are marketed for use in recreation vehicles (RV), boats and electric golf carts – so they may be referred to as RV batteries, marine batteries or golf cart batteries.

1.4.3 Battery Charging Stages:

General descriptions of 4 stages of battery charging are given at Sections 1.4.3.1 to 1.4.3.4 below. Depending upon the type of battery and its application, different Charging Profiles can be created using appropriate charging stages.

NOTE:
7 types of Charging Profiles are available in EVO® through programming parameter "CHARGING PROFILE". Refer to Section 5.6 for details.

1.4.3.1 Stage 1 - Constant Current Bulk Charge Stage: In the first stage, known as the Bulk Charge Stage, the charger delivers a constant, maximum charging current that can be safely handled as specified by the battery manufacturer. The value of the Bulk Charge Current depends upon the total Ampere Hour (Ah) capacity of the battery or bank of batteries. A battery should never be charged at very high charging current as very high rate of charging will not return the full 100% capacity as the Gassing Voltage rises with higher charging current due to "Peukert Effect". Also, very high charging current produces higher temperature in the active material of the plates resulting in loss of cohesion and shedding of the active material that settles on the bottom of the plates. Shedding of the active material results in loss of capacity. If the quantity of the shedded active material at the bottom of the plates rises, it may short the cells.. As a general thumb rule, the Bulk Charging Current should be limited to 10% to 13% of the Ah capacity of the battery (*20 Hour discharge rate*). Higher charging current may be used if permitted by the battery manufacturer. This current is delivered to the batteries until the battery voltage approaches its Gassing Voltage of around 2.4 V per cell at 77 ºF / 25 ºC or, (i) 14.4 V for 12 V Battery Pack/Bank or, (ii) 28.8 V for 24 V Battery Bank. The Bulk Charge Stage restores about 75% of the battery's capacity. The Gassing Voltage is the voltage at which the electrolyte in the battery begins to break down into Hydrogen and Oxygen gases. Under normal circumstances, a battery should not be charged at a voltage above its Gassing Voltage (*except during Equalization Stage*) since this will cause the battery to lose electrolyte and dry out over time. Once the Gassing Voltage is approached, the charger transfers to the next stage, known as the Absorption Stage.

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As the Bulk Charge Stage is a constant current stage, the charger does not control the voltage and the voltage seen at the output terminals of the charger will be the actual battery voltage (this will rise slowly towards the Gassing Voltage under the influence of the constant charging current).

1.4.3.2 Stage 2 - Constant Voltage Absorption Stage During the Absorption Stage, the charger changes from constant current to constant voltage charging. The charging voltage is held constant near the Gassing Voltage to ensure that the battery is further charged to the full capacity without overcharging. The Absorption Stage feeds additional 40% of the capacity that adds up to a total charged capacity of around 115% to take care of around 15% loss of charging efficiency. As the output voltage of the charger is held constant, the battery absorbs the charge slowly and the current reduces gradually till all of the soft Lead Sulfate ($\underline{PbSO_4}$) crystals have been converted to Lead Dioxide ($\underline{PbO_2}$) on the Positive Plates and Sponge Lead ($\underline{Pb}$) on the Negative Plates. The time the charger is held in the Absorption Stage before it transitions to the next Float Stage is determined in one or more of the following conditions:

a) **By a fixed timer (e.g. 4 to 8 Hours)**. This may result in overcharging of almost fully charged batteries.

b) **When charge current drops to specified threshold**: Switching over to the Float Stage when the charge current drops below a certain threshold (*e.g. 10% of the charger Bulk Charge Current*). This may result in overcharging and locking in the Absorption Stage if the battery is feeding an external load that has a value > the specified threshold.

c) **Using Adaptive Charging Algorithm**: This ensures that the battery is completely charged in a safe manner for longer battery life. With the Bidirectional Current Sensing feature enabled, the EVO® detects external DC loads connected to the designated terminals and automatically increases the internal charger output to compensate. This ensures the Adaptive Algorithm calculates (T_0) based on the net current actually entering the battery, preventing overcharging even when DC loads are running. In this algorithm, the time the battery remains in Absorption and Equalization Stages is automatically made proportional to the time the battery remains in the Bulk Charge Stage. A battery that is deeply discharged will remain in Bulk Stage for a longer duration and will require longer time in the Absorption and Equalization Stages for complete charging. On the other hand, a battery that is almost completely charged will remain in the Bulk Stage for a shorter duration and consequently, will remain in Absorption and Equalization stages for a shorter duration. This will prevent overcharging / boiling of the battery. *EVO® Series has 2 programmable options to use this Adaptive Charging Algorithm – (i) 3-Stage Adaptive (Table 5.2, Srl. 1) & (ii) 4-Stage Adaptive for Equalization (Section 5.8).*

1.4.3.3 Stage 3 - Constant Voltage Float Stage: The Float Stage is a maintenance stage in which the output voltage is reduced to a constant lower level, typically about 13.5 V for a 12 V Battery Pack/Bank and 27 V for a 24V Battery Pack/Bank to maintain the battery's charge without losing electrolyte through gassing and also, to compensate for self discharge. Self discharge of Lead Acid Battery is the electrical Ampere Hour (Ah) capacity that is lost when the battery is not being charged and there is no load connected to it. i.e. sits idle in storage. Self-discharge is caused by electro-chemical processes within the battery and is equivalent to application of a small electrical load. For example, Lead Acid battery stored at 30 °C / 86 °F would self-discharge at around 1% of remaining capacity every day. Self-discharge increases with increase in temperature. Self-discharge of the battery under long term storage will create condition equivalent to under charging and consequently, lead to "sulfation" as explained at Section 1.4.4.1.

1.4.3.4 Stage 4 - Constant Voltage Equalization Stage: This stage is normally initiated manually because it is not required every time the battery is recharged *[In EVO®, it is carried out manually through programming parameter "EQUALIZE-4STAGES"(See Section 4.4.2.12 in EVO-RC Remote Control Manual)]*. Normally only vented, wet cell or flooded batteries are equalized. Some sealed AGM batteries may be equalized if recommended by the manufacturer (e.g. Life Line brand of sealed, AGM batteries). Equalization Stage is normally activated after completion of the Bulk and Absorption Stages. During the Equalization Stage, the battery is intentionally charged at a constant voltage at a value above the Gassing Voltage which is normally in the region of 2.5 to 2.7 V per cell at 25 °C / 77 °F (e.g. 15 to 16 V for 12 V Battery Pack/Bank and 30 to 32 V for 24 Battery Pack). The time the battery remains in this stage is determined as follows:

- **By a fixed timer (e.g. 4 to 8 Hours)**: This may result in overcharging of almost fully charged batteries
- **Using an automatic Adaptive Charging Algorithm**: This ensures that the battery is equalized in a safe manner for longer battery life. EVO® Inverter Charger Series uses this Adaptive Charging Algorithm for Equalization. [*Refer to Section 1.4.3.2 (c) for details.*]

Recommendations of the battery manufacturer are to be followed for equalizing the batteries as the equalization voltage, current, time and frequency will depend upon the specific design of the battery. As a guide, a heavily used flooded battery may need to be equalized once per month and a battery in light duty service, every two to four months. The Equalization Charge Current should be a relatively low current of around 2% to 10% of the Ah capacity of the battery. Such a low current prevents an overcharge condition that results in excessive gassing and excessive loss of water.

1.4.4 Why Flooded/Wet Cell Lead Acid Batteries Are Equalized?

For proper health and long life of a Lead Acid battery, it is required to undergo an Equalization Stage (described at Section 1.4.3.4 above) during the charging process to prevent / reduce the following undesirable effects:

1.4.4.1 Sulfation: Section 1.4.1.2 above gives details of basic electrochemical reactions during charging and discharging. If the charging process is not complete due to the inability of the charger to provide the required voltage levels or if the battery is left uncharged for a long duration of time, the soft Lead Sulfate ($PbSO_4$) crystals on the Positive and Negative plates that are formed during discharging/self discharge are not fully converted back to Lead Dioxide (PbO_2) on the Positive plate and Sponge Lead on the Negative plate and *get hardened* and are difficult to dislodge through normal charging. These crystals are less-conducting and hence, introduce increased internal resistance in the battery. This increased internal resistance introduces internal voltage drop during charging and discharging. Voltage drop during charging results in overheating and undercharging and formation of more Lead Sulfate ($PbSO_4$) crystals. Voltage drop on discharging results in overheating and excessive voltage drop in the terminal voltage of the battery. Overall, this results in poor performance of the battery. To dislodge these hardened Lead Sulfate crystals, some chargers are designed to detect a sulfated condition at the start of the charging process and go through an initial De-sulfation Mode that sends high frequency, high voltage pulses at the natural oscillation frequency of the crystals to dislodge the hardened crystals. Sulfation may also be reduced partially by the stirring/mixing action of the electrolyte due to gassing and bubbling because of intentional overcharging during the Equalization Stage.

1.4.4.2 Electrolyte Stratification: Electrolyte stratification can occur in all types of flooded batteries. As the battery is discharged and charged, the concentration of Sulfuric Acid becomes higher at the bottom of the cell and lower at the top of the cell. The low acid concentration reduces capacity at the top of the plates, and the high acid concentration accelerates corrosion at the bottom of the plates and shortens battery life. Stratification can be minimized by the Equalization Stage by raising the charging voltage so that the increased gassing and bubbling agitates/stirs the electrolyte and ensures that the electrolyte has uniform concentration from top to bottom. The stirring action also helps to break up any Lead Sulfate crystals, which may remain after normal charging.

1.4.4.3 Unequal charging of cells: During normal charging, temperature and chemical imbalances prevent some cells from reaching full charge. As a battery is discharged, the cells with lower voltage will be drained further than the cells at higher voltage. When recharged, the cells with the higher voltage will be fully charged before the cells with the lower voltage. The more a battery is cycled, the more cell voltage separation takes place. In a healthy battery, all the individual cells will have the same voltage and same specific gravity. If there is a substantial difference in the cell voltages (*0.2 V or more*) and in the specific gravities (*0.015 or more*) of the individual cells, the cells will require equalization. Equalizing batteries helps to bring all the cells of a battery to the same voltage. During the Equalization Stage, fully charged cells will dissipate the charging energy by gassing while incompletely charged cells continue to charge.

1.4.5 Temperature Compensation To Prevent Over And Under Charging

1.4.5.1.1 Electrochemical reactions during charging / discharging of Lead Acid/Nickel Zinc (Ni-Zn) Batteries are affected by changes in the temperature of the electrolyte. These types of batteries have a Negative Temperature Coefficient of Voltage i.e. the battery charging/discharging voltages will fall due to rise in electrolyte temperature and will rise due to fall in electrolyte temperature. Battery manufacturers, therefore, specify battery voltages and capacity at Standard Room Temperature of 25 ºC / 77 ºF . The Negative Temperature Coefficient is normally within a range of -3 to -5 mV / ºC/Cell or (i) -18 to -30 mV / ºC for a 6-cell, 12 V Battery Pack/Bank or (ii) -36 to -60 mV / ºC for 12-cell, 24 V Battery Bank.

1.4.5.1.2 Lithium Ion charging voltages are not affected by temperature and hence, do not require temperature compensation.

1.4.5.2 Rise/fall in the temperature of the electrolyte with respect to the Standard Room Temperature of 25 °C / 77 °F will require temperature compensation. Charging voltages will be required to be reduced at higher electrolyte temperature and increased at lower electrolyte temperature with respect to the Standard Room Temperature of 25 °C / 77 °F. If charging voltages are not temperature compensated, the battery will boil/be overcharged during higher temperatures and under charged during lower temperatures. This will result in reduced battery life/damage to the battery. *It is, therefore, desirable that a temperature compensated battery charger is used if the Room Temperature swings more than 5 °C / 7 °F . Temperature compensated battery chargers are provided with either internal or external Temperature Sensor.*

1.4.5.3 Effects of Over Charging: Over charging will lead to excessive amount of decomposition of water into Hydrogen and Oxygen and generation of excessive heat. As the battery electrolyte temperature rises, the battery charging voltage is required to be reduced. However, the charger voltage will not reduce in a charger that has no temperature compensation. This condition will drive more current and ,therefore, heating up the electrolyte even further. This is called "thermal runaway" and may damage the battery within a few hours:

- Flooded battery will lose water/shed pasted material.
- Sealed battery will see rise in internal pressure as the rate of generation of Hydrogen and Oxygen will be more than the designed rate of recombination provided by the Recombinant Catalyst. The battery casing will bulge excessively and the pressure release valves may open.

1.4.5.4 Effects of Under Charging – Sulfation: Refer to Section 1.4.4.1 for details.

1.4.6 Self Discharge Of Lead Acid Batteries:

1.4.6.1 Self discharge of Lead Acid Battery is the electrical Ampere Hour (Ah) capacity that is lost when the battery is not being charged and there is no load connected to it i.e. it sits idle in storage. Self-discharge is caused by electro-chemical processes within the battery and is equivalent to application of a small electrical load. For example, Lead Acid battery stored at 30 °C / 86 °F would self-discharge at around 1% of remaining capacity every day. Self-discharge increases with increase in temperature. Self-discharge of the battery under long term storage will create condition equivalent to under charging and consequently, lead to sulfation as explained at Sections 1.4.4.1 above. To prevent this, the battery should be "Float Charged" as explained in Section 1.4.3.3.

1.4.6.2 Float Charging of Batteries under Long Term Storage: In order to prevent sulfation due to under charging as a result of self-discharge, Lead Acid Battery under long term storage should be first fully charged and then left under continuous charge using a suitable "Float Charger" that will Float Charge the battery and provide low value of "Float Charge Current" of around 0.1% of the Ah capacity of the battery to compensate for self discharge.

1.4.7 Rated Capacity Specified in Ampere-hour (Ah)

Battery capacity "C" is specified in Ampere-hours (Ah). An Ampere is the unit of measurement for electrical current and is defined as a Coulomb of charge passing through an electrical conductor in one second. The Capacity "C" in Ah relates to the ability of the battery to provide a constant specified value of discharge current (*also called "C-rate" - see Section 1.4.10*) over a specified time in hours before the battery reaches a specified discharged terminal voltage (*Also called "End Point Voltage"*) at a specified temperature of the electrolyte. As a benchmark, the automotive battery industry rates batteries at a discharge current or C-rate of C/20 Amperes corresponding to 20 Hour discharge period. The rated capacity "C" in Ah in this case will be the number of Amperes of current the battery can deliver for 20 Hours at 80 °F (26.7 °C) till the voltage drops to 1.75 V / Cell. i.e. 10.5 V for 12 V Battery Pack/Bank or 21 V for 24 V Battery Bank. For example, a 100 Ah battery will deliver 5 A for 20 Hours.

1.4.8 Rated Capacity Specified in Reserve Capacity (RC)

Battery capacity may also be expressed as Reserve Capacity (*RC*) in minutes typically for automotive SLI (*Starting, Lighting and Ignition*) batteries. It is the time in minutes a vehicle can be driven after the charging system fails. This is roughly equivalent to the conditions after the alternator fails while the vehicle is being driven at night with the headlights on. The battery alone must supply current to the headlights and the computer/ignition system. The assumed battery load is a constant discharge current of 25 A.

Reserve capacity is the time in minutes for which the battery can deliver 25 Amperes at *26.7 ºC* / 80 ºF till the voltage drops to 1.75V / Cell i.e. 10.5 V for 12 V Battery Pack/Bank or 21 V for 24 V Battery Bank.

Approximate relationship between the two units is: **Capacity "C" in Ah = Reserve Capacity in RC minutes x 0.6**

1.4.9 Typical Battery Sizes

Table 1.4.1 shows details of some popular battery sizes:

TABLE 1.4.1 POPULAR BATTERY SIZES

BCI* Group	Battery Pack Voltage, V	Battery Capacity, Ah
27 / 31	12	66-125
4D	12	180-210
8D	12	200-350
GC2**	6	180-300

* Battery Council International; ** Golf Cart

1.4.10 C-rate of Charge/Discharge

1.4.10.1 The rate of charge/discharge of a battery is normally expressed in "C-rate" which is a *multiple* of the *numerical value* of the battery's Ampere Hour (Ah) Capacity (C) *[See Section 1.4.7 for information on Ampere Hour Capacity]*. Few examples of C-rates (*2C, 1C, 0.2C etc.*) for 100 Ah capacity battery (*C=100 Ah*) are given below:

- 2C = (2x100) A = 200 A *(As the battery capacity is 100 Ah, the battery will be completely discharged in 0.5 Hrs.)*
- 1C = (1x 100) A = 100 A *(As the battery capacity is 100 Ah, the battery will be completely discharged in 1 Hr.)*
- 0.2C (or C/5) = (0.2 x 100) A = 20 A *(As the battery capacity is 100 Ah, the battery will be completely discharged in 5 Hrs.)*

1.4.10.2 Example for Determining C-rate of Charge for Particular Value of Charge Current:

- Determine the Ah capacity (C) of the battery – say 100 Ah (*C=100 Ah*)
- Determine the value of charge current – say 10 Amperes
- C-rate of charge at 10 A = *Multiple* of numerical value Ampere Hour Capacity (C) = (10 ÷ 100) C = 1/10 C or 0.1C

1.4.10.3 Example for Determining C-rate of Discharge for Particular Value of Discharge Current:

- Determine the Ah capacity (C) of the battery – say 100 Ah (C=100)
- Determine the value of discharge current – say 20 Amperes
- C-rate of discharge at 20 A = *Multiple* of numerical value of Ah Capacity (C) = (*20 ÷ 100*) C = 1/5 C

1.4.10.4 Table 1.4.2 gives some examples of typical C-rates of Discharge and applications:

TABLE 1.4.2 TYPICAL "C-rates" OF DISCHARGE	
C-rate of Discharge (Column 1)	**Examples of C-rate of Discharge for 100 Ah capacity battery (Column 2)**
2C	200 A
1C	100 A
C/5 or 0.2C (Inverter application)	20 A
C/8 or 0.125C (UPS application)	12.5 A
C/10 or 0.1C (Telecom application)	10 A
C/20 or 0.05C (Automotive application)	5 A
C/100 or 0.01C	1 A

1.4.11 Charge/Discharge Curves to Determine State of Charge of Lead Acid Battery Based on its Terminal Voltage and C-rates of Charge/Discharge

1.4.11.1 Fig 1.4.1 shows examples of State of Charge/Discharge Curves for different *C-rates* for typical 12 V / 24 V Lead Acid Battery Bank at 26.7 °C / 80 °F. These curves are used to determine the State of Charge/Discharge of the battery based on its terminal voltage.

The Y-Axis shows the terminal voltage of the battery. The X-Axis shows % State of Charge. % State of Discharge can be converted to % State of Charge using formula:

- % State of Charge = (100% - % State of Discharge) e.g. 80% State of Discharge = 100%-80% = 20% State of Charge

1.4.11.2 Example of Determining *State of Charge* (*using Fig 1.4.1*) when Charging 12 V, 100 Ah Battery Pack/Bank at C-rate of 0.1C or C/10 or 10 A: *Refer to Charge Curve marked C\10 of the upper 4 curves marked "CHARGE"*. States of Charge at different battery terminal voltages will be: (a) At 15.3 V = 100% charged; (b) At 14.3 V = 90% charged; (c) At 13.5 V = 70% charged; (d) At 12.5 V = 15% charged

1.4.11.3 Example of Determining State of Discharge (*using Fig 1.4.1*) when Discharging 12 V, 100 Ah Battery Pack/Bank at C-rate of 0.33C or C/3 or 33.3 A: *Refer to Charge Curve marked C\3 of the lower 4 curves marked "DISCHARGE"*. States of Discharge at different battery terminal voltages will be: [a] At 9.5 V = 100% discharged (*0% charged*); [b] At 10.4 V = 80% discharged (20% charged): [c] At 11.5 V = 28% discharged (*72% charged*) and [d] 11.75 V = 0% discharged (*100% charged*).

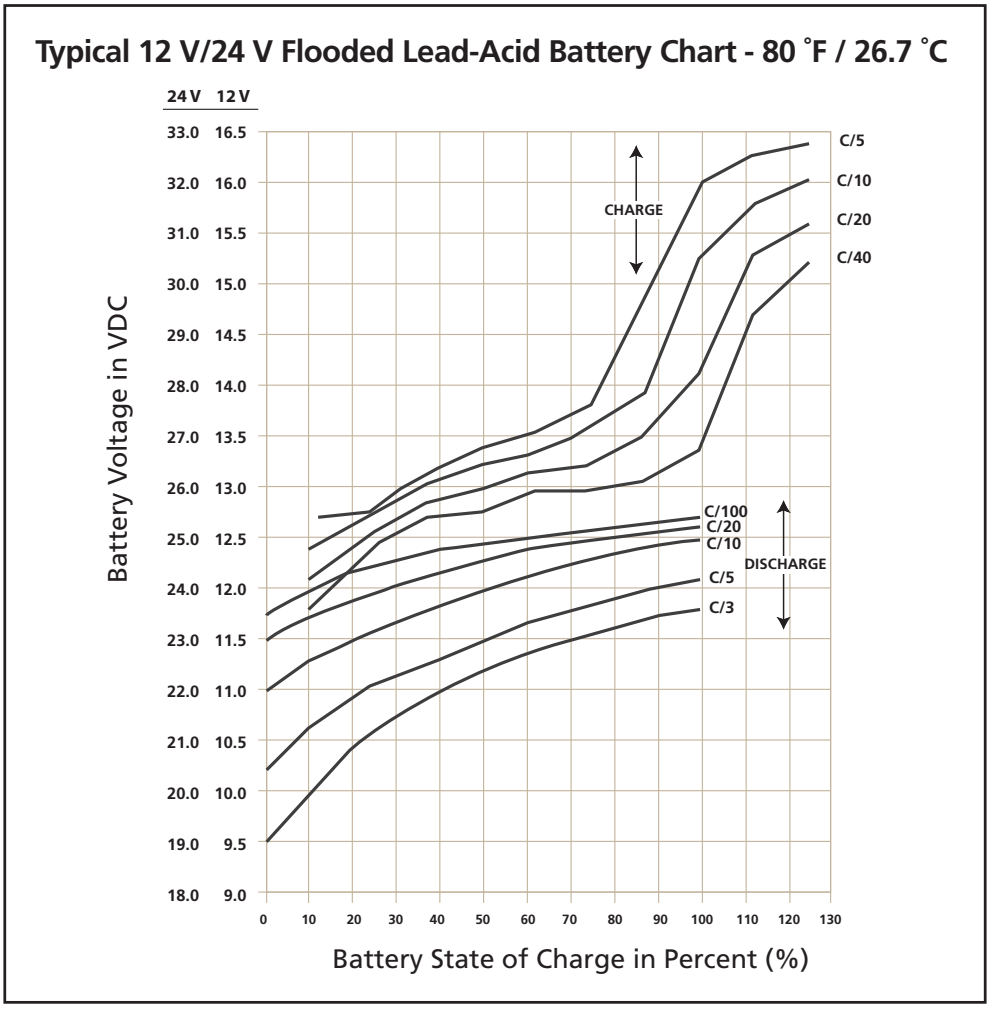


Fig 1.4.1 Charging / Discharging Curves for Typical 12 V/24 V Flooded Lead Acid Battery

1.4.12 Reduction in Usable Capacity at Higher Discharge Rates – Typical in Inverter Application

As stated earlier, the Ah capacity of automotive battery is normally applicable at C-rate of C/20 (*or 0.05C*). As the discharge rate is increased as in cases where the inverters are driving higher capacity loads, the usable Ah capacity reduces due to "Peukert Effect". This relationship is not linear but is more or less according to the Table 1.4.3.

TABLE 1.4.3 BATTERY CAPACITY VERSUS RATE OF DISCHARGE – C-RATE

C-rate Discharge Current	Usable Capacity (%)
C/20 or, 0.05C	100%
C/10 or, 0.10C	87%
C/8 or, 0.125C	83%
C/6 or, 0.17C	75%
C/5 or, 0.20C	70%
C/3 or, 0.34C	60%
C/2 or, 0.50C	50%
1C	40%

Table 1.4.3 shows that a 100 Ah capacity battery will deliver 100% (*i.e. full 100 Ah*) capacity if it is slowly discharged over 20 Hours at the rate of 5 Amperes (*50 W output for a 12 V inverter and 100 W output for a 24 V inverter*). However, if it is discharged at a rate of 50 Amperes (*500 W output for a 12 V inverter and 1000 W output for a 24 V inverter*) then theoretically, it should provide 100 Ah ÷ 50 = 2 Hours. However, Table 1.4.3 above shows that for 2 Hours discharge rate, the capacity is reduced to 50% i.e. 50 Ah. Therefore, at 50 Ampere discharge rate (*500 W output for a 12 V inverter and 1000 W output for a 24 V inverter*) the battery will actually last for 50 Ah ÷ 50 Amperes = 1 Hour.

1.4.13 State of Charge (SOC) of a Battery – Based on "Standing Voltage"

The "Standing Voltage" of a battery under open circuit conditions (no charger or load connected to it) can approximately indicate the State of Charge (*SOC*) of the battery. *The "Standing Voltage" is measured after disconnecting any charging device(s) and the battery load(s) and letting the battery "stand" idle for 3 to 8 hours before the voltage measurement is taken.* Table 1.4.4 shows the State of Charge versus Standing Voltage for a typical 12 V/24 V battery system at 80 °F (26.7 °C).

TABLE 1.4.4 SOC VERSUS STANDING VOLTAGE (*TYPICAL FLOODED BATTERY*)

Percentage of Full Charge	Standing Voltage of Individual Cells	Standing Voltage of 12 V Battery Pack / Bank	Standing Voltage of 24 V Battery Bank
100%	2.105 V	12.63 V	25.26 V
90%	2.10 V	12.6 V	25.20 V
80%	2.08 V	12.5 V	25.00 V
70%	2.05 V	12.3 V	24.60 V
60%	2.03 V	12.2 V	24.40 V
50%	2.02 V	12.1 V	24.20 V
40%	2.00 V	12.0 V	24.00 V
30%	1.97 V	11.8 V	23.60 V
20%	1.95 V	11.7 V	23.40 V
10%	1.93 V	11.6 V	23.20 V
0%	= / < 1.93 V	= / < 11.6 V	= / < 23.20 V

Check the individual cell voltages/specific gravity. If the inter-cell voltage difference is more than a 0.2 V, or the specific gravity difference is 0.015 or more, the cells will require equalization. Refer to Section 1.4.3.4 and 1.4.4 regarding details on equalization. *Please note that only non-sealed vented,flooded and wet cell batteries are equalized. Do not equalize sealed/VRLA type of AGM or Gel Cell Batteries.*

1.4.14 State of Discharge of a Loaded Battery – Low Battery/DC Input Voltage Alarm and Shutdown in Inverters

Most inverter hardware estimate the State of Discharge of the loaded battery by measuring the voltage at the inverter's DC input terminals *[considering that the DC input cables are thick enough to allow a negligible voltage drop between the battery and the inverter]*.

Inverters are provided with a buzzer alarm to warn that the loaded battery has been deeply discharged to around 80% of the rated capacity. *Normally, the buzzer alarm is triggered when the voltage at the DC input terminals of the inverter has dropped to around 10.5 V for a 12 V battery pack / bank or 21 V for 24 V battery bank at C-rate*

discharge current of C/5 Amps and electrolyte temp. of 26.66 °C / 80 °F. The inverter is shut down if the terminal voltage at C/5 discharge current falls further to 10 V for 12 V battery pack / bank or 20 V for 24 V battery bank.

The State of Discharge of a battery is estimated based on the measured terminal voltage of the battery. The terminal voltage of the battery is dependent upon the following:

- **Temperature of the battery electrolyte:** Temperature of the electrolyte affects the electrochemical reactions inside the battery and produces a Negative Voltage Coefficient – during charging / discharging, the terminal voltage drops with rise in temperature and rises with drop in temperature.
- **The amount of discharging current or "C-rate":** A battery has non linear internal resistance and hence, as the discharge current increases, the battery terminal voltage decreases non-linearly.

The discharge curves in Fig. 1.4.1 show the % State of Charge versus the terminal voltage of typical Flooded Lead Acid Battery under different charge /discharge currents, i.e. "C-rates" and fixed temperature of *26.66 °C* / 80 °F. *(Please note that the X-Axis of the curves shows the % of State of Charge. The % of State of Discharge will be 100% - % State of Charge).*

1.4.14.1 Low DC Input Voltage Alarm in Inverters

As stated earlier at Section 1.4.14, the buzzer alarm is triggered when the voltage at the DC input terminals of the inverter has dropped to around 10.5 V for a 12 V battery pack / bank or 21 V for 24 V battery bank at C-rate discharge current of C/5 Amps. Please note that the terminal voltage relative to a particular State of Discharge decreases with the rise in the value of the discharge current. For example, terminal voltages for a State of Discharge of 80% (*State of Charge of 20%*) for various discharge currents will be as given at Table 1.4.5 (*Refer to Fig. 1.4.1 for parameters and values shown in Table 1.4.5*):

TABLE 1.4.5 TERMINAL VOLTAGE AND SOC OF LOADED BATTERY

Discharge Current: C-rate	Terminal Voltage at 80% State of Discharge (20% SOC)		Terminal Voltage When Completely Discharged (0% SOC)	
	12 V	24 V	12 V	24 V
C/3 A	10.45 V	20.9 V	09.50 V	19.0 V
C/5 A	10.90 V	21.8 V	10.30 V	20.6 V
C/10 A	11.50 V	23.0 V	11.00 V	22.0 V
C/20 A	11.85 V	23.7 V	11.50 V	23.0 V
C/100 A	12.15 V	24.3 V	11.75 V	23.5 V

In the example given above, the 10.5 V / 21.0 V Low Battery/DC Input Alarm would trigger at around 80% discharged state (20% SOC) when the C-rate discharge current is C/5 Amps. However, for lower C-rate discharge current of C/10 Amps and lower, the battery will be almost completely discharged when the alarm is sounded. *Hence, if the C-rate discharge current is lower than C/5 Amps, the battery may have completely discharged by the time the Low DC Input Alarm is sounded.*

In view of the above, it may be seen that a fixed Low DC Input Voltage Alarm is not useful. Temperature of the battery further complicates the situation. All the above analysis is based on battery electrolyte temperature of *26.66 °C* / 80 °F. The battery capacity varies with temperature. Battery capacity is also a function of age and charging history. Older batteries have lower capacity because of shedding of active materials, sulfation, corrosion, increasing

number of charge/discharge cycles etc. Hence, the State of Discharge of a battery under load cannot be estimated accurately. However, the low DC input voltage alarm function is designed to protect the inverter from excessive current drawn at the lower voltage.

INFO

EVO® Series Inverter/Chargers have programmable Low DC Input Voltage Alarm that can be set to value applicable for specific operating condition using programming parameter "LOW VOLT ALARM" (*see Table 6.2 under Section 6.4.1 and Section 4.4.2.8 of Owner's Manual for Remote Control Model EVO-RC*).

1.4.14.2 Low DC Input Voltage Shutdown in Inverters

As explained above at Section 1.4.14, at around 80% State of Discharge of the battery at C-rate discharge current of around C/5 Amps, the Low DC Input Voltage Alarm is sounded at around 10.5 V for a 12 V battery pack/bank or, at around 21 V for 24 V battery bank to warn the user to disconnect the battery to prevent further draining of the battery. If the load is not disconnected at this stage, the batteries will be drained further to a lower voltage and to a completely discharged condition that is harmful for the battery and for the inverter.

Inverters are normally provided with a protection to shut down the output of the inverter if the DC voltage at the input terminals of the inverter drops below a threshold of around 10 V for a 12 V battery or, 20 V for 24 V battery. Referring to the Discharge Curves given in Fig 1.4.1, the State of Discharge for various C-rate discharge currents for battery voltage of 10 V / 20 V is as follows: *(Please note that the X-Axis of the curves shows the % of State of Charge. The % of State of Discharge will be 100% - % State of Charge)*:

- 85% State of Discharge (*15% State of Charge*) at very high C-rate discharge current of C/3 Amps.
- 100% State of Discharge (*0 % State of Charge*) at high C-rate discharge current of C/5 Amps.
- 100% discharged (*0% State of charge*) at lower C-rate Discharge current of C/10 Amps.

It is seen that at DC input voltage of 10 V / 20 V, the battery is completely discharged for C-rate discharge current of C/5 and lower.

In view of the above, it may be seen that a fixed Low DC Input Voltage Shutdown is not useful. Temperature of the battery further complicates the situation. All the above analysis is based on battery electrolyte temperature of *26.66 °C* / 80 °F. The battery capacity varies with temperature. Battery capacity is also a function of age and charging history. Older batteries have lower capacity because of shedding of active materials, sulfation, corrosion, increasing number of charge/discharge cycles etc. Hence, the State of Discharge of a battery under load cannot be estimated accurately. However, the low DC input voltage shut-down function is designed to protect the inverter from excessive current drawn at the lower voltage.

INFO

EVO® Series Inverter/Chargers have programmable Low DC Input Voltage Shutdown that can be set to value applicable for specific operating condition using programming parameter "BATT LOW VOLTAGE" (*see Table 6.2 under Section 6.4.1 and Section 4.4.2.9 of Owner's Manual for Remote Control Model EVO-RC*).

1.4.15 Depth of Discharge of Battery and Battery Life

The more deeply a battery is discharged on each cycle, the shorter the battery life. Using more batteries than the minimum required will result in longer life for the battery bank. A typical cycle life chart is given in the Table 1.4.6 below:

TABLE 1.4.6 TYPICAL CYCLE LIFE CHART

Depth of Discharge % of Ah Capacity	Cycle Life of Group 27 /31	Cycle Life of Group 8D	Cycle Life of Group GC2
10	1000	1500	3800
50	320	480	1100
80	200	300	675
100	150	225	550

NOTE: It is recommended that the depth of discharge should be limited to 50%.

1.4.16 Series and Parallel Connection of Batteries

Refer to details at Section 3.4.

1.4.17 Sizing the Inverter Battery Bank

One of the most frequently asked questions is, "how long will the batteries last?" This question cannot be answered without knowing the size of the battery system and the load on the inverter. Usually this question is turned around to ask "How long do you want your load to run?", and then specific calculation can be done to determine the proper battery bank size. There are a few basic formulae and estimation rules that are used:

1. Active Power in Watts (W) = Voltage in Volts (V) x Current in Amperes (A) x Power Factor
2. For an inverter running from a 12V battery pack/bank, the approximate DC current required from the 12 V batteries is the AC power delivered by the inverter to the load in Watts (W) divided by 10 & for an inverter running from a 24 V battery bank, the approximate DC current required from the 24 V battery bank is the AC power delivered by the inverter to the load in Watts (W) divided by 20.
3. Energy required from the battery = DC current to be delivered (A) x Time in Hours (H).

The first step is to estimate the total AC watts (W) of load(s) and for how long the load(s) will operate in hours (H). The AC watts are normally indicated in the electrical nameplate for each appliance or equipment. In case AC watts (W) are not indicated, Formula 1 given above may be used to calculate the AC watts. The next step is to estimate the DC current in Amperes (A) from the AC watts as per Formula 2 above. An example of this calculation for a 12 V inverter is given below:

Let us say that the total AC Watts delivered by the inverter = 1000 W.
Then, using Formula 2 above, the approximate DC current to be delivered by the 12 V battery pack/bank = 1000 W ÷10 = 100 Amperes, or by 24 V battery bank = 1000W ÷ 20 = 50 A.

Next, the energy required by the load in Ampere Hours (Ah) is determined.
For example, if the load is to operate for 3 hours then as per Formula 3 above, the energy to be delivered by the 12 V battery pack/bank = 100 Amperes × 3 Hours = 300 Ampere Hours (Ah), or by the 24V battery bank = 50A x 3 Hrs = 150 Ah.

Now, the capacity of the batteries is determined based on the run time and the usable capacity. From Table 1.4.3 "Battery Capacity versus Rate of Discharge", the usable capacity at 3 Hour discharge rate (C/3) is 60%. Hence, the actual capacity of the 12 V battery pack/bank to deliver 300 Ah will be equal to: 300 Ah ÷ 0.6 = 500 Ah, and the actual capacity of the 24 V battery bank to deliver 150 Ah will be equal to 150 Ah ÷ 0.6 = 250 Ah.

And finally, the actual desired rated capacity of the batteries is determined based on the fact that normally only 80% of the capacity will be available with respect to the rated capacity due to non availability of ideal and optimum operating and charging conditions. So the final requirements will be equal to:

FOR 12 V BATTERY PACK / BANK: 500 Ah ÷ 0.8 = 625 Ah (*Note that the actual energy required by the load was 300 Ah*).

FOR 24 V BATTERY BANK: 250 Ah ÷ 0.8 = 312.5 Ah (*Note that the actual energy required was 150 Ah*).

It will be seen from the above that the final rated capacity of the batteries is almost 2 times the energy required by the load in Ah. *Thus, as a rule of thumb, the Ah capacity of the batteries should be twice the energy required by the load in Ah.*

1.14.18 Charging Batteries

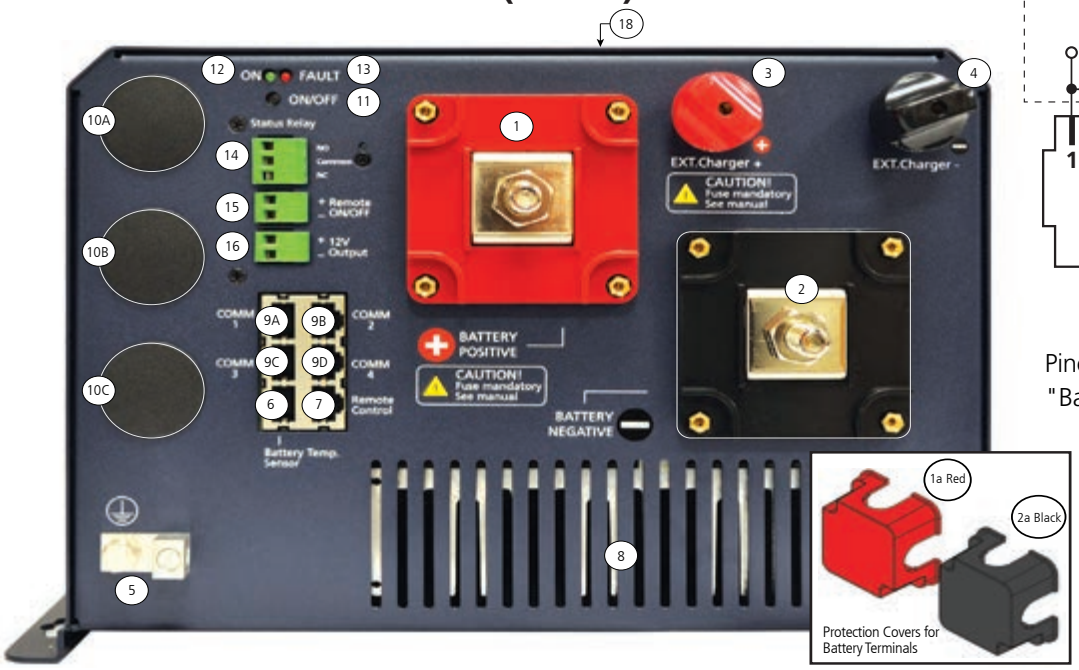
Batteries can be charged by using good quality AC powered battery charger or from alternative energy sources like solar panels, wind or hydro systems. Make sure an appropriate Battery Charge Controller is used. It is recommended that batteries may be charged at 10% to 20% of their Ah capacity (*Ah capacity based on 20 Hr Discharge Rate*). Based on the application, batteries may be charged using 2-Stage, 3-Stage or 4-Stage Charging Profiles as follows:

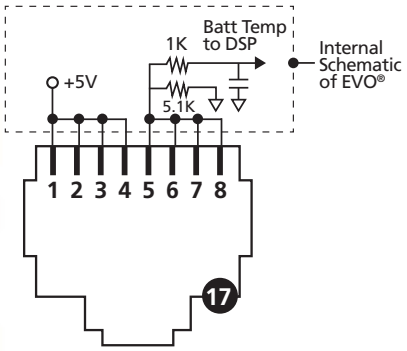
- **Float Application Charging (2-Stage)**
  Stage 1 (*Bulk Stage at constant current*) → Stage 2 (*Absorption Stage at constant voltage. May also be called Float Stage in some applications*)
- **Normal Charging (3-Stages)**
  Stage 1 (*Bulk Stage at constant current*) → Stage 2 (*Absorption Stage at constant voltage)* → Stage 3 *(Float Stage at constant voltage*)
- **Equalization Charging (4-Stages)**
  Stage 1 (*Bulk Stage at constant current*) → Stage 2 (*Absorption Stage at constant voltage*) → Stage 3 (*Equalization Stage at constant voltage*) → Stage 4 (*Float Stage at constant voltage*)

Please refer to Section 5 for details of charging algorithm used in the Battery Charger Section of EVO® Series Inverter/Charger.

SECTION 2 | Components & Layout

2.1 MAIN UNIT: LAYOUT-FRONT (FIG 2.1)





Pinout of RJ-45 Jack marked "Battery Temp. Sensor ⑥

Legend for Fig 2.1

1. Battery Positive (+) Input Connector – Stud & Nut, M10 (*Pitch 1.5 mm)* [*RED Protection Cover 1(a) is removed*]
1a. RED Protection Cover For Battery Positive (+) Input Connector
2. Battery Negative (-) Input Connector – Stud & Nut, M10 (*Pitch 1.5 mm*) [*Black Prot ection Cover 2(a) is removed*]
2a. Black Protection Cover for Battery Negative (-) Input Connector
3. External Charger (+) or DC I/O (+) – Stud & Thumb Nut, M12 (*Pitch 0.75 mm*)
4. External Charger (-) or DC I/O (-) – Stud & Thumb Nut, M12 (*Pitch 0.75 mm*)
5. DC Side Grounding Connector marked ⏚ – Hole Dia 6.5mm for wire sizes up to 25 mm² (*AWG #4*). Set Screw M-8. This is internally connected to the metal chassis of the unit.
6. RJ-45 Jack *[Pinout at ⑦ and at Fig 3.13]* is used for the following:
i. Connecting Battery Temperature Sensor EVO-BCTS (*See Fig 2.5)* for Lead Acid Batteries (*See Section 3.15*)
ii. Feeding potential free contact switching signal from Lithium Ion Battery Management System (*BMS*) to stop charging / inverting *[See Sections 3.16 and 5.11.2]*
7. RJ-45 Jack for EVO-RC Remote Control
8. Air inlet vents for 2 internal cooling fans [Additional air inlet vents at the bottom (*not shown*)]
9A, 9B. RJ-45 Jacks for Communication Ports "COMM 1" and "COMM 2" - For RS-485 networking and MODBUS Serial Communication Protocol
9C, 9D. RJ-45 Jacks for Communication Ports "COM 3" and "COM 4" - For "CANbus" Serial Communication Protocol (*for future use*)
10A to 10C. Knock outs for AC inlet/exit wiring entry [Diameter: 27.8mm / 1 3/32" for ¾" conduit/fittings]
11. ON/OFF Push Button
12. Green LED "ON"
13. Red LED "Fault"
14. Output Terminals for Status Relay - Screw M 2.5; Wire size: up to 4 mm² / AWG #12

- Contact ratings: 125 VAC / 30 VDC ; 3 A
- NO (*Normally Open*)
- Common
- NC (*Normally Closed*)

(i) When the Relay is OFF, "NO" and "Common" contacts are open and "NC" and "Common" contacts are closed.
(ii) When the Relay is ON, "NO" and "Common" contacts are closed and "NC" and "Common" contacts are open.

15. +12V Input Terminals for "Remote ON/OFF" (*9 to 15V, 3mA*) - Screw M 2.5; AWG #30 to #12
16. Output Terminals for +12.5 to 11.5 VDC source (*up to 100 mA*) [*available only when the unit is ON*] - Screw M 2.5; Wire size: up to 4 mm² / AWG#12
17. Pinout of RJ-45 Jack marked "Batttery Temp. Sensor" ⑥
18. Removable Top Cover: fixed with 8 screws - M4 (*Pitch 0.7mm*) x 4mm

Fig 2.1 Layout-Front

2.2 MAIN UNIT: LAYOUT-BACK (FIG 2.2)

Legend for Fig 2.2

1. Air outlet vents for 2 internal fans



Fig 2.2 Layout-Back

2.3 MAIN UNIT: LAYOUT-AC SIDE (FIG 2.3)

Legend for Fig 2.3

1. Cover plate for pocket for AC Input/Output terminals
2. Pocket for AC Input/Output Terminals (*behind cover plate 1*)
3. AC Input/Output Terminal Block
- Terminal hole diameter: 6mm for up to AWG #6
- Set Screw: M4

4. Grid Input - Line
5. Grid Input - Ground
6. Grid Input - Neutral
7. Generator Input - Line
8. Generator Input - Ground
9. Generator Input - Neutral
10. AC Output - Line
11. AC Output - Ground
12. AC Output - Neutral
13. Male/Female Insulated Quick Disconnect "QD" for disabling Output Neutral to Chassis Ground bond in Inverter Mode *[Please see Section 4.5.1(c) and Fig 3.12]*

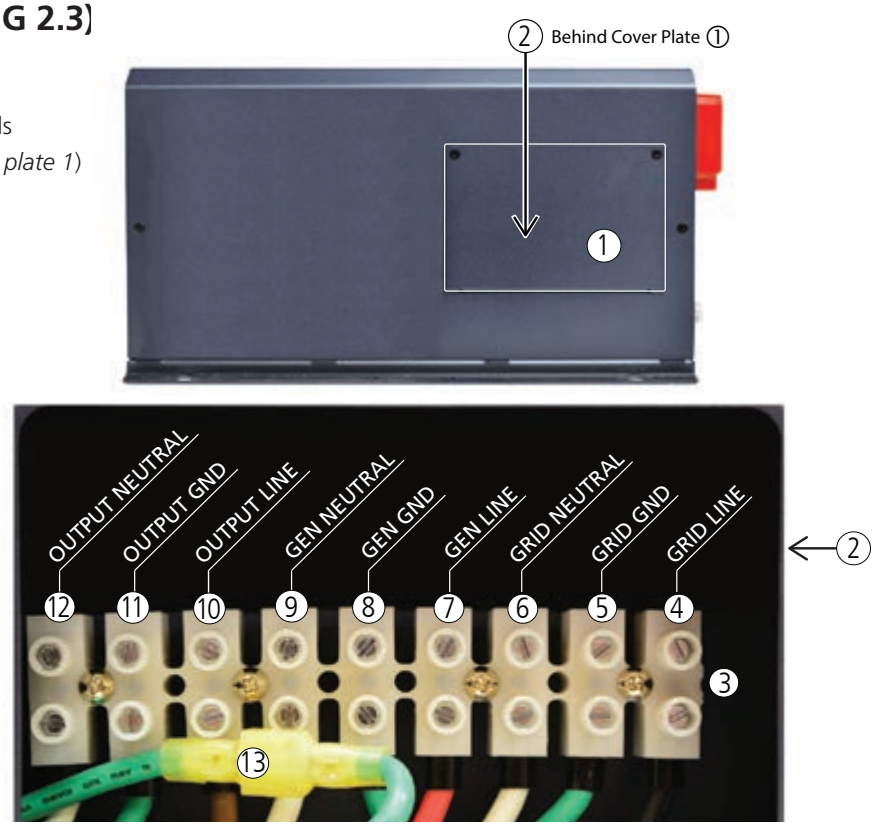


Fig 2.3 Layout-AC Side (Behind Cover Plate 1)

2.4 REMOTE CONTROL EVO-RC (FIG 2.4) [OPTIONAL]

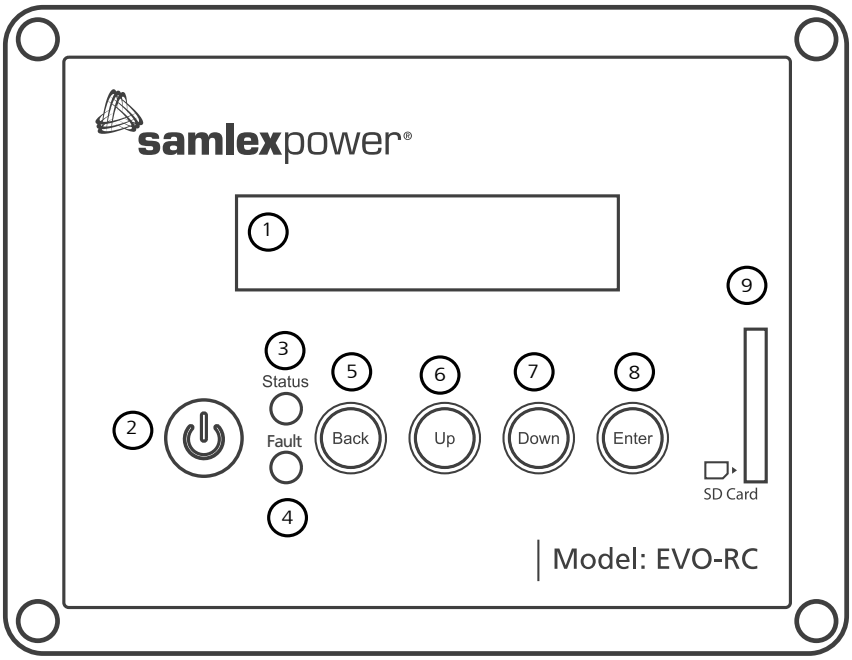


Fig 2.4(a) Optional Remote Control EVO-RC

1. LCD Screen - 2 rows of 16 characters each
2. ON/OFF Key
3. Green LED "Status"
4. Red LED "Fault"
5. Navigation Key "Back"
6. Navigation Key "Up"
7. Navigation Key "Down"
8. Navigation Key "Enter"
9. SD Card Slot - FAT16/32 format; Up to 32GB
10. RJ-45 Jack (*At the back-not shown*)
11. RJ-45 Data Cable (*Straight Wired*), 10 meter/33 feet length {*Fig 2.4(b)*}

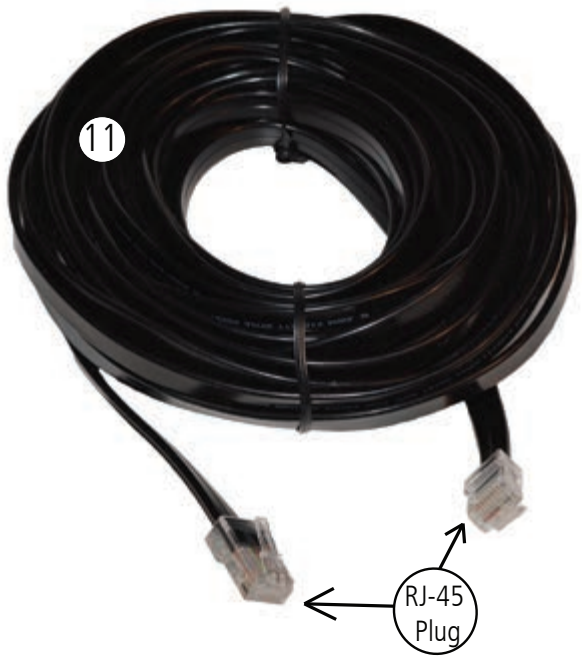


Fig 2.4(b) Cable for Remote Control

2.5 BATTERY TEMPERATURE SENSOR EVO-BCTS [FIG 2.5 (a)]

1. Temperature Sensor: Mounting hole: 10mm/0.39" suitable for 3/8" or 5/16" battery studs
2. RJ-45 Plug
3. 5 meter/16.5 ft cable

Note: Mount the sensor on the Positive or Negative terminal stud on the battery as shown in Fig 2.5(b)



Fig 2.5(a) Temperature Sensor Model EVO-BCTS



Fig 2.5(b) Temperature Sensor Installation

2.6 CONTENTS OF PACKAGE

- EVO® Inverter/Charger
- Temperature Sensor EVO-BCTS [*Fig 2.5(a)*]
- DC Terminal Covers (*1a, 1b: Fig 2.1*) (*Fitted on the unit with 2 screws each*)
- Mating Connectors (*14, 15, 16: Fig 2.1*)



2 pieces (*15, 16 Fig 2.1*)



1 piece (*14 Fig 2.1*)

- Wire End Terminals for AC Wiring (*Fig 3.11*)

MODEL	1.5 mm² AWG#16	2.5 mm² AWG#14	4 mm² AWG#12	6 mm² AWG#10
EVO-2212E	3	6	-	-
EVO-2224E	3	6	-	-
EVO-3012E	3	-	6	-
EVO-4024E	-	3	-	6

- Owner's Manual
- Quick Start Guide

SECTION 3 | Installation

3.1 SAFETY OF INSTALLATION

WARNING!

Please ensure safety instructions given under Section 1 are strictly followed.

AVERTISSEMENT !

Se il vous plaît assurer consignes de sécurité fournies à la section 1 sont strictement suivies.

3.2 OVERALL DIMENSIONS

The overall dimensions and the location of the mounting holes are shown in Fig. 3.1.

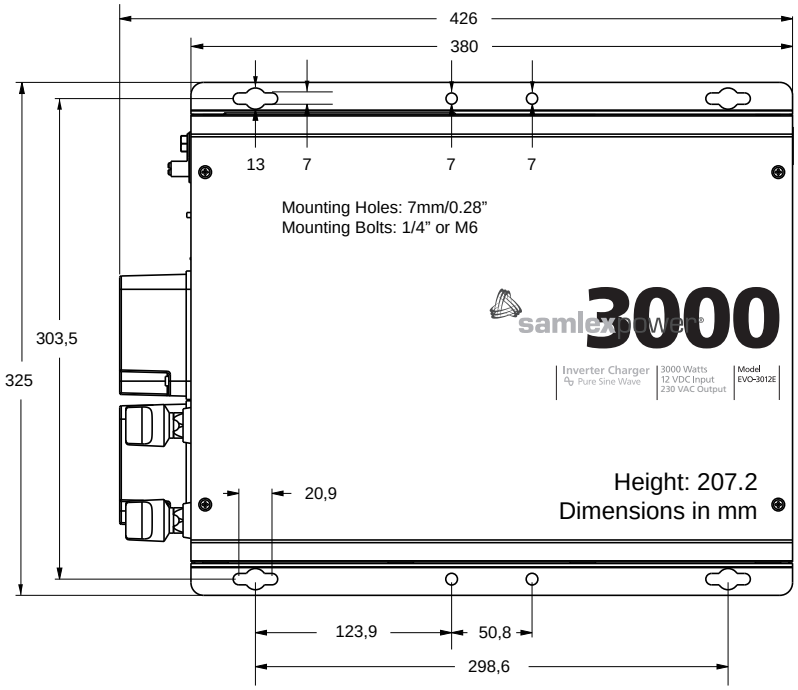


Fig. 3.1 Mounting Dimensions

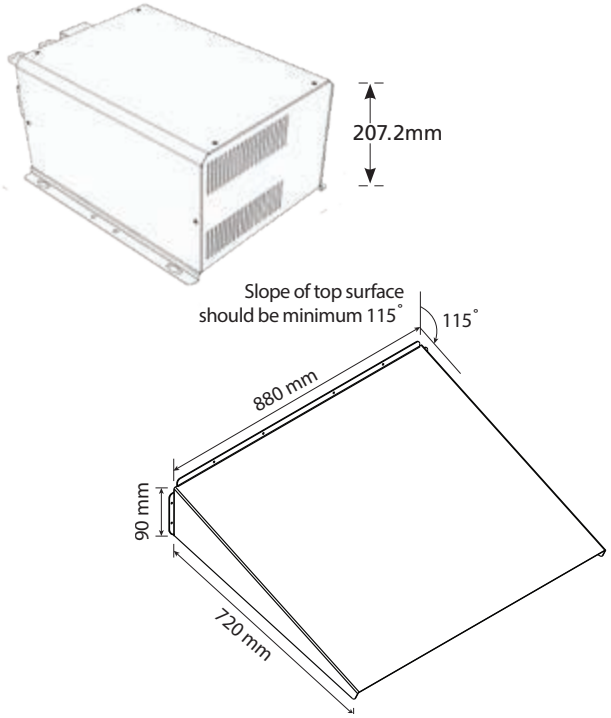


Fig. 3.1(a) Dimensions of Sloping Guard

3.3 MOUNTING OF THE UNIT

In order to meet the regulatory safety requirements, the mounting has to satisfy the following requirements:

- Mount on a non-combustible material
- The mounting surface should be able to support a weight of at least 60 Kg / 132 lbs. Use 4 pcs of 1/4" or M6 mounting bolts and lock washers
- Installation in area that has possibility of water or small objects falling from top will require use of Sloping Guard shown in Fig 3.1(a). Drawing of Drip Shield is given at Fig 3.1(a). Configurations using the Drip Shield are shown under "Mounting Orientation".

Cooling: The unit has openings on the front, bottom and back for cooling and ventilation. Ensure that these openings are not blocked or restricted. Install in cool, dry and well ventilated area.

SECTION 3 | Installation

CAUTION!

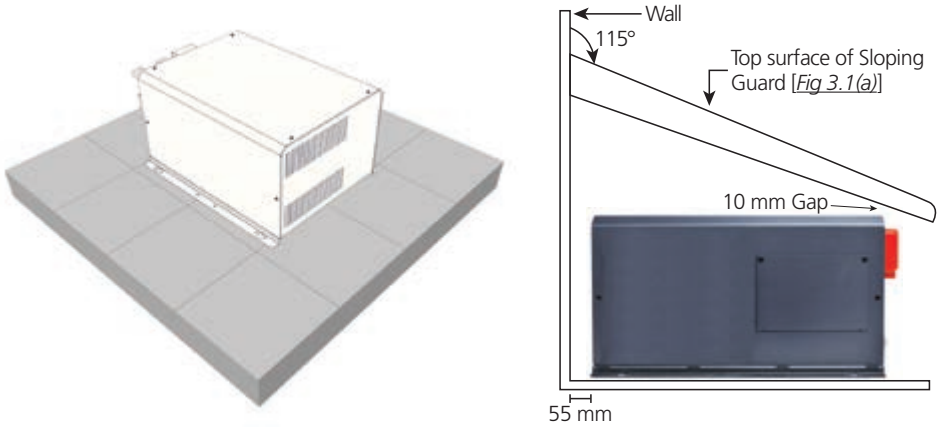
Ensure there is OVER 200 mm clear space surrounding the inverter for ventilation.

ATTENTION !

Assurer qu'il y a PLUS QUE 200 mm d'espace DÉGAGÉ entourant l'onduleur pour faciliter la ventilation.

Mounting Orientation:

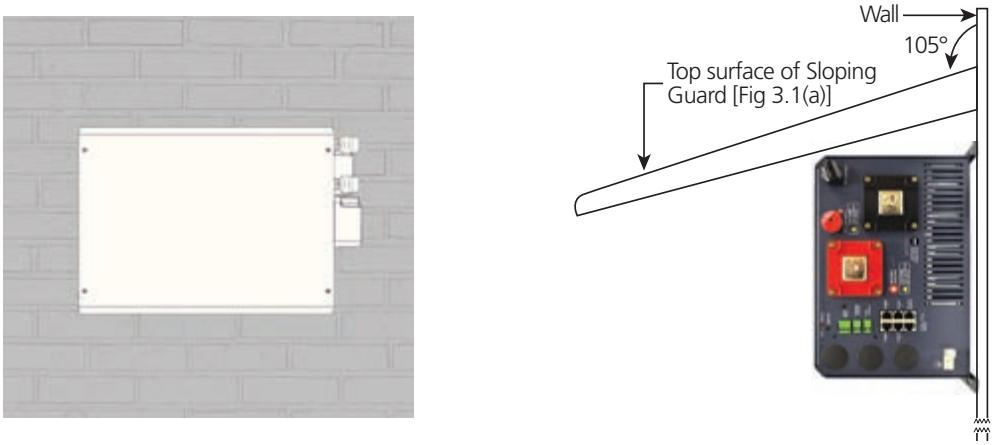
- Mount horizontally on a horizontal surface (e.g. table top or a shelf). Please see Fig. 3.2.



(a) Normal Installation **(b) Installation with Sloping Guard [Fig 3.1(a)]**

Fig 3.2 Mounting Arrangement: Horizontally On Horizontal Surface

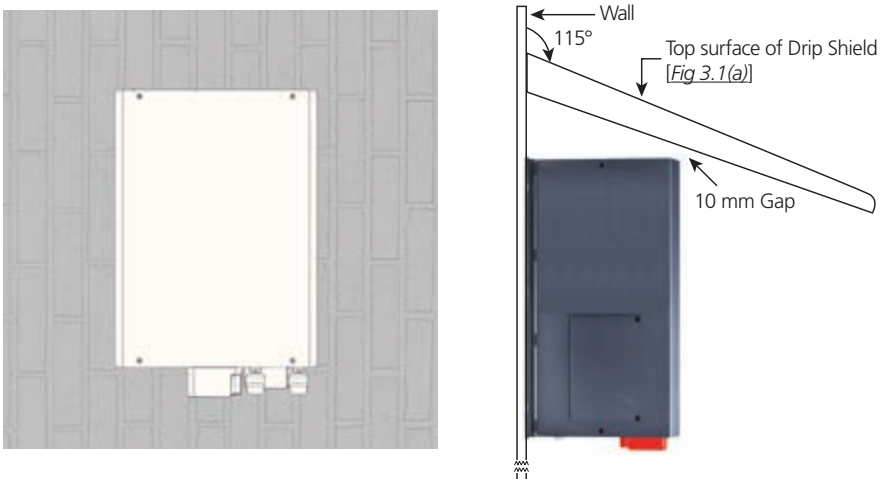
- Mount horizontally on a vertical surface (like a wall) with the fan axis horizontal. Please see Fig. 3.3.



(a) Normal Installation **(b) Installation using Sloping Guard [Fig 3.1(a)]**

Fig 3.3 Mounting Arrangement 1: On Vertical Surface

- Mount vertically on a vertical surface, see Fig. 3.4. Protect against possibility of small objects or water entering the ventilation openings on the top. (If necessary, install a suitable Sloping Guard [Fig 3.1(a)], at least 200mm from the top surface). Also, ensure there is no combustible material directly under the unit.



(a) Normal Installation **(b) Installation using Sloping Guard [Fig 3.1(a)]**

Fig 3.4 Mounting Arrangement 2: On Vertical Surface

3.4 INSTALLING BATTERIES - SERIES AND PARALLEL CONNECTION

Battery packs are normally available in voltages of 2 V, 4 V, 6 V, 8 V and 12 V and with different Ah capacities. A number of individual battery packs can be connected in series and in parallel to form a bank of battery packs with the desired increased voltage and capacity.

3.4.1 Series Connection

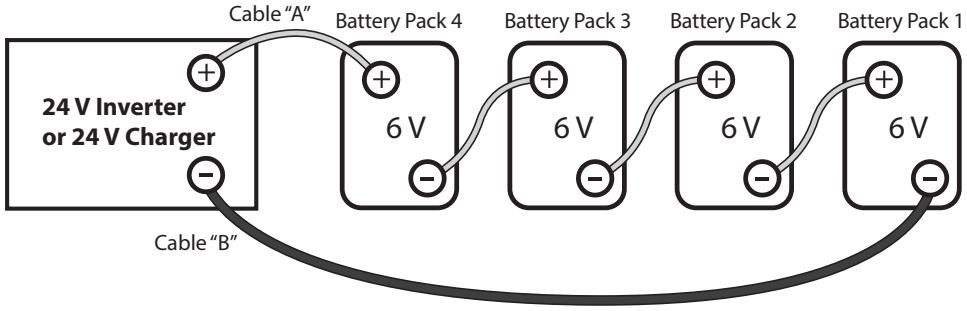


Fig 3.5 Series Connection

When two or more battery packs are connected in series, their voltages add up but their Ah capacity remains the same. Fig. 3.5 shows 4 pieces of 6 V, 200 Ah battery pack connected in series to form a battery bank of 24 V with a capacity of 200 Ah. The Positive terminal of battery pack 4 becomes the positive terminal of the 24 V bank. The Negative terminal of battery pack 4 is connected to the Positive terminal of batter pack 3. The Negative terminal of battery pack 3 is connected to the Positive terminal of battery pack 2. The Negative terminal of battery back 2 is connected to the Positive terminal of battery pack 1. The Negative terminal of battery pack 1 becomes the Negative terminal of the 24 V battery bank.

3.4.2 Parallel Connection

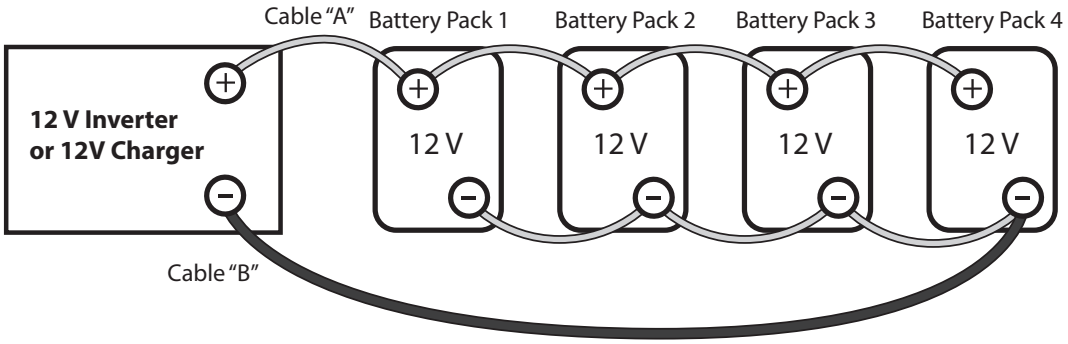


Fig 3.6 Parallel Connection

When two or more battery packs/banks are connected in parallel, their voltage remains the same but their Ah capacities add up. Fig. 3.6 above shows 4 pieces of 12 V, 100 Ah battery packs/banks connected in parallel to form a battery bank of 12 V with a capacity of 400 Ah. The four Positive terminals of battery packs/banks 1 to 4 are paralleled (*connected together*) and this common Positive connection becomes the Positive terminal of the 12 V bank. Similarly, the four Negative terminals of battery packs/banks 1 to 4 are paralleled (*connected together*) and this common Negative connection becomes the Negative terminal of the 12 V battery bank.

3.4.3 Series – Parallel Connection

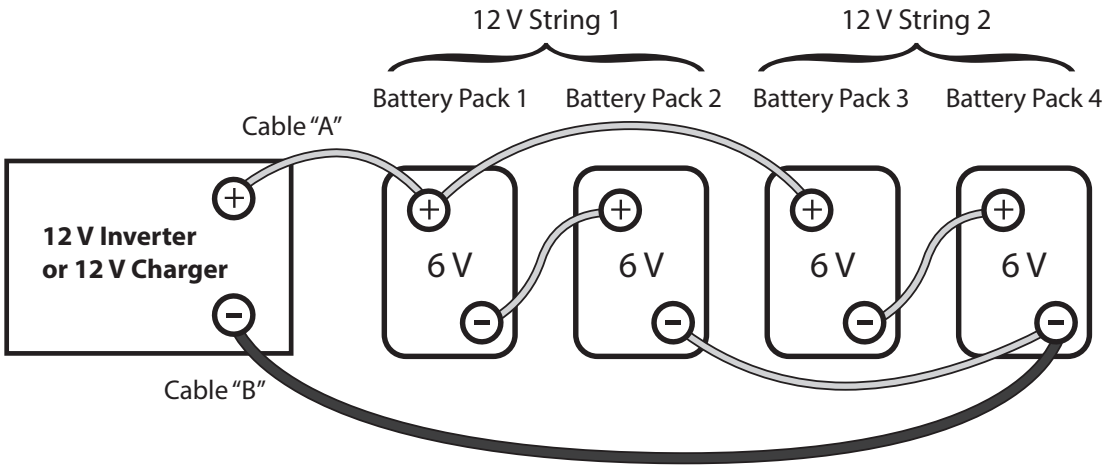


Fig. 3.7 Series-Parallel Connection

Figure 3.7 shows a series – parallel connection consisting of four 6 V, 200 Ah battery packs to form a 12 V, 400 Ah battery bank. Two 6 V, 200 Ah battery packs, Battery Packs 1 and 2 are connected in series to form a 12 V, 200 Ah battery bank (*String 1*). Similarly, two 6 V, 200 Ah battery packs, Battery Packs 3 and 4 are connected in series to form a 12 V, 200 Ah battery bank (*String 2*). These two 12 V, 200 Ah Strings 1 and 2 are connected in parallel to form a 12 V, 400 Ah bank.

3.4.4 Wiring Order in Parallel Connection of Batteries

CAUTION!

When 2 or more battery packs/battery strings are connected in parallel and are then connected to inverter/charger (*See Figs 3.6 and 3.7*), attention should be paid to the manner in which the inverter/charger is connected to the battery bank. Please ensure that if the Positive output cable of the inverter/charger (*Cable "A"*) is connected to the Positive battery post of the first battery (*Battery Pack 1 in Fig 3.6) or to the Positive battery post of the first battery string (Battery Pack 1 of String 1 in Fig. 3.7*), then the Negative output cable of the inverter/charger (*Cable "B"*) should be connected to the Negative battery post of the last battery (*Battery Pack 4 as in Fig. 3.6*) or to the Negative Post of the last battery string (*Battery Pack 4 of Battery String 2 as in Fig. 3.7*).

This connection ensures the following:

- The resistances of the interconnecting cables will be balanced.
- All the individual batteries/battery strings will see the same series resistance.
- All the individual batteries will charge/discharge at the same charging/discharging current and thus, will be charged/discharged to the same state at the same time.
- None of the batteries will see an overcharge/overdischarge condition.

If the Positive output cable of the inverter/charger (*Cable "A"*) is connected to the Positive battery post of the first battery (*Battery Pack 1 in Fig. 3.6*) or to the Positive battery post of the first battery string (*Battery Pack 1 of String 1 in Fig. 3.7*), and the Negative output cable of the inverter/charger (*Cable "B"*) is connected to the Negative battery post of the first battery (*Battery Pack 1 as in Fig. 3.6*) or, to the Negative Post of the first battery string (*Battery Pack 1 of Battery String 1 as in Fig 3.7*), the following abnormal conditions will result:

- The resistances of the connecting cables will not be balanced.
- The individual batteries will see different series resistances.
- All the individual batteries will be charged/discharged at different charging/discharging current and thus, will reach fully charged/discharged state at different times.
- The battery with lower series resistance will take shorter time to charge/discharge as compared to the battery which sees higher series resistance and hence, will experience over charging/over discharging and its life will be reduced.

ATTENTION !

Lorsque 2 blocs-batteries / chaînes de batteries ou plus sont connectés en parallèle et sont ensuite connectés à l'onduleur / chargeur (voir les figures 3.6 et 3.7), il convient de prêter attention à la manière dont l'onduleur/ chargeur est connecté au groupe de batteries. Veuillez vous assurer que si le câble de sortie positive de l'onduleur /chargeur (câble «A») est connecté à la borne positive de la batterie de la première batterie (bloc-batterie 1 sur la figure 3.6) ou à la borne positive de la batterie de la première chaîne de batteries (Battery Pack 1 of String 1 in Fig. 3.7), puis le câble de sortie négatif de l'onduleur / chargeur (câble «B») doit être connecté à la borne de batterie négative de la dernière batterie (Battery Pack 4 comme sur la Fig. 3.6) ou à la borne négative de la dernière chaîne de batteries (bloc de batteries 4 de la chaîne de batteries 2 comme sur la Fig. 3.7).

Cette connexion assure la suivante:

- *Les résistances des câbles interconnectés seront équilibrées.*
- *Tous les batteries/ fils de batterie dans la série auront la même résistance.*
- *Toutes les batteries individuelles vont recharger au même courant, ainsi elles seront rechargées à l'état pareille, au même temps.*
- *Aucune des batteries auront une condition de surcharge.*

Si le câble de sortie positif de l'onduleur / chargeur (câble «A») est connecté à la borne positive de la batterie de la première batterie (batterie 1 sur la Fig. 3.6) ou à la borne positive de la batterie de la première chaîne de batteries (batterie 1 de la chaîne 1 sur la figure 3.7), et le câble de sortie négatif de l'onduleur / chargeur (câble «B») est connecté à la borne négative de la batterie de la première batterie (bloc-batterie 1 comme sur la figure 3.6) ou, à la borne négative de la première chaîne de batteries (bloc-batterie 1 de la chaîne de batteries 1 comme sur la figure 3.7), les conditions anormales suivantes se produiront:

- *Les résistances des câbles interconnectés seront pas équilibrées.*
- *Tous les batteries/ fils de batterie dans la série n'auront pas la même résistance.*
- *Toutes les batteries individuelles vont recharger à des courants différentes, ainsi elles atteindront un état de rechargement complèt mais en décalage.*
- *La batterie ayant le moins de résistance dans la série prendrait moins de temps pour être rechargée comparé aux autres batteries. Alors elle serait surchargée et, en conséquence aurait une vie plus courte.*

3.5 DC SIDE CONNECTIONS

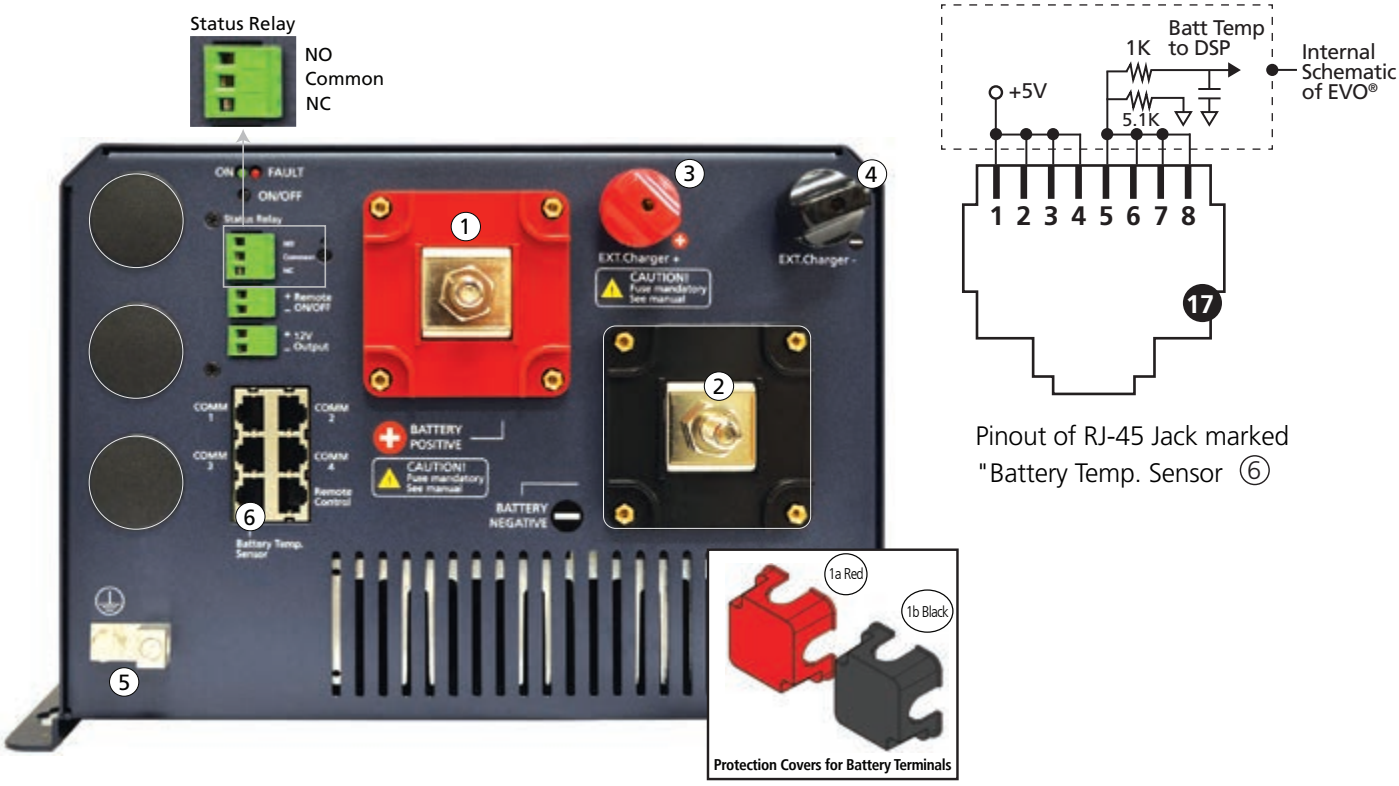


Fig 3.8 D.C Side Connections

LEGEND FOR FIG 3.8

1. Battery Positive (+) Input Connector – M10 x 1.50 Nut & Bolt (*RED Protection Cover 1(a) is removed*)

1a. RED Protection Cover For Battery Positive (+) Input Connector

2. Battery Negative (-) Input Connector – M10 x 1.50 Nut & Bolt (*Black Protection Cover 1(b) is removed*)

2a. Black Protection Cover for Battery Negative (-) Input Connector

3. External Charger (+) or DC I/O (+) – M12 x 0.75 Thumb Nut & Bolt

4. External Charger (-) or DC I/O (-) – M12 x 0.75 Thumb Nut & Bolt

5. DC Side Grounding Connector – Hole Dia 6.5mm for up to 25mm² (*AWG #4*). Set Screw M-8. This is internally connected to the metal chassis of the unit

6. RJ-45 Jack for Battery Temperature Sensor EVO-BCTS

17. Pinout of RJ-45 Jack marked "Battery Temp. Sensor" ⑥

3.5.0 Making DC Side Connections

The following DC side connections are required to be made (*see Fig 3.8*):

- Deep cycle batteries are connected to the battery input terminals (1) and (2). The terminals are provided with protective covers – RED for Positive and BLACK for Negative. Fit these covers once connections have been made. For details on sizing and charging of batteries, please refer to Section 1.4 under "General Information-Lead Acid Batteries".
- Use appropriate external fuse (*Refer to Table 3.1*) within 7" of battery Positive terminal.
- The maximum capacity of the DC I/O terminals (3 and 4, Fig. 3.8) is 50 A.

- Battery Temperature Sensor EVO-BCTS is connected to the RJ-45 Jack (6). See Fig 2.5 (a) and 2.5 (b) for details.
- DC Side Grounding Connector (5) is connected to the Earth ground/vehicle chassis ground as per recommendations at Section 3.14.

3.5.1 Preventing DC Input Over Voltage

It is to be ensured that the DC input voltage of this unit does not exceed 17.5 VDC for the 12 V battery version EVO-2212E and EVO-3012E, and 35 VDC for the 24 V battery versions EVO-2224E and EVO-4024E to prevent permanent damage to the unit.

3.5.2 Preventing Reverse Polarity On The Input Side

CAUTION!

When making battery connections on the input side, make sure that the polarity of battery connections is correct (*Connect the Positive of the battery to the Positive terminal of the unit and the Negative of the battery to the Negative terminal of the unit*). If the input is connected in reverse polarity, external DC fuse in the input side will blow and may also cause permanent damage to the inverter.

Damage caused by reverse polarity is not covered by warranty.

ATTENTION !

Au moment de faire les connexions de la batterie sur le côté entrée, assurez-vous que la polarité des connexions de la batterie est correcte (Connecter la borne positive de la batterie à la borne positive de l'unité et la valeur négative de la batterie à la borne négative de l'appareil). Si l'entrée est reliée à l'inversion de polarité, DC externe fusible dans le côté d'entrée fera fondre et peut également causer des dommages permanents à l'onduleur.

Dommages causés par l'inversion de polarité n'est pas couvert par la garantie.

3.5.3 Connection From Batteries/External Charger To The DC Input Side – Sizing of Cables And Fuses

WARNING!

The input section of the inverter has large value capacitors connected across the input terminals. As soon as the DC input connection loop (*Battery (+) terminal → Fuse → Positive input terminal of EVO® → Negative input terminal of the EVO® → Battery (–) terminal*) is completed, these capacitors will start charging and the unit will momentarily draw very heavy current that will produce sparking on the last contact in the input loop even when the unit is in powered down condition.

Ensure that the fuse is inserted only after all the connections in the loop have been completed so that sparking is limited to the fuse area.

SECTION 3 | Installation

Flow of electric current in a conductor is opposed by the resistance of the conductor. The resistance of the conductor is directly proportional to the length of the conductor and inversely proportional to its cross-section (*thickness*). The resistance in the conductor produces undesirable effects of voltage drop and heating. The size (*thickness/cross-section*) of the conductors is designated in mm^2 or by AWG (*American Wire Gauge*). Conductors thicker than AWG #4/0 are sized in MCM/kcmil.

Conductors are protected with insulating material rated for specific temperature e.g. 90 ºC /194 ºF. As current flow produces heat that affects insulation, there is a maximum permissible value of current (*called "Ampacity"*) for each size of conductor based on temperature rating of its insulation. The insulating material of the cables will also be affected by the elevated operating temperature of the terminals to which these are connected. Ampacity of cables is based on British Standard BS7671. Please see details given under "Notes for Table 3.1".

The DC input circuit is required to handle very large DC currents and hence, the size of the cables and connectors should be selected to ensure minimum voltage drop between the battery and the inverter. Thinner cables and loose connections will result in poor inverter performance and will produce abnormal heating leading to risk of insulation melt down and fire. Normally, the thickness of the cable should be such that the voltage drop due to the current & the resistance of the length of the cable should be less than 2%. Use oil resistant, multi-stranded copper wire cables rated at 90 ºC minimum. Do not use aluminum cable as it has higher resistance per unit length. Cables can be bought at a marine/welding supply store.

Effects of low voltage on common electrical loads are given below:

- **Lighting circuits - incandescent and Quartz Halogen:** A 5% voltage drop causes an approximate 10% loss in light output. This is because the bulb not only receives less power, but the cooler filament drops from white-hot towards red-hot, emitting much less visible light.
- **Lighting circuits - fluorescent:** Voltage drop causes a nearly proportional drop in light output.
- **AC induction motors -** These are commonly found in power tools, appliances, well pumps etc. They exhibit very high surge demands when starting. Significant voltage drop in these circuits may cause failure to start and possible motor damage.
- **Battery charging circuits** - These are critical because voltage drop can cause a disproportionate loss of charge current to charge a battery. A voltage drop greater than 5% can reduce charge current to the battery by a much greater percentage.

SECTION 3 | Installation

AVERTISSEMENT !

La section d'entrée de l'onduleur a des condensateurs de grande valeur qui sont connecté aux bornes d'entrées. Tant que le boucle de connexion d'entrée CC (la borne (+) de la batterie → le fusible la borne → d'entrée positive du EVO^{MC} → la borne d'entrée négative du EVO^{MC} → la borne (-) de la batterie est complèt, les condesateurs commençeront à recharger. L'appareil prendra un courant fort brièvement pour s'alimenter qui va produire une étincelle sur le dernier contact du boucle d'entrée même si l'interrupteur ON/OFF du l'onduleur est dans la position OFF.

Assurez que le fusible est insèrer seulement après que toutes les connexions sont faites dans le boucle pour que des étincelles se produisent seulement à l'endroit du fusible

Le flux du courant dans un conducteur est opposé par la résistance du conducteur. La résistance du conducteur est corrélative à la longueur du conducteur et inversement corrélatif à son diamètre (l'épaisseur). La résistance dans un conducteur produit des effects indésirables comme une perte de tension et une surchaffe. La taille (l'épaisseur) des conducteurs est classée par le AWG (American Wire Guage). Les conducteurs qui sont plus épais que la taille AWG #4/0 sont classé par MCM/kcmil.

Les conducteurs sont protègés par des matériaux isolants classés pour une température spécifique, par exemple,une température de 90 °C / 194 °F. Le flux de courant produit de la chaleur et affecte l'isolation. Alors, il y a une valeur de courant maximale (aussi appellé « L'ampacité ») qui est permise pour chaque taille de conducteur et pour la classification température de l'isolation. Les matériaux isolants des câbles seront aussi affecter par la température de fonctionnement élèvée des bornes, à qui ils sont connectés. L'ampacité des câbles est basé sur UL-1741 et la Norme Nationale Électrique (NEC)-2014. « Notes for table 3.1 »

Le circuit d'entrée CC doit subir à des courants CC forts et ainsi, il faut que la taille des câbles et des connecteurs est sélectionnée pour réduire la perte de tension entre la batterie et l'onduleur. Avec des câbles moins épais et des connexions lâches la performance de l'onduleur est diminuée et en plus, ça pourrait produire une réchauffement anormale qui risque de fondre l'isolation ou commencer un incendie. Normalement, il faut que le câble soit assez épais pour réduire la perte de tension, dû au courant/ la résistance du câble, à moins que 2%. Utilisez des câble multifiliares (fils en cuivre et résistant à l'huile) qui sont classés au moins à 90 °C. N'utilisez pas des câbles en aluminium car ils ont une résistance plus haute (par la longueur de l'unité). On peut achèter des câbles aux magasins de fournitures pour marin/soudage.

Les effets d'une faible tension pour des charges électriques communes

- ***Circuits d'allumage*** *- incandescent et Halogène Quartz: Une perte de tension à 5% causera une perte de 10% de la lumière émise. Cet effet est grâce à deux choses, non seulement l'ampoule reçoive moins de puissance mais, aussi le filament refroidi change de la chaleur-blanc à la chaleur-rouge, qui émet moins de lumière visible.*
- ***Circuits d'allumage*** - fluorescent: la perte de tension est presque proportionelle à la perte de la lumière émise.
- ***Moteurs à Induction CA*** - Souvent, Ils font partie des outils électriques, des dispositifs, pompe à puits, etc. Au démarrage, ils exigent une surcharge de puissance. Si la tension baisse trop, ils pourraient pas marcher et même seront endommager.
- ***Circuit de rechargement de batterie -*** La perte de tension pourrais causer une perte de puissance disproportionée. Par exemple, une perte de tension à 5% peut réduire le courant de charge par une pourcentage beaucoup plus grande que 5%.

3.5.4 Fuse Protection In The Battery Circuit

A battery is an unlimited source of current. Under short circuit conditions, a battery can supply thousands of Amperes of current. If there is a short circuit along the length of the cables that connects the battery to the inverter, thousands of Amperes of current can flow from the battery to the point of shorting and that section of the cable will become red-hot, the insulation will melt and the cable will ultimately break. This interruption of very high current will generate a hazardous, high temperature, high-energy arc with accompanying high-pressure wave that may cause fire, damage nearby objects and cause injury. To prevent occurrence of hazardous conditions under short circuit conditions, the fuse used in the battery circuit should limit the current (should be "Current Limiting Type"), blow in a very short time (should be Fast Blow Type) and at the same time, quench the arc in a safe manner. For this purpose, UL Class T fuse or equivalent should be used (As per UL Standard 248-15) or Type HRC per British Standard BS882/IEC60269-2. This special purpose current limiting, very fast acting fuse will blow in less than 8 ms under short circuit conditions. Appropriate capacity of the above Class T fuse or equivalent should be installed within 7" of the battery Plus (+) Terminal (Please see Table 3.1 for fuse sizing).

WARNING!

It is mandatory to use appropriately sized external fuse in the battery and External Charger Circuits. If external fuse is not used and reverse polarity connection is made by oversight, the input section of the unit will be damaged/burnt. **Warranty will be voided in such a situation.**

AVERTISSEMENT !

Il est obligatoire d'utiliser un fusible externe de taille appropriée à la batterie et les circuits chargeur externe. Si le fusible externe est pas utilisé et les inversions de polarité est faite par la surveillance , la section d'entrée de l'unité est endommagée / brûlé . ***La garantie sera annulée dans une telle situation.***

3.5.5 DC Input Connection for Battery

Battery is connected to terminals 1, 2 shown in Fig 3.8. The terminal consists of M10 Stud & Nut. Tightening torque for the nut is 70 kgf.cm (5 lbf.ft). Sizes of cables and fuses are shown in Table 3.1. Sizing is based on safety considerations specified in British Standard BS7671. See details under "Notes for Table 3.1".

3.5.6 Connection for External Charger or DC Loads

Convenient connection for an external charger (solar charge controller) or an external load (3,4 in Fig. 3.8)

- Maximum Current Rating: 50 A (not fused, not controlled)
- Tightening torque for the Thumb Nut is 35 kgf.cm (2.5 lbf.ft)

WARNING!

User must not connect DC loads exceeding the amperage for these terminals (typically 50/100 A dependent on the units), even if the battery bank can support it!

AVERTISSEMENT !

L'utilisateur ne doit pas raccorder de charges CC dont l'intensité dépasse l'ampérage nominal de ces bornes (généralement 50/100 A selon l'unité), même si le parc de batteries peut fournir cette intensité !

- Install a fuse based on your wire rating or 50 A. Whichever is less.
- Please refer to Section 5.4 for details of charging using an external charge controller.

TABLE 3.1 SIZING OF BATTERY SIDE CABLES AND EXTERNAL BATTERY SIDE FUSES

Item	Rated Continuous DC Input Current (See Note 1)	Size of External Fuse Based on DC Input Current at Column 2 (See Note 2)	90 °C Copper Conductor. Size Based on Ampacity at Column (3) or 2% Voltage Drop, whichever is Thicker (See Note 3)	
			Cable Running Distance between the Unit and the Battery (Cable Routing In Free Air)	
			Up to 5 ft.	Up to 10 ft.
(Column 1)	(Column 2)	(Column 3)	(Column 5)	(Column 6)
EVO-2212E	266 A	300 A	95 mm^2 or AWG #3/0	*120 mm^2 or AWG #4/0
EVO-2224E	133 A	150 A	35 mm^2 or AWG #2	35 mm^2 or AWG #2
EVO-3012E	373 A	400 A	120 mm^2 or AWG #4/0	*2x 95 mm^2 in parallel or 2x AWG #3/0 in parallel
EVO-4024E	266 A	300 A	95 mm^2 or AWG #3/0	95 mm^2 or AWG #3/0
External Charge Controller	= 1.25 times the Short Circuit Current of the solar panel / array	Based on Column 2	Determine the size based on guidelines given at Note 3	

* Size is based on 2% voltage drop as it is thicker than the size based on BS 7671 (See Note 3)

NOTES FOR TABLE 3.1 - SIZING OF BATTERY SIDE CABLES AND EXTERNAL BATTERY SIDE FUSES

1) Column 2 indicates the Rated Continuous DC Input Current drawn from the battery in Inverter Mode or, 1.25 times the Short Circuit Current of the solar panel/array (for Charge Controller).
2) Column 3 indicates size of external fuse not less than the Rated DC Input Current at Column 2. Next standard capacity is to be used.

3) Columns 5 and 6 indicate cable conductor size that is based on the following 2 considerations. Thicker conductor out of the following 2 considerations has been chosen:
   a) As per guidelines in British Standard BS 7671 - Table 4E 1A (Reference Method "C" for 2 cables). Following have been considered: (i) Ampacity = the fuse size at Column 3, (ii) Copper conductor with temperature rating of 90 °C / 194 °F, (iii) Ambient temperature of 30 °C / 86 °F and (iv) Positive and Negative cables in free air, clipped on direct to masonary or wooden wall.
   b) Voltage drop across the length of cables has been limited to 2% of 12 V / 24 V. Voltage drop has been calculated by multiplying the Rated DC Input Current (*Column 2*) and the resistance of the total length of Copper conductor (*the total length of conductor has been taken as 2 times the running distance between the unit and the battery to cover 2 lengths of Positive and Negative cable conductors*).
4) Column 3 indicates the size of external fuse in the battery circuit. It is mandatory to install this fuse within 7" of the battery Positive terminal to protect the internal DC Input Section of the unit and also to protect the battery cables against short circuit. Amp rating of the fuse is based on the following considerations:
   a) Not less than the Rated Continuous DC Input Current (*Column 2*)
   b) Closest Standard Ampere Rating of Fuse has been used
   c) Type of fuse: Fast-acting, Current Limiting, UL Class – Type "Class T" as per UL Standard 248-15 or Type "HRC" as per BS 88-2 / IEC60269-2

3.5.7 Using Proper DC Cable Termination

The battery end and the inverter end of the wires should have proper terminal lugs that will ensure a firm and tight connection. Choose lugs to fit the wire size and the stud sizes on the inverter and battery ends.

3.5.8 Reducing RF Interference

To reduce the effect of radiated interference, shield the wires with sheathing/copper foil/braiding. For details, refer to Limiting Electro-Magnetic Interference" at Section 1.3.4.

3.5.9 Taping Battery Wires Together To Reduce Inductance

Do not keep the battery wires far apart. Keep them taped together to reduce their inductance. Reduced inductance of the battery wires helps to reduce induced voltages. This reduces ripple in the battery wires and improves performance and efficiency. For details, refer to Limiting Electro-Magnetic Interference" at Section 1.3.4.

3.6 AC INPUT AND OUTPUT - LAYOUT AND CONNECTION ARRANGEMENT

AC side layout and connection arrangement are shown in Fig 3.9.

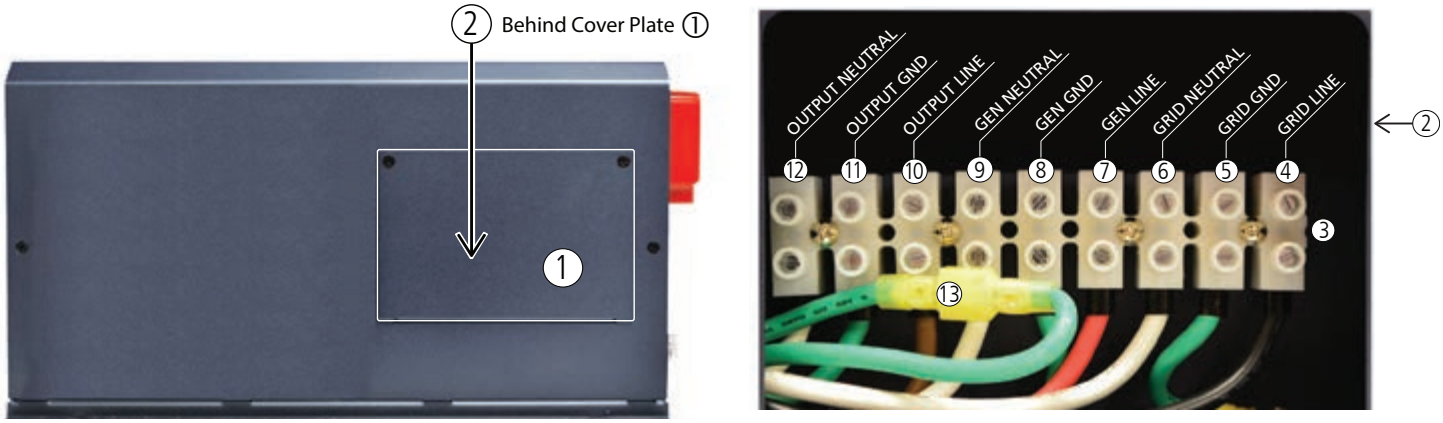


Fig 3.9 AC Input and Output

LEGEND for Fig 3.9

1. Cover plate for pocket for AC Input/Output terminals
2. Pocket for AC Input/Output Terminals (*behind Cover Plate 1*)
3. AC Input/Output Terminal Block
   - Terminal hole diameter: 6mm for up to AWG #6
   - Set Screw: M4
4. Grid Input - Line
5. Grid Input - Ground
6. Grid Input - Neutral
7. Generator Input - Line
8. Generator Input - Ground
9. Generator Input - Neutral
10. AC Output - Line
11. AC Output - Ground
12. AC Output - Neutral
13. Male/Female Insulated Quick Disconnect "QD" for disabling Ouptut Neutral to chassis Ground bond in Inverter Mode *[Please see Section 4.5.1(c) and Fig 3.12]*

CAUTION!

Make sure you use the appropriate Wire End Terminals (refer to Section 3.7.1 when connecting the wires to AC Input/Output terminal block (No. 3 in Fig. 3.9).

ATTENTION !

Assurez-vous d'utiliser les cosses de terminaison de câble appropriées (voir la section 3.7.1) lors du raccordement des fils au bornier d'entrée/sortie CA (n° 3 à la figure 3.9).

3.6.1 System Grounding and Output Neutral to Chassis Ground Bond Switching

WARNING!

- In "Inverting Mode" (*default condition*), the Neutral of the AC output of the unit gets bonded to the metal chassis of the unit through the internal "Neutral to Chassis Switching Relay" (*Relay K4 in Fig 4.1*).
- In "Charging Mode", the internal "Output Neutral to Chassis Switching Relay" (*Relay K-4 in Fig 4.1*) disconnects the Neutral of the AC output connection from the chassis of the unit. The Neutral of the AC output connection of the unit will get bonded to the Earth Ground through the Neutral to Earth Ground bond in the AC Breaker Panel/Load Center supplying Grid power/AC output connections of the generator.
- **Disabling Neutral to Ground Bond**: In some applications, the Output Neutral may be required to remain isolated from chassis/ground at all times. For this, automatic Output Neutral to chassis Ground bond can be disabled by disconnecting the Male/Female Disconnect (*13, Fig 3.9*) located in the AC Wiring Compartment.
- System grounding, as required by National/Local Electrical Codes/Standards, is the responsibility of the user/system installer.

For further details please refer to Sections 4.5.1 to 4.5.3.

AVERTISSEMENT !

- *En état de défaut, le neutre de la sortie CA de l'unité dans le "Mode de l'onduleur / décharge" obtient lié au châssis métallique de l'unité à travers la interne "Neutre à châssis relais de commutation". (Relais K-4, Fig 4.1)*
- *En «mode de charge», le «relais de commutation du neutre de sortie vers le châssis» interne (Relais K-4 sur la figure 4.1) déconnecte le neutre de la connexion de sortie CA du châssis de l'unité. Le neutre de la connexion de sortie CA de l'unité sera lié à la terre par le biais de la liaison neutre à la terre dans le panneau de disjoncteur CA/centre de charge fournissant les connexions d'alimentation du réseau/sortie CA du générateur.*
- ***Désactivation du lien neutre à mise a terre:** Dans certaines applications, il est nécessaire que la sortie neutre soit isolé du châssis/mise a terre à tout moment. Pour cela, le lien de la sortie automatique neutre au châssis/mise a terre peut être désactivé en débranchant la connexion male/femme (13 , figure 3,9) situé dans le compartiment câblage CA.*
- *Mise à la terre du système, tel que requis par la National/codes électriques locaux / normes, est de la responsabilité de l'installateur utilisateur/système.*

3.6.2 AC Input Considerations – Voltage And Frequency

The EVO® unit is designed to accept 230 VAC, 50 Hz / 60 Hz single phase AC power from grid or generator. These 230 VAC versions come preset for 50 Hz operation. Frequency can be programmed at 60 Hz using optional Remote Control EVO-RC (*or EVO-RC-PLUS. Find more detailed information on our Samlex America website: samlexamerica.com*).

3.6.3 Preventing Paralleling of the AC Output

WARNING!

The AC output of the unit cannot be synchronized with another AC source and hence, it is not suitable for paralleling on the output side. The AC output of the unit should never be connected directly to an electrical breaker panel/load center which is also fed from another AC source. Such a connection may result in parallel operation of different power sources and AC power from the other AC source will be fed back into the unit which will instantly damage the output section of the unit and may also pose a fire and safety hazard. If an electrical breaker panel/load center is fed from this unit and this panel is also required to be powered from additional alternate AC source, the AC power from the additional AC source should first be fed to a suitable Manual/Automatic Transfer Switch and the output of the transfer switch should be connected to the electrical breaker panel/load center. To prevent possibility of paralleling and severe damage to the inverter, never use a simple jumper cable with a male plug on both ends to connect the AC output of the inverter to a handy wall receptacle in the home, RV, motor home or caravan.

AVERTISSEMENT !

La sortie de courant alternatif de l'unité ne peut pas être synchronisée avec une autre source de courant alternatif et, par conséquent, il ne convient pas pour mise en parallèle du côté de la sortie. La sortie AC de l'unité ne doit jamais être connecté directement à un panneau central / de charge disjoncteur électrique qui est également alimenté par une autre source de courant alternatif. Une telle connexion peut entraîner un fonctionnement parallèle de différentes sources d'énergie et la puissance AC de l'autre source de courant alternatif est réinjecté dans l'unité qui va instantanément endommager la section de sortie de l'unité et peuvent aussi poser un risque d'incendie et de sécurité. Si un centre panneau de disjoncteur électrique / charge est alimentée à partir de cette unité et ce panneau est également nécessaire pour être alimenté à partir de suppléant supplémentaire source de courant alternatif, l'alimentation de la source de courant alternatif supplémentaire doit d'abord être introduit dans un manuel approprié / commutateur de transfert automatique et le sortie du commutateur de transfert doit être relié au centre panneau / de la charge électrique du disjoncteur. Pour éviter possibilité de mise en parallèle et de graves dommages à l'onduleur, ne jamais utiliser un câble de raccordement simple avec une fiche mâle sur les deux extrémités pour raccorder la sortie AC de l'onduleur à une prise murale à portée de main à la maison,RV, camping-car, ou caravane.

3.7 AC INPUT & OUTPUT WIRING

WARNING!

Please ensure that the AC input voltage from the Grid/Generator is connected to the AC input terminals and not to the AC output terminals and that this connection is made only when the unit is in off condition.

Please note that when the unit is powered on, a Self Test is carried out which includes a check if the AC input voltage from the Grid/Generator connection has been erroneously connected to the AC output terminals instead of AC input terminals. If this wrong connection is detected, (*voltage > 20 VAC is seen on terminals OUTPUT LINE & OUTPUT NEUTRAL at the time of switching on of the unit*), the unit will not be powered on and a message "Output failure!" will be displayed. This protection against error in connection of the AC input wiring is active only when this wrong connection is made when the unit is in off condition and is switched on subsequently.

If the AC input voltage from the Grid/Generator is erroneously connected/fed to the AC output connections when the unit is ON condition, the above protection will not work and the Inverter Section will be burnt instantaneously and may become a fire hazard.

AVERTISSEMENT !

Se il vous plaît faire en sorte que la tension d'entrée d'alimentation de la grille/générateur est reliée aux bornes d'entrée de courant alternatif, et non aux bornes de sortie à courant alternatif et que cette connexion est établie uniquement lorsque l'appareil est dans un état hors tension.

Se il vous plaît noter que lorsque l'appareil est sous tension, un auto-test est effectué qui inclut un contrôle si la tension d'entrée CA de la connexion réseau / générateur a été à tort connecté aux bornes de sortie CA à la place de bornes d'entrée AC. Si cette mauvaise connexion est détectée, (tension> 10 V ca se voit sur les bornes de sortie LINE et neutre de sortie au moment de la mise sous tension de l'appareil), l'unité ne sera pas allumé et un message "Sortie défaut" sera affiché. Cette protection contre les erreurs dans le cadre du câblage d'alimentation est active uniquement lorsque cette mauvaise connexion est établie lorsque l'appareil est en état hors et est allumé par la suite.

Si la tension d'entrée CA de la Grille/générateur est erronée connecté/nourri aux connexions de sortie CA lorsque l'appareil est en état, la protection ci-dessus ne fonctionnera pas et la Section de l'onduleur sera brûlé instantanément et peut devenir un risque d'incendie.

3.7.1 AC Input/Output Supply Connections

The AC input and output supply connections are located in a pocket protected by a cover with a removable front plate (*1,2 Fig 3.9*). Three 27.8mm / 1 3/32" diameter holes (*10 A to 10C, Fig 2.1*) have been provided for cable/conduit entry. Remove the caps covering the holes and install appropriate ¾" Trade Size Fitting for routing the AC input and output wires/conduits.

Screw down type of terminal block (*3, Fig 3.9*) is used for connecting the wires. The hole size for wire entry is 6 mm and set screw size is M4. It can accommodate conductors with solid or multi-stranded wire size range of AWG #6 to AWG #20 (*13.3 mm^2 to 0.5mm^2*).

Strip adequate insulation from the end of the wire (*Fig. 3.11*). Avoid nicking the wire when stripping the insulation. Wire End Terminals have been provided (*See Section 2.6*) for firm connection under the set screw. Insert the stripped bare end of the wire (*Fig 3.10*) into the barrel portion of the Wire End Terminal (Fig 3.11) & crimp barrel portion using suitable crimping tool.

Insert the terminated end of the wire fully into the terminal slot till it stops. Tighten the screw firmly. Tightening torque for the screws – 7 to 12 Kgf*cm / 0.5 to 0.9 lbf*ft.

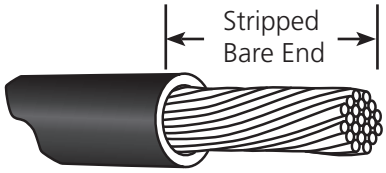


Fig 3.10 Stripped Wire End

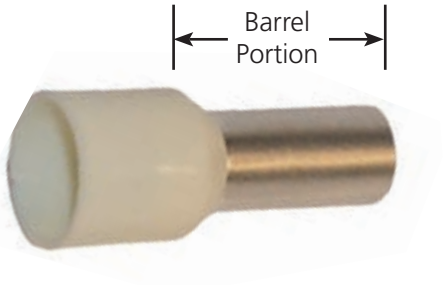


Fig 3.11 Wire End Terminal for AC Wiring

3.7.2 Tightening Torques

Tightening torques to be applied to the wiring terminals are given in Table below:

TIGHTENING TORQUES		
Battery Input Connectors	**External Charger Input Connectors**	**AC Input and Output Connectors**
70 kgf.cm (5.0 lbf.ft)	35 kgf.cm (2.5 lbf.ft)	7 to 12 kgf.cm (0.5 to 0.9 lbf.ft)

3.8 SIZING OF WIRING AND BREAKERS - AC INPUT SIDE

WARNING!

AC Breakers for the AC input circuits have NOT been provided internally. These have to be provided externally by the installer/user based on guidelines given below. Please note that guidelines given below on wire sizing and over-current protection will be superseded by the applicable National/Local Electrical Codes.

AVERTISSEMENT !

Breakers AC pour les circuits d'entrée AC ont pas été fournis en interne. Ceux-ci doivent être fournies à l'extérieur par l'installateur/utilisateur sur la base des directives données ci-dessous. Se il vous plaît noter que les directives ci-dessous sur dimensionnement des câbles et protection contre les surintensités seront remplacées par les nationaux/codes électriques locaux applicables.

3.8.1 Tables for Wire and Breaker Sizing - AC Input Side

Tables 3.2.1 to 3.2.3 provide details of wire and breaker sizing for the AC input side.

- **Table 3.2.1:** For EVO-2212E and 2224E for full rated capacity [*AC Input Current Limit ("GRID MAX CURRENT" and "GEN MAX CURRENT") programmed at 19 A for EVO-2212E and 20A for EVO-2224E*]
- **Table 3.2.2:** For EVO-3012E for full rated capacity [*AC Input Current Limit ("GRID MAX CURRENT" and "GEN MAX CURRENT") programmed at 25 A*]
- **Table 3.2.3:** For EVO-4024E for full rated capacity [*AC Input Current Limit ("GRID MAX CURRENT" and "GEN MAX CURRENT") programmed at 35 A*]

AC input side wiring and breaker sizes depend upon the maximum continuous AC input current under various operating conditions described in the succeeding paragraphs.

- The Maximum Load Current on the output side has to be limited to the rated output Amp capacity of the specific model when operating in Inverter Mode (Column 1).
- When Grid/Generator input is available and the unit is operating in Charging/Pass Through Mode, the AC Input Current will be determined as follows:
  - The maximum possible AC Input Current (*Column 4*) for a particular model will be equal to the sum of the Rated AC Side Battery Charging Current (*Column 3*) and the Rated Pass Through current (*Column 2*). Rated Pass Through Current (*Column 2*) = the Rated Output Current in Inverter Mode (*Column 1*).
  - The AC Input current in Charging / Pass Through Mode will be restricted by the maximum Amp rating of the Generator or the Amp rating of the breaker in the Grid Branch Circuit that is feeding the unit. The AC Input Current drawn by the unit can be programmed to the desired limit (*Column 5*) to match the output Amp rating of the Generator or the Amp rating of breaker in the Grid Branch Circuit. Optional Remote Control EVO-RC is required to change this limit. (*See The EVO-RC Owner's Manual - Section 4.5.2.2 for programming parameter "GRID MAX CURRENT" and Section 4.5.2.3 for programming parameter "GEN MAX CURRENT"*).
  - All the 4 models EVO-2212E, 2224E, 3012E and 4024E come with Input "GRID MAX CURRENT" and "GEN MAX CURRENT" " set at safe default value of 16 A. This default value has been used for convenience of powering the units from the standard 16 A mains power inlet plug on 230 VAC, 50 Hz motorhome, caravan, or vehicle.

TABLE 3.2.1 SIZING OF GRID AND GENERATOR INPUT WIRING AND BREAKERS FOR EVO-2212E AND EVO-2224E

Model No. and Rated Output Power in Inverter Mode	Rated AC Pass Through Current (See Note 1)	Rated AC Charging Current (See Note 2)	Total Rated AC Input Current (Columns 2 +3) (See Note 3)	Programmed Value of "GRID MAX CURRENT" and "GEN MAX CURRENT" (See Note 4)	External Breaker Size Based on Column 5 (See Note 5)	Conductor Size Based on Breaker Size at Column 6 (See Note 6)
(Column 1)	(Column 2)	(Column 3)	(Column 4)	(Column 5)	(Column 6)	(Column 7)
EVO-2212E (2200 VA, 10 A)	10 A	9 A	19 A	19 A	20 A	2.5 mm^2 or AWG #14
EVO-2224E (2200 VA, 10 A)	10 A	10 A	20 A	20 A	20 A	

TABLE 3.2.2 SIZING OF GRID AND GENERATOR INPUT WIRING AND BREAKERS FOR EVO-3012E

Model No. and Rated Output Power in Inverter Mode	Rated AC Pass Through Current (See Note 1)	Rated AC Charging Current (See Note 2)	Total Rated AC Input Current (Columns 2 +3) (See Note 3)	Programmed Value of "GRID MAX CURRENT" and "GEN MAX CURRENT" (See Note 4)	External Breaker Size Based on Column 5 (See Note 5)	Conductor Size Based on Breaker Size at Column 6 (See Note 6)
(Column 1)	(Column 2)	(Column 3)	(Column 4)	(Column 5)	(Column 6)	(Column 7)
EVO-3012E (3000 VA, 13 A)	13 A	12 A	25 A	25 A	25 A	4 mm^2 or AWG #12

TABLE 3.2.3 SIZING OF GRID AND GENERATOR INPUT WIRING AND BREAKERS FOR EVO-4024E						
Model No. and Rated Output Power in Inverter Mode	**Rated AC Pass Through Current (See Note 1)**	**Rated AC Charging Current (See Note 2)**	**Total Rated AC Input Current (Columns 2 +3) (See Note 3)**	**Programmed Value of "GRID MAX CURRENT" and "GEN MAX CURRENT" (See Note 4)**	**External Breaker Size Based on Column 5 (See Note 5)**	**Conductor Size Based on Breaker Size at Column 6 (See Note 6)**
(Column 1)	**(Column 2)**	**(Column 3)**	**(Column 4)**	**(Column 5)**	**(Column 6)**	**(Column 7)**
EVO-4024E (4000 VA, 18 A)	18 A	18 A	36 A	35 A	35 A (Use 40 A if 35 A is not available)	6 mm^2 or AWG #10

NOTES FOR TABLES 3.2.1 TO 3.2.3 - SIZING OF GRID AND GENERATOR INPUT WIRING AND BREAKERS

1) Column 2 indicates the Rated AC Pass Through Current when in Charger/Pass Through Mode (*value of this current = Rated AC Output Current in Inverter Mode*).

2) Column 3 indicates the Rated AC Side Charging Current in Charger/Pass Through Mode.

3) Column 4 indicates the total Rated AC Input Current which is the sum of the Rated AC Pass Through Current (*Column 2*) and the Rated AC Side Charging Current (*Column 3*).

4) Column 5 indicates the programmed value of the AC input current limit. The value of this current limit is called "GRID MAX CURRENT" and "GEN MAX CURRENT" for programming purposes and can be programmed using the optional Remote Control EVO-RC (*See the EVO-RC Owner's Manual - Section 4.5.2.2 for programming parameter "GRID MAX CURRENT" and Section 4.5.2.3 for programming parameter "GEN MAX CURRENT"*). The desired value can be programmed to match the available Ampere capacity of grid feeder circuit / rated Ampere capacity of the generator. The default value of "GRID MAX CURRENT" and "GEN MAX CURRENT" for all 4 models has been set at 16A based on convenience of powering the units from the standard 16A mains power inlet plug on 230 VAC, 50 Hz caravan, motorhome or RV. Details of various values of "GRID MAX CURRENT" and "GEN MAX CURRENT" used for sizing of AC wiring and breaker are given below:

   i. Table 3.2.1 is for EVO-2212E and 2224E and is based on the AC Input Current Limit ("*GRID MAX CURRENT*" *and*"*GEN MAX CURRENT*") set as follows:

      a. EVO-2212E: The AC Input Current Limit ("*GRID MAX CURRENT*" *and*"*GEN MAX CURRENT*") is set at 19 A which is its full rated AC input current requirement and is equal to the sum of the full rated AC side charging current of 9 A (*for full rated DC side charging current of 100 A*) and full rated AC pass through current of 10 A (*equal to the full rated AC output current of 10 A in Inverting Mode*).

      b. EVO-2224E: The AC Input Current Limit ("*GRID MAX CURRENT*" *and*"*GEN MAX CURRENT*") is set at 20 A which is its full rated AC input current requirement and is equal to the sum of the full rated AC side charging current of 10 A (*for full rated DC side charging current of 70 A*) and full rated AC pass through current of 10 A (*equal to the full rated AC output current of 10 A in Inverting Mode*).

   ii. Table 3.2.2 is for EVO-3012E and is based on the AC Input Current Limit ("*GRID MAX CURRENT*" *and*"*GEN MAX CURRENT*") set at 25 A which is its full rated AC input current requirement and is equal to the sum of the full rated AC side charging current of 12 A (*for full rated DC side charging current of*

130 A) and full rated AC pass through current of 13 A (*equal to the full rated AC output current of 13 A in Inverting Mode*).

iii. Table 3.2.3 is for EVO-4024E and is based on the AC Input Current Limit ("*GRID MAX CURRENT*" *and* "*GEN MAX CURRENT*") set at 36A which is its full rated AC input current requirement and is equal to the sum of the full rated AC side charging current of 18 A (*for full rated DC side charging current of 110A*) and full rated AC pass through current of 18 A (*equal to the full rated AC output current of 18A in Inverting Mode*).

5) Column 6 indicates the Amp rating of EXTERNAL breaker that is required to be installed in the Consumer unit, load center and breaker panel feeding the unit. The Amp rating of this breaker is based on the following considerations:

   a. Not less than the programmed value of the AC Input Current Limit ("*GRID MAX CURRENT*" *and* "*GEN MAX CURRENT*" *at Column 5*)

   b. Type of breaker: Standard Moulded Case Circuit Breaker (*MCCB*) for 230 VAC, 50Hz consumer unit, load center and breaker panel

6) Column 7 indicates conductor size based on the following guidelines:

   a. British Standard BS 7671 : 2008 - Requirements for Electrical Installations:

      (i) Table 4D2A for multi-core, 70 °C / 158 °F copper conductor cable
      (ii) Ambient temperature of 30 °C / 86 °F
      (iii) Reference method "B"- enclosed in conduit on a wall or in trunking, etc.
      (iv) 1 two-core cable with Protective Earth (*PE*) conductor
      (v) Conductor temperature rating has been taken as 70 °C / 158 °F to meet 70 °C / 158 °Fmaximum temperature of MCCB terminals as per BS EN-60947-2

   b. Current carrying capacity = the MCCB rating at Column 6

3.9 SIZING OF WIRING AND BREAKERS - AC OUTPUT SIDE

WARNING!

AC Breakers for the AC output circuits have NOT been provided internally. These have to be provided externally by the installer/user based on guidelines given below. Please note that guidelines given below on wire sizing and over-current protection will be superseded by the applicable National/Local Electrical Codes.

AVERTISSEMENT !

Breakers AC pour les circuits d'entrée AC ont pas été fournis en interne. Ceux-ci doivent être fournies à l'extérieur par l'installateur / utilisateur sur la base des directives données ci-dessous. Se il vous plaît noter que les directives ci-dessous sur dimensionnement des câbles et protection contre les surintensités seront remplacées par les nationaux/codes électriques locaux applicables.

3.9.1 Tables for Wire and Breaker Sizing - AC Output Side

Table 3.3 provides details of wire and breaker sizing for the AC output side.

AC wiring and breaker sizes on the AC output side are required to be determined by the Rated Load Current when operating in Inverter Mode (*Column 1*).

Table 3.3 SIZING OF AC OUTPUT WIRING AND BREAKERS

Model No. and Rated Output Power in Inverter Mode (Column 1)	Rated AC Output Current in Inverter Mode (See Note 1) (Column 2)	External Breaker Size Based on Column 2 (See Note 2) (Column 3)	Conductor Size Based on External Breaker Size at Column 3 (See Note 3) (Column 4)
EVO-2212E (2200 VA, 10 A)	10 A	10 A	1.5 mm^2 or AWG #16
EVO-2224E (2200 VA, 10 A)	10 A	10 A	1.5 mm^2 or AWG #16
EVO-3012E (3000 VA, 13 A)	13 A	16 A	1.5 mm^2 or AWG #16
EVO-4024E (4000 VA, 18 A)	18 A	20 A	2.5 mm^2 or AWG #14

NOTES FOR TABLE 3.3 - AC OUTPUT WIRING AND BREAKERS

1) Column 2 indicates the Rated AC Output Current in Inverter Mode

2) Column 3 indicates the Amp rating of EXTERNAL breaker that is required to be installed in the load consumer unit, center and breaker panel that is being fed from the AC output from this unit. Amp rating of the breaker is based on the following considerations:

   a) Not less than the rated output current at Column 2
   b) Type of breaker: Standard Moulded Case Circuit Breaker (MCCB) for 230 VAC, 50 Hz consumer unit, load center and breaker panel

3) Column 4 indicates conductor size based on the following guidelines:

   a. British Standard BS 7671: 2008 - Requirements for Electrical Installations:

      (i) Table 4D2A for multi-core, 70 °C / 158 °F copper conduct cable
      (ii) Ambient temperature of 30 °C / 86 °F
      (iii) Reference method "B"- enclosed in coduit on a wall or in trunking, etc.
      (iv) 1 two-core cable with Protective Earth (PE) conductor
      (v) Conductor temperature rating has been taken as 70 °C / 158 °F to meet 70 °C / 158 °F maximum temperature of MCCB terminals as per BS EN-60947-2

   b. Current carrying capacity = the MCCB rating at Column 3

3.10 RESIDUAL CURRENT DEVICE (RCD) PROTECTION FOR 230VAC MOTORHOME/ CARAVAN APPLICATION

When this unit is installed in 230 VAC motorhome/caravan, ensure that appropriate capacity of Residual Current Device (*RCD*) is used in the vehicle wiring system to protect all load circuits. (*Refer to Fig 3.14*)

3.11 GROUNDING TO EARTH OR TO OTHER DESIGNATED GROUND

Grounding means connecting (*bonding*) to Earth Ground or to other designated Ground. For example, in a motorhome, caravan or RV, the metal frame of the motorhome, caravan or RV is normally designated as the Negative DC Ground. Similarly, all metal portions of boats or marine craft are bonded together and called Boat Ground.

Grounding is required for (i) protection against damage due to lightning strike and (ii) protection against electric shock due to "Ground Fault". In case of EVO®, "Ground Fault" may occur due to inadvertent contact between an energized ungrounded current carrying conductor and exposed metal surface resulting in voltage getting fed to (i) the metal chassis of the EVO® or (ii) to the metal chassis of the devices connected to EVO® or (iii) to the metal frame/chassis in a motorhome/caravan. When this energized exposed surface is touched, the voltage will drive current through the body to Earth Ground producing electric shock. When properly grounded to Earth Ground (*or Frame/Chassis Ground in motorhome or caravan*), the Leakage Current Protection Device (like RCD, GFCI etc.) or Over Current Protection Device (*like Circuit Breaker or Fuse*) will trip and interrupt the circuit feeding power from the AC source (*EVO®/Grid/Generator*) or the DC source (*12 V / 24 V battery*). Proper grounding will ensure that all exposed metal surfaces will have equal potential and will be bonded to (i) a single common Earth Ground point i.e. the Ground Rod/buried metallic water/gas pipe at the premises or (ii) the Frame/Chassis Ground in a motorhome/caravan.

Please read the following on-line White Papers for complete understanding of Grounding at www.samlexamerica.com (Home > Support > White Papers):

- "Grounding System and Lightning/Ground Fault Protection"

3.12 GROUNDING ARRANGEMENT IN EVO® SERIES

Schematic at Fig 3.12 illustrates typical grounding arrangement of EVO® Series for shore based installations with TN-C-S / Protective Multiple Earthing (PME) Power Distribution System. Internally, EVO® consists of AC and DC Sections isolated by a transformer (*Fig 3.12*). Both these sections are required to be grounded appropriately.

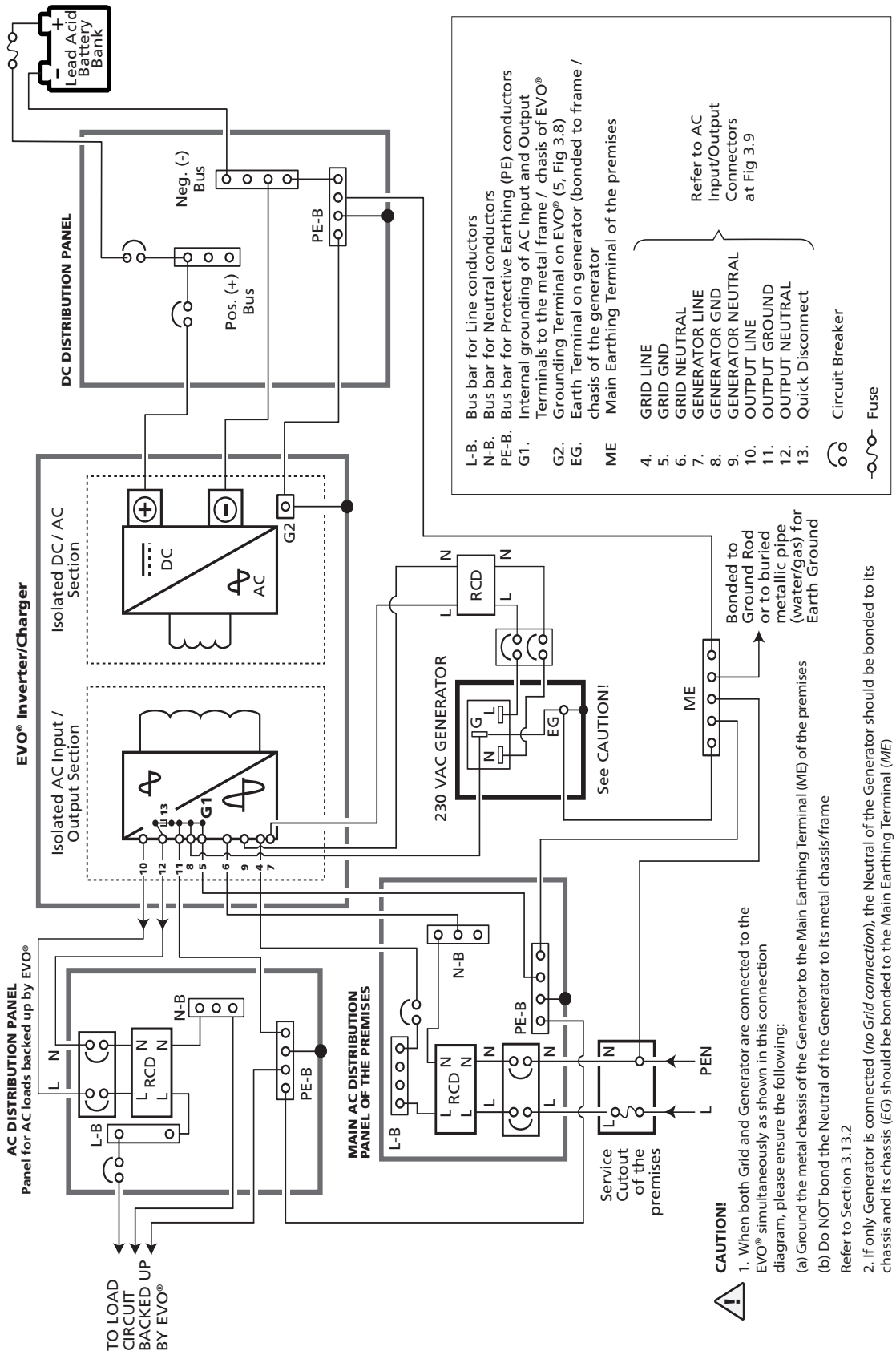


Fig 3.12 Grounding Arrangement for Shore Based Installation - Both Grid and Generator Connected to EVO®

3.13 AC SIDE GROUNDING

3.13.1 AC Side Grounding For Typical Shore Based Installations using TN-C-S/PME Distribution System (Please see Fig. 3.12)

Please refer to Fig 3.12 which shows typical grounding arrangement for shore based installation where both the Grid and Generator are simultaneously connected to the EVO®.

- The bus bars for Protective Earth (PE) conductors "PE-B" located in (i) the Main AC Distribution Panel of the Premises (ii) the DC Distribution Panel and (iii) the AC Distribution Panel for AC Loads Backed Up by EVO® are all electrically bonded to the "Main Earthing Terminal" of the premises "ME" which, in turn, is bonded to the Earth Ground through the Ground Rod or through the buried metallic pipe (*water / gas*). Similarly, the Earthing Terminal "EG" of the Generator is also bonded to the Earth Ground through the Main Earthing Terminal of the Premises "ME".
- The terminals for AC Input Ground of EVO® {*Grid GND (5) and GEN GND (8)*} and the terminal for AC Output Ground {*OUTUT GND (11)*} of EVO® are all internally bonded to the metal frame/chassis of the EVO® (G1)
- For proper operation of the Residual Current Device (RCD) on the output side of the generator, it is to be ensured that the Neutral of the generator is either bonded internally to the frame/chassis of the generator or externally to the Earthing Terminal "EG" on the generator. This will create a Neutral to Earth Ground bond in the generator (*Neutral of generator → Frame / chassis of generator → Earthing Terminal "EG" on the generator → Main Earthing Terminal "ME" of the Premises → Earth Ground*). Also, this will ensure that if a ground fault occurs, leakage current is able to return back to the Neutral of generator winding through the Earth ground path for tripping of the RCD.

For Typical Mobile Installation (*Please refer to Fig. 3.15*)

- All structural metallic parts of the frame of the motorhome/caravan which are accessible from within the motorhome/caravan are electrically bonded together to ensure protective equi-potential surfaces. Any such electrically bonded structural metallic parts is termed "chassis" and is shown by symbol "⏚"
- The Negatives of the Battery System and the alternator are bonded to the "Chassis ⏚"
- (i) The Grounding Terminal "G" of the 230 VAC, 16 A Mains Inlet/Hook-up Connector (ii) bus bar "PE-B" for Protective Earth (PE) conductors of the Distribution Panel for loads backed up by EVO® and (iii) the metallic frame/earthing terminal "EG" of the generator are all electrically bonded to the Main Earthing Terminal "ME" of the motorhome/caravan which, in turn, is bonded to the "chassis ⏚"
- The terminals for AC Input Ground of EVO® {*Grid GND (5) and GEN GND (8)*} and the terminal for AC Output Ground {*OUTPUT GND (11)*} of EVO® are all internally bonded to the metal frame/chassis of the EVO® (*This internal bonding is shown as "G1" in Fig 3.12)*
- For proper operation of RCD on the output side of the generator, it is to be ensured that the Neutral of the generator is either bonded internally to the frame/chassis of the generator or externally to the Earthing Terminal "EG" on the generator. This will ensure that if a ground fault occurs, leakage current is able to return back to the Neutral of generator winding through the "Chassis ⏚" path for tripping of the RCD.

3.13.2 Grounding and Neutral to Ground Bond Requirements Of External Generator

3.13.2.1 Grounding and Neutral to Ground Bond Requirements for Generator in Shore Based Installation when Both Grid and the Generator are Simultaneously Connected to the EVO®

As explained at Section 3.13.1 above and shown in Figs 3.12 and 3.14, the Neutral Terminals of Grid Input, Generator Input and AC Output are internally bonded to the metal chassis of the EVO® and the metal chassis of the EVO® is connected to the earth ground through the Main Earthing Terminal of the premises ("*ME*" *in Figs 3.12 and 3.14*). As the internal Transfer Relay does NOT transfer the Neutral of the Grid and Generator Inputs, the Neutral Terminal of the external Generator will get solidly connected to the Neutral of Main AC Distribution Panel of the premises (*Figs 3.12 and 3.14*). With this type of neutral connections, the external generator will NOT be considered as a separately derived system as per FPN 1 in Section 250.20(D) of NEC 2011 and hence, the neutral conductor of the external generator is **NOT** required to be grounded to earth ground through ground rod as per Section 250.30 of NEC 2011.

Small portable generators supplied with receptacles will often have the Neutral conductor bonded to the generator frame. **If the generator frame gets grounded to Earth Ground, then the generator can only be used with a Transfer Switch that transfers the Neutral also.**

Larger generators typically do not have the Neutral grounded to the frame.

CAUTION!

When connecting both the Generator and Grid *simultaneously* to the EVO® for shore based installation (*See Figs 3.12 and 3.14*), please ensure that (i) the generator chassis/frame is grounded to the Earth Ground through the Main Earthing Terminal of the premises (ME) and (ii) the Neutral conductor of the generator is **NOT** bonded to the chassis/frame of the generator. If the bond between the Neutral conductor of the generator and it's chassis/frame is not removed, RCD protected breaker supplying Grid power to the EVO® will trip due to splitting of some return Neutral current through the path: Common Neutral → Neutral of Generator → Neutral to chassis/frame bond in the Generator → Neutral to Ground bond in the Main AC Distribution Panel of the premises → Neutral of the Main AC Distribution Panel of the Premises ***(current returning through this path will not return through the RCD protected Grid breaker and the RCD will trip the breaker***).

ATTENTION !

Lors de la connexion simultanée du générateur et du réseau à l'EVO[MD] pour une installation à terre (voir les figures 3.12 et 3.14), veuillez vous assurer que (i) le châssis/châssis du générateur est mis à la terre à la terre via la borne de mise à la terre principale des locaux (ME) et (ii) le conducteur neutre du générateur **N'EST PAS** *lié au châssis / cadre du générateur. Si la liaison entre le conducteur neutre du générateur et son châssis / châssis n'est pas supprimée, le disjoncteur protégé par RCD fournissant l'alimentation du réseau à l'EVO[MD] se déclenchera en raison de la division d'un courant neutre de retour à travers le chemin: Neutre commun → Neutre du générateur → Neutre au châssis/à la liaison du châssis dans le générateur → Liaison du neutre à la terre dans le panneau de distribution CA principal des locaux → Neutre du panneau de distribution CA principal des locaux* ***(le courant retournant par ce chemin ne reviendra pas via le disjoncteur réseau protégé par RCD et le Le disjoncteur déclenchera le disjoncteur).***

3.13.2.2 Grounding and Neutral to Ground Bond Requirements in Generator When Only Generator is connected to the EVO®

CAUTION!

When only a Generator is connected to the EVO® (*no Grid connection*), it is considered to be a separately Derived System as per NEC and hence, its Neutral is required to be bonded to its metal body and the metal body has to be grounded to the Grounding Electrode (GE)/Ground Rod of the premises.

ATTENTION !

Lorsque seul un générateur est connecté à l'EVO[MD] (pas de connexion au réseau), il est considéré comme un système dérivé séparément selon NEC et, par conséquent, son neutre doit être lié à son corps métallique et le corps métallique doit être mis à la terre. l'électrode de mise à la terre (GE)/tige de terre des locaux.

3.13.3 Switching of Bonding of Output Neutral to Chassis Ground

Automatic Output Neutral to Chassis Ground bond switching arrangement has been provided in these units through "Output Neutral to Chassis Ground Bond Switching Relay" [*K4 in Fig 4.1*] to switch bonding of the Output Neutral Terminal of the Inverter Charger as follows:

- **When operating as an inverter**, the current carrying conductor of the Inverter Section that is connected to the Output Neutral Terminal of the Inverter Charger is bonded to the metal chassis of the inverter by the "Output Neutral to Chassis Ground Bond Switching Relay" [*K4 in Fig 4.1*]. As the metal chassis of the inverter is in turn bonded to the "Chassis ⏚" of the motorhome/caravan/vehicle or to the Boat Ground (*DC Negative Grounding Bus Bar and the Main AC Grounding Bus Bar are tied together in a boat and this is called the "Boat Ground"*), this current carrying conductor of the Inverter Section (*connected to the Output Neutral Terminal*) will become the Grounded Conductor (GC) or the Neutral of the Inverter Section.
- **When in Charging Mode**, the Neutral conductor of the grid power/generator will be connected to the Output Neutral Terminal of the Inverter Charger. At the same time, the "Output Neutral to Chassis Ground Bond Switching Relay" [*K4 in Fig 4.1*] will unbond (*disconnect*) the Output Neutral connector of the Inverter Charger from the chassis of the Inverter Charger. This will ensure that the Grounded Conductor (GC)/Neutral of the grid power/ generator is bonded to the earth ground at one single point at the location of the AC Power Distribution System of the motorhome, caravan and park or marina.
- **Disabling Neutral to Ground Bond**: In some applications, the Output Neutral may be required to remain isolated from the chassis/Ground at all times. For this, automatic Ouput Neutral to Chassis Ground bond can be disabled by disconnecting the Male/Female Quick Disconnect located in the AC wiring compartment. [*Please see (i) 13, Fig 3.9 and (ii) "QD" in Fig 4.1*]

3.14 GROUNDING - DC SECTION

13.14.1 General

DC side grounding involves bonding of the metal chassis of EVO®, the metal chassis of the DC Electrical Panel and the Battery Negative Terminal to the Earth Ground in shore based installation or to the metal frame / "Chassis ⏚" of the motorhome/caravan. This ensures that in case of a ground fault in the +12 V / +24 V circuit, the fuse in the +Battery line blows to clear the fault. This fuse in the +Battery line has Ampere capacity matching the rated DC input current of the EVO® in Inverter Mode i.e. 150 A to 400 A depending upon the model of the EVO® being used. The wire size used for DC side grounding should be minimum 10mm^2 or of the same size as the battery cable, whichever is thicker (Battery cable size should have minimum Ampacity ≥ the Ampere rating of this battery fuse (*150A to 400A) depending upon the model of the EVO® being used*). This recommendation on sizing of the DC Side Grounding Wire will be superseded by the National/Local Electrical Codes.

CAUTION!

As per American Boat and Yacht Council (ABYC) Safety Standard E-11 for the AC and DC Electrical Systems on Boats, the size of DC side grounding wire shall not be smaller than one size under that required for current carrying conductors supplying the device. Hence, for application on EVO® on boat/yacht, the size of the DC side grounding conductor should be of the same or one size smaller than the size of battery cable specified in Table 3.1.

ATTENTION !

Conformément « American Boat et Yacht Council » (ABYC) la norme de sécurité E - 11 , la taille du fil de mise a terre du côté CC ne doit pas être inférieure à un format sous celle requise pour les conducteurs tenant le courant pour alimenter l'appareil. Par conséquent, pour l'application EVO^{MD} sur le bateau/yacht, la taille du conducteur de mise a terre côté CC devrait être de la même ou strictement une taille plus petite que la taille du câble de batterie indiqué dans le tableau 3.1.

INFO

As described at Section 3.13, the metal frame/chassis of the EVO® (Fig 3.12, G1) is bonded to the Main Earthing Terminal "ME" for AC side grounding. It may be argued that if the metal frame/chassis of EVO® is already bonded to Main Earthing Terminal "ME" for AC side grounding, why is it necessary to provide an additional DC side grounding wiring? (Wiring that bonds DC Grounding Terminals "GE", "PE-B" and "ME" in Fig 3.1). If separate thicker grounding wire of the same size as the battery cable was not provided for the DC side grounding and there was a ground fault in the battery circuit, very large DC fault current from Battery+ would flow through the smaller size AC grounding wires to the Battery Negative through the Main Earthing Terminal "ME". These smaller size AC side grounding wires would be damaged due to very high DC side fault current (150 A to 400 A depending on the Model of the EVO® being used).

3.14.2 DC Side Grounding Arrangement for Typical Shore Based Installations using Protective Multiple Earthing (PME) or "TN-C-S" Earthing System (*Please refer to Fig. 3.12*)

A DC Side Grounding Connector (G2) (*5 in the DC side layout in Fig. 2.1)* is provided in the EVO®. This connector is internally bonded to the metal frame/chassis of the EVO®. Connect this DC Side Grounding Connector (G2) to the Negative (-) Bus in the DC Distribution Panel (*In case DC Distribution Panel is not used, connect it directly to the Battery Negative Terminal*). The wire size should be minimum 10 mm^2 or of the same size as the battery cable, whichever is thicker. Battery cable size should have minimum Ampacity ≥ the Ampere rating of the battery fuse (*150 A to 400 A*) depending on the model of the EVO® being used. The Negative Terminal of the battery gets connected to the Earth Ground through the path: Battery Negative → Negative (-) Bus in the DC distribution panel → Bus bar for Equipment Grounding Conductors (PE-B) in the DC Distribution Panel → Main Earthing Terminal "ME" → Earth Ground through Ground Rod/buried metallic water/gas pipe. Hence, the Battery Negative, the metal frame/chassis of the DC Distributional Panel and the metal frame/chassis of the EVO® will all be bonded to the Earth Ground. If there was a +12 V / +24 V ground fault in the EVO®, very large DC fault current (*150 A to 400 A depending on the Model of EVO® being used*) from Battery+ would flow through the larger DC side grounding wires to the Battery Negative and will blow the Battery fuse.

3.14.3 DC Side Grounding Arrangement for Typical Mobile Installation (*Please refer to Fig. 3.14*)

A DC Side Grounding Connector (5) is provided in the EVO®. This connector is internally bonded to the metal frame/chassis of the EVO®. Connect this DC Side Grounding Connector (5) to the Main Earthing Terminal "ME" in the motorhome/caravan. The wire size should be minimum 10mm^2 or of the same size as the battery cable, whichever is thicker. Battery cable size should have minimum Ampacity ≥ the Ampere rating of the battery fuse (*150 A to 400 A*) depending on the model of EVO® being used. The DC Side Grounding Connector (5) will get connected to the Battery Negative Terminal through the path: DC Side Grounding Connector (5) → Main Earthing Terminal "ME" → "Chassis ⏚ " of the motorhome/caravan → Battery Negative Terminal. Hence, the metal frame/chassis of the EVO® will be bonded to the Battery Negative Terminal. If there was a +12 V / +24 V ground fault in the EVO®, very large DC fault current (*150 A to 400 A depending on the Model of the EVO® being used*) from Battery+ would flow through the larger DC side grounding wire to the Battery Negative and will blow the Battery fuse.

3.15 BATTERY TEMPERATURE SENSOR: MODEL NO. EVO-BCTS

3.15.1 Temperature Compensation of Battery Charging Voltages

Please refer to Section 5.5 for detailed information on temperature compensation of battery charging voltages using Battery Temperature Sensor EVO-BCTS.

3.15.2 Constructional Details and Installation

The Temperature Sensor consists of 5 meters / 16.5 ft cable with Temperature Sensor Head for the battery end [*1 in Fig 2.5(a)*] and RJ-45 Plug [*2 in Fig 2.5(a)*] for EVO® end.

Temperature Sensor Head [*1 in Fig 2.5(a)*]: The Temperature Sensor Head is installed on the Positive/Negative battery Stud [*Fig 2.5(b)*] to monitor the temperature of the battery electrolyte. The Sensor Head contains an embedded Negative Temperature Coefficient (NTC) Resistor with 2 internal terminals "NTC+" and "NTC -". Internal terminal "NTC+" is wired to Pin 4 of the RJ-45 Plug [*2 in Fig 2.5(a)*] and internal terminal "NTC -" is wired to Pin 5 of the RJ-45 Plug.

RJ-45 Plug [2 in Fig 2.5(a)]: The RJ-45 Plug is required to be plugged into the RJ-45 jack marked "Battery Temp Sensor" on the front panel of EVO® (*6 in Fig 2.1*). Pinout of the RJ-45 jack is shown in Fig 3.13.

RJ-45 Jack on The Front Panel of EVO® (*6, Fig 2.1*) for Connecting Battery Temperature Sensor.

Pinout of this RJ-45 Jack [marked "Battery Temp Sensor" on the front panel of EVO® (*6 in Fig 2.1*)] is shown at Fig 3.13 below:

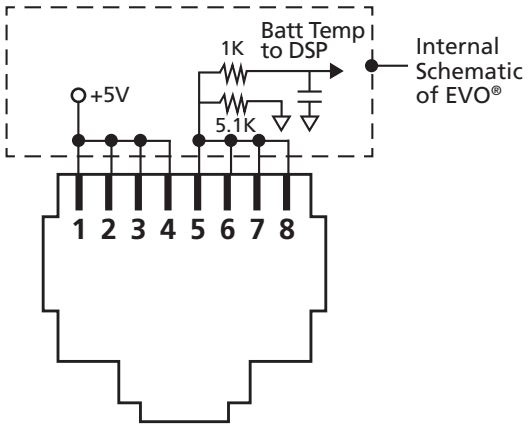


Fig 3.13 Pinout of RJ-45 Jack marked "Battery Temp Sensor" on the front panel of EVO® [*6 in Fig 2.1*].

3.16 INSTALLING CONTROL INPUT WIRING FROM LITHIUM BATTERY MANAGEMENT SYSTEM (BMS) TO ENABLE/DISABLE CHARGING OR INVERTING

Refer to Section 5.11.2 regarding "Stop Charging" or "Stop Inverting" protections for Lithium Ion Batteries when parameter "BATTERY TYPE" is programmed for Option 2 - "1=Lithium" [*See programming details at Section 4.4.2.22.2 in the EVO-RC Owner's Manual*]

The Battery Charger Section of EVO® is designed to charge 3 types of batteries - Lead Acid/Nickel Zinc (*Ni-Zn*)/ Lithium Ion. Lead Acid and Nickel Zinc (Ni-Zn) battery charging voltages are required to be compensated based on the temperature of the battery cells. Hence, Battery Temperature Sensor Model EVO-BCTS is required to be connected to the RJ-45 Jack [*6, Fig 2.1*] as explained at Section 3.15.

Charging voltages of Lithium Ion Battery are not affected by temperature and hence, *Battery Temperature Sensor Model EVO-BCTS is NOT required to be used when Lithium Ion batteries are used*. The RJ-45 Jack (*6, Fig 2.1*) can be used to feed control signals from certain Lithium Ion Battery Management Systems (*BMS*) that may have capability of enabling/disabling "Stop Charging" or "Stop Inverting" control signals for inverter chargers. This control signal is normally generated by the BMS by switching ON (*enabling*) or switching OFF (*disabling*) potential free, Drain (+) and Source (-) terminals of mini Opto Isolated Mosfet Switch [*Solid-State Relay (SSR)*]. Connect the control signal output from the BMS to RJ-45 Jack marked "Battery Temp. Sensor" [*6, Fig 2.1*] as follows:

- **BMS control signal terminal marked "+":**
  - Connect to any of Pins 1/2/3/4 [*Refer to Fig 3.13 for pinout of RJ-45 Jack. Pins 1 to 4 are internally shorted*]
- **BMS control signal terminal marked "-":**
  - Connect to any of Pins 5/6/7/8 [*Refer to Fig 3.13 for pinout of RJ-45 Jack. Pins 5 to 8 internally shorted*

3.17 SHORE BASED INSTALLATION

3.17.1 Typical Shore Based Installation - Both Grid and Generator Connected to EVO®

Fig. 3.14 illustrates a typical shore based installation.

Battery is connected to the DC input connections through an appropriate fuse in the Battery + line to protect the DC input cables against short circuit

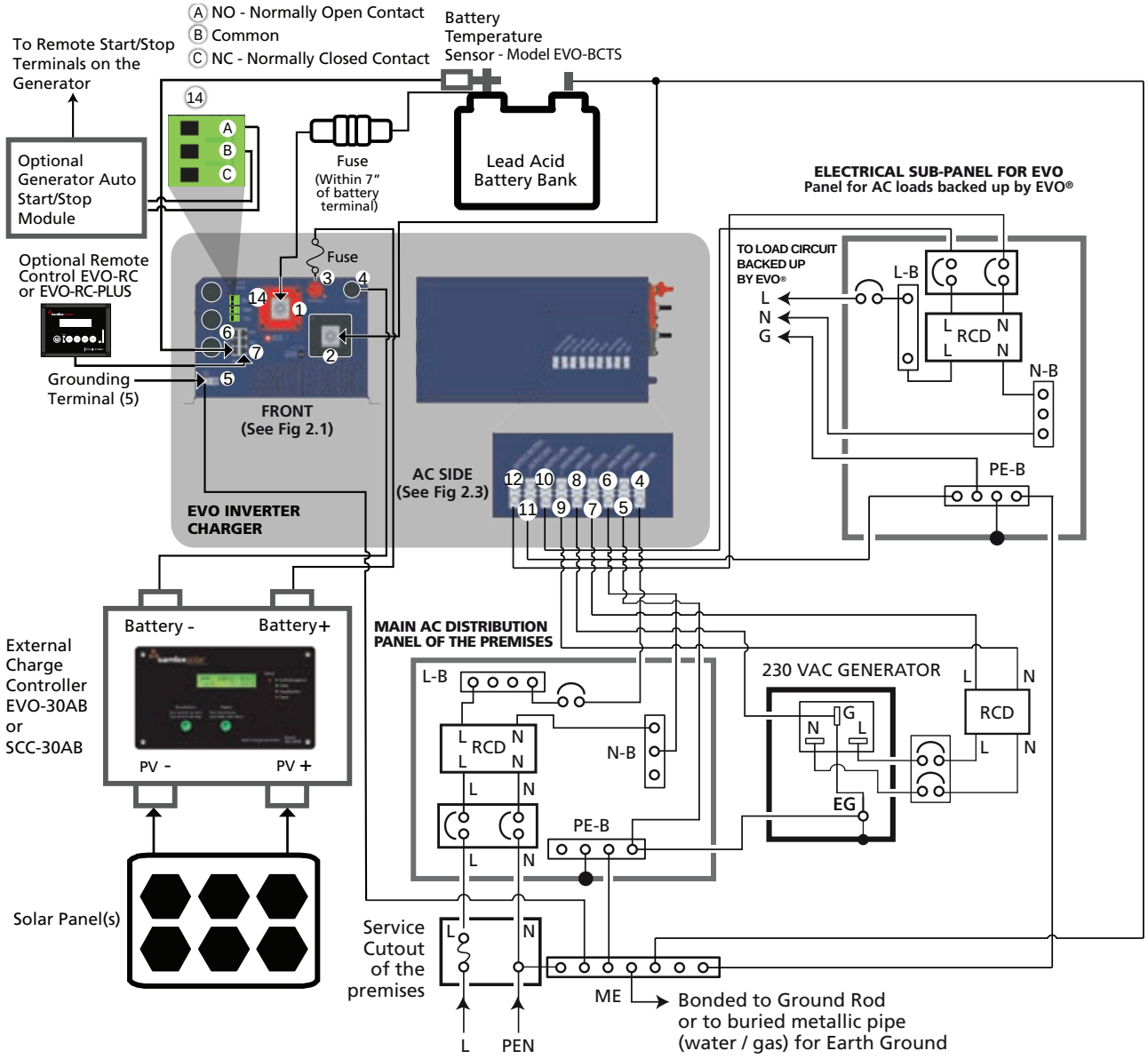
- Battery Temperature Sensor Model EVO-BCTS is installed on the Positive or Negative post of the battery and connected to the port for the Temperature Sensor
- Supplementary battery charging is being carried out through a solar array and a Charge Controller connected to the DC input provided for external battery charger
- AC input to the EVO® is fed from the Grid and Generator Panels
- AC output from the EVO® is fed to the AC Distribution Panel for AC loads backed up by EVO®
- Automatic Generator start/stop is possible. Please see Section 4.7 for details
  - Neutral of the generator is bonded to the chassis of the generator either internally or externally through the Earthing Terminal "EG" and the chassis of the generator is bonded to the Earth Ground. Path: Neutral of Generator → Earthing Terminal "EG" → Bus Bar for Protective Earthing "PE-B" → Main Earthing Terminal "ME" → Earth Ground.

CAUTIONS!

1. When connecting both the Grid and Generator simultaneously, please ensure that the Neutral of the Generator is NOT bonded to the metal chassis/frame of the Generator. See Section 3.13.2.1 for details.
2. When connecting only the Generator (*No Grid connection*), the Neutral of the Generator is *required to be bonded* to its metal chassis. See Section 3.13.2.2 for details.

ATTENTION !

1. *Lors de la connexion simultanée du réseau et du générateur, veuillez vous assurer que le neutre du générateur n'est PAS lié au châssis/cadre métallique du générateur. Voir la section 3.13.2.1 pour plus de détails.*
2. *Lorsque vous connectez uniquement le générateur (pas de connexion au réseau), le neutre du générateur doit être lié à son châssis métallique. Voir la section 3.13.2.2 pour plus de détails.*



DC SIDE OF EVO®

1. Battery Positive
2. Battery Negative
3. External Charger (+) or DC I/O (+)
4. External Charger (-) or DC I/O (-)
5. Ground Terminal
6. RJ-45 Jack for Temperature Sensor
7. RJ-45 Jack for Optional Remote Control
14. Status Relay Terminals for initiating automatic generator start / stop ("NO" & Common)

AC SIDE OF EVO®

4. GRID LINE
5. GRID GND
6. GRID NEUTRAL
7. GEN LINE
8. GEN GND
9. GEN NEUTRAL
10. OUTPUT LINE
11. OUTPUT GND
12. OUTPUT NEUTRAL

OTHER

- Circuit Breaker
- Fuse
- L-B. Bus bar for Line conductors
- N-B. Bus bar for Neutral conductors
- PE-B. Bus bar for Protective Earthing (PE) conductors
- PEN. Conductor with Protective Earthing (PE) and Neutral (N) combined
- RCD. Residual Current Device
- L. Line terminal
- N. Neutral terminal
- G. Grounding terminal
- EG. Earthing terminal on Generator (Bonded to frame)
- ME. Main Earthing terminal of the premises

Fig 3.14 Typical Shore Based Installation for TN-C-S / Protective

3.18 MOBILE INSTALLATION - GENERAL INFORMATION

3.18.1 RCD Protection For Motorhome/Caravan/Vehicle Application

WARNING!

1. When this unit is installed in a motorhome, or caravan please ensure that appropriate Residual Current Devices (*RCD*) are installed as recommended in the typical installation diagram at Fig 3.15.
2. Installation shown in Fig 3.15 is based on Section 721 of British Standard BS 7671 : 2008.
3. Please Ensure that your installation complies with the national / local Electrical Codes.

MISE EN GARDE !

1. *Lorsque l'appareil est installé dans un camping-car ou caravane s'il vous plaît assurer que les dispositifs appropriés résiduels ACTUELLES (RCD) sont installés ainsi comme recommandé dans le schéma d'installation typique à la figure 3,15.*
2. *L'installation de la figure 3,15 est basée sur l'article 721 de la norme britannique BS 7671 : 2008.*
3. *S'il vous plaît assurez-vous que votre installation se conforme aux codes électriques nationaux / locaux.*

3.18.2 Requirement Of Deep Cycle, Auxiliary Battery And Battery Isolator For Powering Inverters In Mobile Installations

Basic information on Lead Acid Batteries is given in Section 1.4 under "General Information - Lead Acid batteries".

For details, read on-line White Paper titled "Batteries, Chargers & Alternator" at: www.samlexamerica.com *(Home > Support > White Papers)*.

A motorhome/caravan/vehicle has Starter, Lighting and Ignition (*SLI*) battery. As explained under Section 1.4.2.3, SLI batteries are designed to produce high power in short bursts for cranking.

SLI batteries use lots of thin plates to maximize the surface area of the plates for providing very large bursts of current (*also specified as Cranking Amps*). This allows very high starting current but causes the plates to warp when the battery is cycled. Vehicle starting typically discharges 1%–3% of a healthy SLI battery's capacity. The automotive SLI battery is not designed for repeated deep discharge where up to 80% of the battery capacity is discharged and then recharged. If an SLI battery is used for this type of deep discharge application, its useful service life will be drastically reduced. Hence, this type of battery is not recommended for the storage of energy for inverter applications. A second deep cycle auxiliary battery must be installed in the motorhome/caravan/vehicle for powering the EVO® (*A deep cycle, auxiliary battery is shown in Fig. 3.15*).

When the second auxiliary deep cycle battery is used, a Battery Isolator is required that will allow parallel connection of the two batteries for charging when the alternator is ON and disconnecting the parallel connection when the alternator is stopped (Isolator is shown in Fig. 3.14). The capacity of the Battery Isolator should be as follows:

- **For EVO-2012E:** The maximum continuous DC current required is 266 A. The capacity of the Battery Isolator should be more than 266 A or more than the capacity of the alternator, whichever is higher
- **For EVO-2224E:** The maximum continuous DC current required is 133 A. The capacity of the Battery Isolator should be more than 133 A or more than the capacity of the alternator, whichever is higher
- **For EVO-3012E:** The maximum continuous DC current required is 373 A. The capacity of the Battery Isolator should be more than 373 A or more than the capacity of the alternator, whichever is higher
- **For EVO-4024E:** The maximum continuous DC current required is 266 A. The capacity of the Battery Isolator should be more than 266 A or more than the capacity of the alternator, whichever is higher

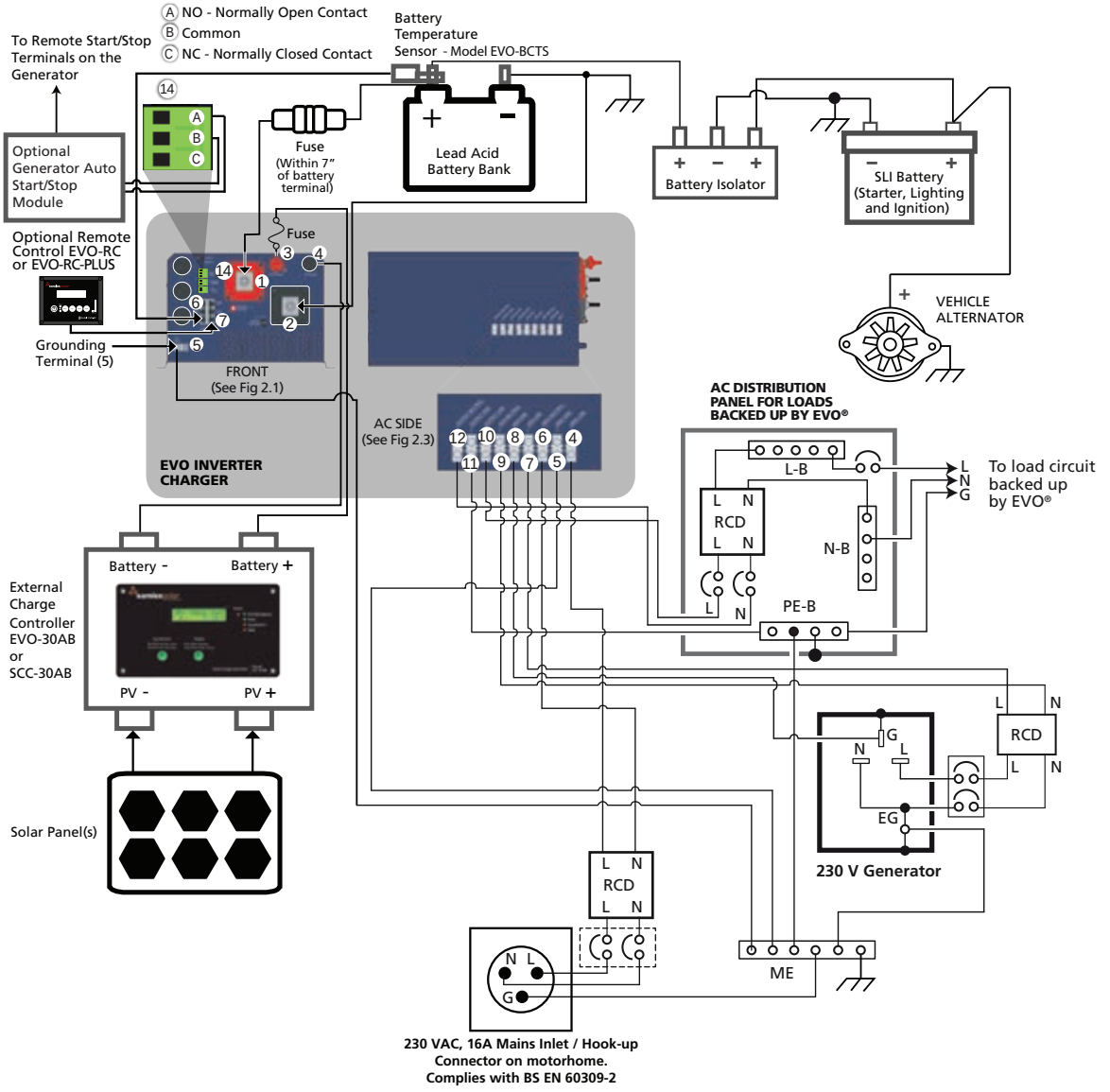
3.18.3 Requirement To Keep The Neutral Conductor Of Shore Power Isolated From The Chassis Ground Of The Motorhome/Caravan/Vehicle

As per Section 721 of British Standard BS 7671 : 2008 the Neutral conductor in electrical installations in motorhomes/caravans/vehicles is NOT bonded to the "chassis ⏚" of the motorhome/caravan/vehicle. The neutral is floating with respect to the "chassis ⏚". This is necessary for safety because if the neutral was bonded to the chassis of the RV and if the Neutral and the Hot got reversed by mistake, the chassis of the RV will be at 230 VAC with respect to the Earth Ground. If a person standing on the earth ground touches the chassis of the RV, he will be fed with 230 VAC and will receive electrical shock!

3.18.4 Typical Mobile Installation

Fig. 3.15 illustrates a typical installation on motorhome/caravan/vehicle using 230 VAC, 16 A Service Inlet for 16 A motorhome/caravan/vehicle power supply cord. The installation is based on Section 721 of British Standard BS 7671 : 2008. Please check that your installation complies with the national and local Electrical Codes.

- Auxiliary battery is connected to the DC input connections through an appropriate fuse to protect the DC input cables against short circuit
- Auxiliary battery will be charged by the alternator through the Battery Isolator
- Battery Temperature Sensor Model BTS-EVO is installed on the positive or negative post of the auxiliary battery and connected to the port for the Temperature Sensor
- Supplementary battery charging is being carried out through a solar array and a Charge Controller connected to the DC input provided for external battery charger
- AC input to the EVO® is fed from typical 230 VAC, 16 A Power Inet [*through suitable double pole breaker and RCD (Residual Current Device*] and from the generator (*through suitable breaker and RCD*)
- AC output from the EVO® is fed to the double pole Distribution Panel Board for loads backed up by EVO®
- Automatic Generator start/stop is possible. Please refer to Section 4.7 for full details.
- When using generator, please ensure the following (*Please see Fig 3.15*):
  - Neutral of the generator is bonded to the chassis of the generator either internally or externally through the Earthing Terminal "EG" and the chassis of the generator is bonded to Main Earthing Terminal "M" on the motorhome/caravan/vehicle.



DC SIDE OF EVO®

1. Battery Positive
2. Battery Negative
3. External Charger (+) or DC I/O (+)
4. External Charger (-) or DC I/O (-)
5. Ground Terminal
6. RJ-45 Jack for Temperature Sensor
7. RJ-45 Jack for Optional Remote Control
14. Status Relay Terminals for initiating automatic generator start / stop (see below)

Status Relay

NO, Common, NC → To optional Generator Auto Start/Stop Module

AC SIDE OF EVO®

4. GRID LINE
5. GRID GND
6. GRID NEUTRAL
7. GEN LINE
8. GEN GND
9. GEN NEUTRAL
10. OUTPUT LINE
11. OUTPUT GND
12. OUTPUT NEUTRAL

OTHER

- Circuit Breaker
- L-B. Bus bar for Line conductors
- N-B. Bus bar for Neutral conductors
- PE-B. Bus bar for Protective Earthing (PE) conductors
- Chassis of the motorhome / caravan / vehicle
- RCD. Residual Current Device
- L. Line terminal
- N. Neutral terminal
- G. Grounding terminal
- EG. Earthing terminal on Generator (bonded to frame)
- ME. Main Earthing terminal on the motorhome / caravan / vehicle

Fig 3.15 Typical Mobile Installation for Motorhome / Caravan / Vehicle

SECTION 4 | General Description & Principles of Operations

4.1 GENERAL DESCRIPTION

EVO® is a Hybrid Pure Sine Wave, Bi-directional, Single-Phase Inverter/Charger with a Transfer Relay that operates either as an inverter OR as a smart battery charger. It uses a common Converter Section that can work in two directions – in one direction it converts external AC power to DC power to charge the batteries using Grid or Generator (*Charging Mode*) and in the other direction, it converts DC power from the battery to AC power (*Inverting Mode*). This allows the same power components to be used in both directions resulting in high-energy transfer efficiency with fewer components. *Please note that it can NOT work in both the directions at the same time i.e. it cannot work as an inverter and as a charger at the same time.*

High performance 100 MHz DSP (*Digital Signal Processing*) type of micro-controller and Pulse Width Modulated (*PWM*) conversion circuits are used for the above implementation.

4.2 COMPONENTS OF THE SYSTEM

It consists of 3 Sections – Inverter Section, Battery Charger Section and AC Input/Transfer Relay Section. The unit is fed with the following inputs:

- Up to 2 external AC input power sources – Grid or Generator or both with PRIORITY for Grid if both Grid and Generator inputs are available at the same time
- DC Battery Source consisting of 12 V / 24 V battery bank. 4 versions of EVO® are available. 2 versions for 12 VDC battery input (*EVO-2212E and EVO-3012E*) & 2 for 24 VDC battery input (*EVO-2224E and EVO-4024E*)
- EXT Charger Connection: This is an additional DC connection to the main EVO battery terminal that functions as a Bidirectional Input/Output Node. It features a shunt for bidirectional current sensing, allowing the system to distinguish between the direction of current flow from an External Charging Source or an External DC Load. This enables the unit to perform Dynamic DC Load Compensation by automatically adjusting its internal AC charger output to maintain the programmed BULK CURRENT setting. It is rated for an external charger or load up to 50 A.

4.3 INVERTER SECTION

The Inverter Section is a heavy-duty, continuous rated, DSP micro-controller based inverter generating a pure sine wave output of 230 VAC, 50 Hz / 60 Hz (*50 Hz default*) from the DC Battery Source. It is able to supply AC power to various types of AC loads such as resistive loads (*heaters, incandescent lamps, etc.*) or reactive loads [*motors, air conditioners, refrigerators, vacuum cleaners, fans, pumps, Switched Mode Power Supplies (SMPS) used in audio / video equipment and computers, etc.*].

4.3.1 Principle of working of Inverter Section

The low DC voltage from the DC Battery Source is inverted to the AC voltage in two steps. The low DC voltage from the DC Battery Source is first converted to low frequency (*50 Hz or 60 Hz ; 50 Hz default*), low voltage synthesized sine wave AC using an H-bridge configuration and high frequency PWM (*Pulse Width Modulation*) technique. The low frequency, low voltage synthesized sine wave is then stepped up to 230 VAC pure sine wave voltage using a low frequency Isolation Transformer and filtration circuit. This type of DC to AC inversion is called Hybrid Type – a combination of low frequency and high frequency implementation. Other distinctive features of the Inverter Section are given below:

Soft Start: The inverter design incorporates "Soft Start" feature with the following advantages and protections:

- When the unit powers up, it starts in Inverting Mode first. The output voltage ramps up gradually from around 96

VAC to 230 VAC in around 200 ms. This reduces otherwise very high starting inrush current drawn by AC loads like Switched Mode Power Supplies (*SMPS*) and motor driven loads like fans, pumps, compressors etc. This will result in lower motor inrush current (*which typically can be up to 650% of the full load current of the motor*), which means lesser mechanical stresses, wear and tear and increased lifetime of the motor, coupling and fan. Additionally, the impact on the load side components is greatly reduced, meaning less likelihood of causing problematic voltage drops during starting.

Power Surge – Up to 300%:

- The inverter is able to deliver very high surge power / current of up to 300% for 1 ms followed by 200% for 100 ms. This range of high instantaneous power is delivered at the rated voltage and hence, it is able to provide very high starting torque for difficult motor driven loads like compressors and pumps that require higher Locked Rotor Current during startup.
- If the power drawn by the load exceeds the above surge ratings, the inverter protects itself by limiting the load current to 300% / 200% which results in reduction of output voltage and consequent reduction in load current. The output voltage recovers automatically when power drawn by the load drops below the above surge limits

Power Boost up to 150%: Higher percentage of rated power can be provided for limited time periods as follows:

- 150% for 5 sec
- 140% for 30 sec
- 120% for 5 min
- 110% for 30 min

4.4 DIRECT DUAL AC INPUT ARCHITECTURE

For higher reliability and redundancy, direct AC input from Grid and Generator can be fed simultaneously to separate AC Input Terminals marked GRID (4, 5, 6 in Fig 2.3) and GEN (7, 8, 9 in Fig 2.3). Only one AC source is selected at one time. When both Grid and Generator are available simultaneously, Grid is given priority. Transfer from grid to generator or from generator to grid is always routed through the inverter. Please see details under Section 4.5.3 to 4.5.6.

4.5 TRANSFER RELAY SECTION

Transfer Relay Section is used to either feed AC power to the Battery Charger Section and at the same time, pass through the AC power from the external AC input power source to the load (*As long as the external AC input power from Grid/Generator is available and is within the programmed limits of voltage and frequency*) or to transfer the load to the Inverter Section (*In case of loss of the external AC input power source or if this source is not within the programmed limits of voltage and frequency*). Typical transfer time is 16 milliseconds from Grid/Generator to Inverter and <1ms from Inverter to Grid/Generator. Heavy duty 40 A rated Transfer Relays (*K2, K3, K4 in Fig 4.1*) are used for reliable transfer of up to 300% surge power and for Neutral to Ground Bond Switching.

4.5.1 AC Transfer and Output Neutral To Chassis Ground Bond Switching

Automatic switching of bonding between the Ouput Neutral and Chassis Ground has been provided in EVO® through "Output Neutral to Chassis Ground Bond Switching Relay" (*K4 in Fig 4.1*). Switching of bonding is carried out as follows:

- When operating as an inverter, the current carrying conductor of the Inverter Section that is connected to the Output Neutral terminal (*12 in Fig 3.9*) of EVO® is bonded to the metal chassis of EVO® by the "Output Neutral to Chassis Ground Bond Switching Relay" (*K4 in Fig 4.1*). As the metal chassis of EVO® is in turn bonded to the Earth Ground (*in shore installations*) or, to the vehicle Ground (chassis of RV / motor home / caravan) or, to the Boat Ground (*DC Negative Grounding Bus Bar and the Main AC Grounding Bus Bar are tied together in a boat and this is called the "Boat Ground"*), this current carrying conductor of the Inverter Section (*connected to the output terminal*) will become the Grounded Conductor (*GC*) or the Neutral of the Inverter Section.
- When in Charging Mode, the Neutral conductor of the Grid power/Generator will be connected to the Output Neutral terminal of EVO®. At the same time, the "Output Neutral to Chassis Ground Bond Switching Relay" (*K4 in Fig 4.1*) will unbond (*disconnect*) the Output Neutral connector of EVO® from the metal chassis of EVO®. This will ensure that the Grounded Conductor (*GC*) i.e. the Neutral of the Grid power/Generator is bonded to the Earth Ground at one single point at the location of the AC Power Distribution System of the Marina/RV Park/Shore Power.
- **Disabling Neutral to Ground Bond**: In some applications, the Output Neutral of EVO® may be required to remain isolated from the chassis/Ground at all times. For this, automatic Output Neutral to Ground bond can be disabled by disconnecting the Male/Female Quick Disconnect located in the AC wiring compartment. [*Please see (i) 13, Fig 3.9 and (ii) "QD' in Figs 4.1*]

Please read the following on-line White Papers for more details at www.samlexamerica.com (Home > Support > White Papers):

- **"Neutral to Ground Switching in RV and Marine Applications"**

4.5.2 Operation of Transfer Relay and Output Neutral to Chassis Ground Bond Switching Relay

Refer to Schematic at Fig 4.1.

The Bi-directional Transformer is used as follows:

- Feeds AC output from the Inverter Section when Grid/Generator power is not available.
- Feeds Grid/Generator power to the Battery Charger Section when Grid/Generator are available.

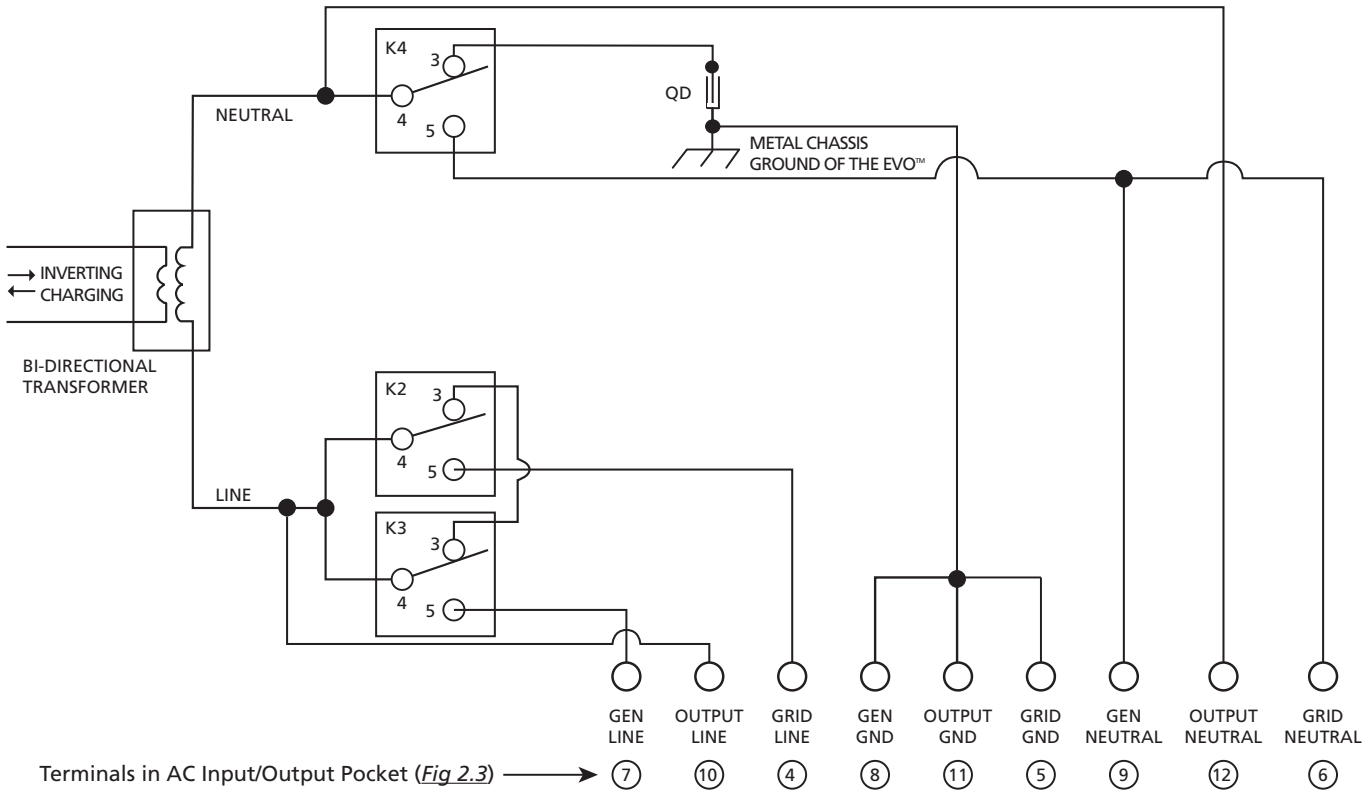
Switching of Hot Output (*OUTPUT LINE*)

- 40 A rated SPDT Relays K2 and K3 are used to switch the Hot Output Connector (*OUTPUT LINE*) to either the Inverter Section or to Grid/Generator.
- When Grid/Generator Power is available, relays K2 or K3 will be energized and contact 4 switches over to contact 5 [*AC input source connected to AC Input Terminals marked GRID (4, 5, 6 in Fig 2.3) has PRIORITY over AC Input Source connected to AC Input Terminal marked GEN (7, 8, 9 in Fig 2.3) if both the inputs are present simultaneously*]. The Bidirectional Transformer works as a battery Charger. The Hot AC input from the Grid (*GRID LINE*) or from the Generator (*GEN LINE*) is fed to the Hot input of the Bi-directional Transformer for battery charging and at the same time, it is passed through to the Hot Out (*OUTPUT LINE*) for powering the AC loads.
- When Grid/Generator power fails, relays K2/K3 will be de-energized and contact 4 switches back to contact 3. Output from the Inverter Section is fed to the Bi-directional Transformer and onwards to the Hot Out (OUTPUT LINE) for powering the AC loads.

Switching of Bonding of Output Neutral to Chassis Ground

- 40 A rated SPDT Relay K4 is used to switch the bonding of the Output Neutral Connector (*OUTPUT NEUTRAL*) to the chassis of the unit.

- When Grid/Generator Power is available, relay K4 will be energized and contact 4 switches over to contact 5. Neutral input from the Grid (*GRID NEUTRAL*) or from the Generator (*GEN NEUTRAL*) is fed to the Neutral input of the Bi-directional Transformer for battery charging and at the same time, it is passed through to the Output Neutral (*OUTPUT NEUTRAL*) for powering the AC loads. Please note that in this condition, the Output Neutral (*OUTPUT NEUTRAL*) is isolated from the chassis of the unit.
- When Grid/Generator power fails, relay K4 will be de-energized and contact 4 switches back to contact 3. Neutral output from the Inverter Section is fed to the Neutral of the Bi-directional Transformer and onwards to the output Neutral (*OUTPUT NEUTRAL*) for powering the AC loads. At the same time, the output Neutral (OUTPUT NEUTRAL) gets bonded to the metal chassis of the unit through the mated contacts of the Insulated Quick Disconnect "QD" located in the AC Wiring Compartment (*13, Fig 3.9*).



K2	Transfer Relay, SPDT, 40 A for Grid, Line
K3	Transfer Relay, SPDT, 40 A for Generator, Line
K4	Relay, SPDT, 40 A for Neutral to Ground bond Switching
4, 3	Normally Closed Contacts
4, 5	Normally Open Contacts
QD	Quick Disconnect (*13, Fig 3.9*) for disconnecting Output Neutral to Chassis Ground bond in Inverting Mode (*Default - connected*)
NOTE:	Relays are de-energized in Inverting Mode and are energized in Charging Mode

Fig 4.1 Operation of Transfer Relay and Neutral to Ground Bond Switching

4.5.3 Synchronized Transfer of Power

4.5.3.1 General information

When the frequency and phase of output voltages of two AC power sources are the same (*in sync*), the two AC sources are considered to be "synchronized".

Critical AC loads require un-interruptible AC input power. It is, therefore, necessary that when the primary AC input power is interrupted/fails, the load should be transferred to the backup AC source "*very quickly*" within the "holdup time" of the load(s).

When AC power feeding motors or inductive loads like transformers etc. is interrupted/fails, residual voltage is induced in the load due to "generator effect" created by a rotating motor or by the stored energy released from the inductive loads like transformer's windings or core. The induced residual voltage in the load has the same frequency and phase as the voltage of AC input power when it failed and, this voltage does not dissipate immediately but within a few seconds. This induced residual voltage in the load can cause extremely high inrush currents to occur when such loads are "*very quickly*" transferred to a "*non-synchronized*" source of backup AC power (*the loads are transferred to the "non-synchronized" backup source before the residual voltage in the load(s) has dissipated*). The resulting effect, frequently described as "bumping" can initiate nuisance tripping of circuit protective devices or in extreme cases, cause mechanical damage to motor shaft and couplings. To prevent this abnormal operating condition when the load is transferred between the primary and backup AC sources "*very quickly (normally within around 16 ms)*", it is to be ensured that the voltage of the backup AC power source is always kept "*synchronized*" with the voltage of the primary AC power source.

Synchronization control logic used in a backup AC source is required to be based on the frequency stability characteristics of the primary AC source which can be Grid or Generator. The frequency of Grid voltage is very stable. On the other hand, the frequency of Generator voltage (*except Inverter Generators*) may vary considerably depending upon the performance of its Speed Governor that compensates for the drop in RPM/frequency when electrical load is switched on/increased or, rise in RPM/frequency when electrical load is decreased/switched off.

4.5.3.2 Synchronization Algorithm Options in EVO® for Grid and Generator Inputs

When operating as an Inverter Charger, the EVO® is designed to accept external AC input power directly from two AC input sources through AC input terminals marked "GRID" (*4,5,6 in Fig 2.3*) and "GEN" (*7,8,9 in Fig 2.3*). *Internally, only one AC input source is selected at one time*. When both AC input sources are available simultaneously, AC input source connected to terminals marked "GRID" is given priority (*See Section 4.5.7*).

The frequency and phase of the internal backup Inverter Section are always kept synchronized with the AC input source. This facilitates "extremely fast" transfer time of up to 16 ms. *Also, transfer from the Inverter Section to the AC input source and vice versa takes place at zero crossing of the voltage waveform – this ensures (i) negligible arcing/erosion of Transfer Relay contacts and (ii) negligible Electromagnetic Interference (EMI) associated with arcing*.

2 Programming parameters "SYNC GRID" [*for AC input source connected to AC input terminals marked "GRID" (4,5,6 in Fig 2.3)*] and "SYNC GEN" [*for AC input source connected to AC input terminals marked "GEN" (7,8,9 in Fig 2.3)*] have been provided with two synchronization algorithm options each: (i) 0= Fine, or (ii) 1= Coarse as shown in TABLE 4.1. Option "0 =Fine" is recommended for AC input power source that has more stable output frequency like Grid/Inverter Generator. Option "1= Coarse" is recommended for AC input power source with less stable output frequency like Generator.

TABLE 4.1 SYNCHRONIZATION ALGORITHM OPTIONS ON AC INPUT TERMINALS

AC Input Terminals	Synchronization Algorithm Options			
	AC Input Source is Grid or Inverter Generator		AC Input Source is Generator	
	Programming Parameter	Option	Programming Parameter	Option
GRID (*4,5,6 in Fig 2.3*)	SYNC GRID (*See NOTE 1*)	0=Fine (*Default*)	SYNC GRID (*See NOTE 1*)	1=Coarse
GEN (*7,8,9 in Fig 2.3*)	SYNC GEN (*See NOTE 2*)	0=Fine	SYNC GEN (*See NOTE 2*)	1=Coarse (*Default*)

NOTES:

1. For programming details for parameter SYNC GRID, please refer to Section 4.5.2.8 in EVO-RC Remote Control Manual.
2. For programming details for parameter SYNC GEN, please refer to Section 4.5.2.9 in EVO-RC Remote Control Manual.

4.5.4 Transfer From Inverter Section to AC Input Source

In EVO, AC source connected to the Grid Input Terminals (*4, 5, 6 in Fig 2.3*) has priority over AC source connected to the Generator Input Terminals (*7, 8, 9 in Fig 2.3*).

- If Grid was connected to the Grid Input Terminals and subsequently, Generator output was fed to Generator Input Terminals, the load will continue to be powered from the Grid.
- If Generator was feeding the Generator Input Terminals and subsequently, Grid is fed to the Grid Input Terminals, the load will be transferred from the Generator the Grid (*see Section 4.5.6*).

When power from AC input source connected to terminals marked "GRID" (*4,5,6 in Fig 2.3*) or "GEN" (*7,8,9 in Fig 2.3*) is made available, its voltage and frequency are monitored for 2 sec to check if these are within the programmed limits. If yes, the output voltage of the Inverter Section is synchronized with the AC input source. This synchronization process takes few seconds. Once synchronization is completed, the load is transferred instantly (*within 1 ms*) to the AC input source at Zero Crossing of the voltage waveform for safer transfer and for better protection of Transfer Relay contacts. The unit now operates in "Charging Mode" with the AC power from the AC input source charging the batteries as well as providing power to the AC loads.

4.5.5 Transfer From AC Input Source to Inverter Section

When the unit is operating in "Charging Mode" with the AC input source charging the batteries as well as passing through power to the AC loads, the phase and frequency of the AC input source are tracked continuously. In case AC input source fails or is disconnected, the inverter will be forced to transfer at voltage which is at the same phase and frequency at which the AC input source had been disconnected. Load will be transferred to the inverter within 16ms at zero crossing. The unit will now work in "Inverting Mode" and the batteries will start discharging.

4.5.6 Transfer Between AC Sources Connected to Terminals Marked "GRID" & "GEN"

As discussed in section 4.5.4 above, the EVO® prioritizes the AC source connected to AC input terminals marked "GRID" over the AC source connected to AC input terminals marked "GEN". If the EVO® is operating with the AC source connected to terminals marked "GEN" and the AC input from AC source connected to AC input terminals marked "GRID" is restored, the EVO® will first transfer the load to its Inverter Section, and then transfer back

to the AC source connected to AC input terminals marked "GRID". Both operations are synchronized and the transfer is at the zero crossing for a seamless transfer.

4.6 BATTERY CHARGER SECTION

The Battery Charger Section of these units provide 2/3/4 stage charging with 7 programmable charging profiles as detailed at Section 5.6. The same Isolation Transformer and the H-Bridge configuration of the Inverter Section are used to work in the reverse direction, i.e. the AC input is stepped down and rectified to the programmed DC battery charging voltage using Pulse Width Modulation (*PWM*) Control. That is why it is called a Bi-directional device. Further, the charging voltages and currents are programmable to take care of a wide range of battery types like Lead Acid, Nickel-Zinc (*Ni-Zn*) & Lithium Ion.
Important battery charging features are as follows:

- Adaptive Charging Control for 2 Charging Profiles out of the 7 profiles
- Dynamic Input Power Diversion Control
- Parallel charging through External Charge Controller
- Temperature compensated charging
- Programmable Charging Profiles for Lead Acid, Nickel-Zinc (*Ni-Zn*) and Lithium Batteries

Please see details under Section 5 titled "Battery Charging in Evolution® Series".

4.7 AUTO GENERATOR START/STOP

Auto Generator Start / Stop function has been provided using "Common" and Normally Open "NO" contacts of Status Relay (*14, Fig 2.1*). The relay is SPDT Type with contacts rated at 3 A, 125 VAC / 30 VDC. Appropriate external Generator Auto Start / Stop Module will be required for using this function. 3 options (*Options 2, 3 and 4 under programming parameter "RELAY FUNCTION"*) are available for carrying out this function depending upon user requirements. *For details, please refer to Section 4.8.2.5.2 in the EVO-RC Remote Control Manua.*

The "Common" and "NO" terminals are wired to the optional Generator Auto Start/Stop Control Module which, in turn, is wired to the Remote Start/Stop connections on the Generator. The AC output terminals of the Generator are wired to the Generator Input Terminals on the EVO® (*7, 8, 9 in Fig 2.3*). *For installation details, please refer to Section 3.17 / Fig 3.14 and Section 3.18 / Fig 3.15A & B.*

INFO

It is recommended that "GSCM-Mini" Series of Generator Start/Stop Control Module, appropriate for the generator to be used, may ordered directly from Atkinson Electronics www.atkinsonelectronics.com

Based on the Generator Start Logic contained in of one of the selected Options 2, 3 or 4 (*under programming parameter "RELAY FUNCTION" [See Sections 4.8.2.5.2 in EVO-RC Remote Control Manual]*, the Status Relay will be switched ON (*energized*), its "Common" and "NO" contacts will close and the external Generator Start/Stop Control Module will initiate automatic starting of the Generator. Once the Generator has started and starts feeding AC output to EVO® (*within the programmed limits of voltage and frequency*), the EVO® will be synchronized with

the Generator and once synchronization is completed, the load will be transferred instantly *(within 1 ms)* to the Generator at Zero Crossing of the voltage waveform for seamless transfer and for better protection of Transfer Relay contacts. The EVO® will now operate in "Charging Mode" with the AC power from the Generator charging the batteries as well as providing power to the AC load(s).

Based on the Generator Stop Logic contained in one of the selected Options 2, 3 or 4 under programming parameter "RELAY FUNCTION" *[See Sections 4.8.2.5.2 in EVO-RC Remote Control Manual]*, the Status Relay will be switched OFF (*de-energized*), its "Common" and "NO" contacts will open and the external Generator Auto Start Control Module will initiate automatic stopping of the Generator. When AC output of the generator is shut down, the EVO® will automatically transfer the AC load(s) to the "Inverter Section" within 16 ms.

4.8 MODES OF OPERATION

4.8.1 Charging Mode

As long as the external AC input power from the Grid/Generator is available and is within the programmed limits of voltage and frequency, it is passed through to the AC load through the Transfer Relay Section. At the same time, the Battery Charger Section converts the external AC input power from the Grid/Generator to DC power to charge the DC Battery Source.

4.8.2 Inverting Mode

If at any instant, the external AC input power from the Grid/Generator is interrupted or is not within the programmed limits of voltage and frequency, the Transfer Relay is de-energized and the load is transferred to the Inverter Section and internal battery charging is terminated. This is called the Inverting Mode.

4.8.3 Power Saving Mode

Power Saving Mode related to inverters is a function designed to conserve battery power when the inverter is in ON condition and no AC loads are connected to it or, AC loads are connected to it but have been switched OFF. This condition is also called *"No Load Condition"*.

When an inverter is operating under "*No Load Condition*", it will consume a small amount of input power from the battery to keep all internal circuits alive and be ready to deliver the full rated output voltage and power to the load once the load is switched ON. This input power drawn from the battery when no load is being supplied by the inverter is called the "No Load Power Draw" (*also called "Idle Power" or "Self Power Consumption*). This "No Load Power Draw" is proportional to the size of the inverter e.g. a 150 Watt inverter may have "No Load Power Draw" of around 6 W and a 3000 W may have "No Load Power Draw" of around 30 W. *This power is wasted and drains the battery unnecessarily. It is, therefore, desirable to reduce the "No Load Power Draw" to the minimum.*

The "No Load Power Draw" of EVO® Series in the Normal Operating Mode is around 25-30 W.

The EVO® has an *optional programmable* operating mode called "Power Saving Mode" that is designed to reduce this "No Load Power Draw" to less than 8W during conditions where the Inverter Section is ON but is not supplying any load *[Applicable only when the unit is operating in "Inverting Mode"]*.

Enabling/disabling of "Power Saving Mode" is carried out using optional Remote Control Model EVO-RC. The EVO® is shipped with the "Power Saving Mode" option in "Disabled" condition *[Programming Parameter "POWER SAVING"*

is set at "0=Disabled" in the Default condition – See Section 4.8.2.1 of the EVO-RC Remote Control Manual].

When "Power Saving Mode" is enabled, the Inverter Section will NOT provide full rated output voltage of 230 VAC of Normal Operating Mode but pulsing output voltage consisting of 3, 50 Hz cycles of "reduced 96 Vrms load search voltage" every 0.5 sec. This output voltage is used to "search" if a load is being powered and also to measure the power drawn by this load *[The power drawn by the load will be initially measured based on pulsing output voltage consisting of 3, 50 Hz cycles of "reduced 96VAC load search voltage" every 0.5 sec and from there, the power will be calculated based on the rated output voltage of 230 VAC for the Normal Operating Mode]*. Operation of the "Power Saving Mode" is controlled through the following programming parameters:

- **4.8.3.1 Parameter "ENTER POINT"** *[See Section 4.8.2.2 in the EVO-RC Remote Control Manual]*

This parameter determines the threshold of power drawn by the load at which the EVO® will exit the Normal Operating Mode (*full 230 VAC output voltage; No Load Power Draw from the battery will be 25-30 W*) and "enter" Power Saving Mode (*output voltage consisting of 3, 50 Hz cycles of "reduced 96 VAC load search voltage" every 0.5 sec; No Load Power Draw from the battery will be < 8 W*).

The programmable range of this parameter is 4-50 Watts; Default value is 6 W for EVO-2212E / 2224E and 8 W for EVO-3012E/4024E.

Whenever the Inverter Section is switched ON with "Power Saving Mode" in enabled condition, it will initially start in Normal Operating Mode *[Full 230 VAC output voltage; No Load Power Draw from the battery will be 25-30 W]*. It then measures the power drawn by the load, if any, based on Normal Operating Voltage of 120 VAC. If the power drawn by the load is ≤ the programmed power value of "Enter Point", the Inverter Section will enter "Power Saving Mode" (*pulsing output voltage consisting of 3, 50 Hz cycles of "reduced 96 Vrms load search voltage" every 0.5 sec*). It is, therefore, important to first determine the running power consumption of your load in Watts and then, ensure that the programmed value of parameter "ENTER POINT" is > the running power of the load. If the running power of the load is < the programmed value of parameter "ENTER POINT", the load may turn ON initially due to higher initial startup surge power but will turn OFF when it starts drawing lower running power that is < the programmed value of parameter "ENTER POINT". (***NOTE**: The initial startup surge power of AC loads may be up to 10 times higher than their "running power" depending upon the type of AC load*).

- **4.8.3.2 Parameter "WAKE UP POINT"** *[See Section 4.8.2.3 in the EVO-RC Remote Control Manual]:*

Once the inverter enters "Power Saving Mode" as described at Section 4.8.3.1 above *[Output voltage consisting of 3, 50 Hz cycles of "reduced 96 VAC load search voltage" every 0.5 sec; Power draw from the battery will be < 8 W]*, it will continue to remain in this mode till the time the power drawn by the load is ≥ than the programmed threshold of Parameter "WAKE UP POINT" *[Programmable range is 4-50 Watts; Default is 7 W for EVO-2212E / 2224E and 10 W for EVO-3012E / 4024E]*. When the power drawn by the load ≥ the programmed threshold of Parameter "WAKE UP POINT", the EVO® will wake up and change to the Normal Operating Mode (*full 230 VAC output voltage; No Load Power Draw from the battery will be 25-30 W*).

INFO

Power Saving Mode should be disabled for the following loads:

- Low power loads that draw less than 5 W e.g. digital clocks, satellite receivers, phones/answering machines etc.
- Audio/video/computing devices that consume normal operating power > 50 W but draw less than 5 W on entering Sleep Mode when switched off or , when no activity is seen for a specified time.
- Some devices like small fluorescent lights, refrigerators, microwaves, computers and other sophisticated electronics may not be detected when scanned by the output voltage characteristics of the Power Saving Mode [Output voltage consisting of 3, 50 Hz cycles of "reduced 96 VAC load search voltage" every 0.5 sec]. These devices have power supplies in their front end that do not present a load until the full 230 VAC line voltage is available.

4.8.4 Power Saving Mode - Transfer Characteristics

- **Transfer from Grid/Generator to Inverter:** If qualified Grid or Generator AC input power is available (*its voltage and frequency are within the programmed range*), the Transfer Relay remains energized and the AC input power is passed through to the load and at the same time, the unit operates as a battery charger. If AC input power from Grid/Generator fails or is not qualified (*its voltage and frequency are not within the programmed range*), the Transfer Relay is de-energized and the load is transferred to the inverter. *When this transfer takes place, the inverter initially operates in Normal Mode*. If the AC load was greater than the programmed value of "Wake-up Point", the inverter continues in Normal Mode. However, if it sees a load less than the programmed value of "Enter Point" for around 5 sec, it enters Power Saving Mode.

- **Transfer from Inverter to Grid/Generator:** As soon as qualified AC input power from grid/generator is available, the inverter will exit Power Saving Mode and will switch over to Normal Mode. *This switch over is necessary for synchronizing the AC output of the inverter with the AC input before transfer (Synchronization can not be carried out with pulsing wave form during Power Saving Mode)*. After synchronization is completed, the load is transferred to the Grid/Generator at zero crossing of the voltage waveform.

4.8.5 Normal (Off-Line), On-Line and Charger Only Modes

EVO® has 3 modes of operation as follows that can be programmed through programming parameter "MODE" *[For details, see Section 4.4.2.13 in the EVO-RC Remote Control Manual]*

i. **Option "0=Normal"** (*Default*). Also called Off-Line Mode. See details at Section 4.8.5.1 below
ii. **Option "1=On-Line"**. See details at Section 4.8.5.2 below
iii. **Option "2=Charger Only"**. See Section 4.8.5.3 below

4.8.5.1 Option "0=Normal" (*Default*). This option is also called "Off-Line UPS Mode" (*UPS stands for **U**n-interruptible **P**ower **S**upply*). In this mode, AC input from the source is the PRIMARY source of AC power and the batteries/Inverter Section of EVO® is the BACK-UP source of DC-AC power. If qualified AC input (*within the programmed voltage and frequency limits*) is available, the EVO® will operate in "Charging Mode" and qualified AC input will be passed through to the AC output and at the same time, the Internal AC Charger will start charging the batteries. If an external Solar Charge Controller is also connected to the External Charging Terminals (*3, 4 in Fig 2.1*), the internal AC Charger of EVO® will limit the charging current as follows:

Value of charging current produced by EVO® Charging Section	=	Programmed "BULK CURRENT" + External Load Current (negative for Charging current in charge mode).

When AC input fails or, is not within the programmed values of voltage and frequency, the unit will change over to "Inverting Mode" and the AC Output will be fed from the internal Inverter Section of EVO®. When the AC input is restored, the EVO® will revert back to "Charging Mode" to charge the batteries and at the same time, pass through the AC input to the AC output.

4.8.5.2 Option "1= On-Line": This option is also called "On-Line UPS Mode" (*UPS stands for **U**n-interruptible **P**ower **S**upply*). In this mode, the Inverter Section of the EVO® is the PRIMARY DC-AC source of power. The AC input source is the BACK-UP source of AC power. In this mode, even if qualified AC input is available (within the programmed voltage and frequency limits), the EVO® will still operate in "Inverting Mode" and AC output will be provided by the Inverter Section as long as the batteries are in charged condition above the specified programmed value of low battery voltage that is set through programmable parameter "LOW VOLT ALARM" *[See Section 4.4.2.8 of EVO-RC Remote Control Manual]* . When the battery discharges to the programmed voltage threshold of "LOW VOLT ALARM", or lower and remains at this threshold, or below for a sustained programmed time period set by programmable parameter "GS DETECT TIME" *[See Section 4.4.2.16 of EVO-RC Remote Control Manual*], the EVO® will change over to "Charging Mode". On changing over to "Charging Mode", qualified AC input will be passed through to the AC Output and at the same time, the Internal AC Charger will start charging the battery. If an external Solar Charge Controller is also connected to the External Charger or I/O (+) and External Charger or I/O (-) terminals (*3, 4 in Fig 2.1*), the internal AC Charger will limit the charging current as follows:

Value of charging current produced by EVO® Charging Section	=	Programmed "BULK CURRENT" + External Load Current (negative for Charging current in charge mode).

Under the following 2 conditions, "Charging Mode" will be terminated, and the EVO® will switch back to "Inverting Mode". Switching from "Charging Mode" back to "Inverting Mode" has 2 options under programming parameter "ONLINE OPTION" *[See Section 4.4.2.14 of EVO-RC Remote Control Manual]*:

i. When Parameter "**ONLINE OPTION**" is set at option "0= Option 1" *[See Section 4.4.2.14 in the EVO-RC Remote Control Manual]:*

   EVO® will switch back from "Charging Mode" to "Inverting Mode" after completion of 3-Stage/ 2-Stage charging profile programmed through parameter "CHARGING PROFILE" *[See Section 4.4.2.21 in the EVO-RC Remote Control Manual]*

ii. When Parameter "**ONLINE OPTION**" is set at option "1= Option 2" *[See Section 4.4.2.4 in the EVO-RC Remote Control Manual]:*

EVO® will switch back from "Charging Mode" to "Inverting Mode" when the batteries have charged to the voltage threshold set by parameter "RESET VOLTAGE" *[See Section 4.4.2.7 in the EVO-RC Remote Control Manual]* and have remained at this threshold or higher for time period set by parameter "GEN OFF DELAY" *[See Section 4.4.2.18 in the EVO-RC Remote Control Manual].*

INFO

Online Mode is suitable for installations where both Grid and Photovoltaic (PV) Solar Battery Charging System are available. It is also desirable in areas where Grid/Utility Energy Rates are very high and use of supplementary battery based photovoltaic power system is more cost effective.

4.8.5.3 Option "2=Charger Only".

In Off-grid DC powered homes, for efficiency consideration, all lighting and other loads/appliances are normally powered from batteries that are primarily charged through solar/wind power. Generator backup is used for powering AC to DC battery charger for charging the batteries during extended periods of cloudy/no wind conditions. To meet this requirement, the EVO® can be programmed to operate as a battery charger ONLY i.e. when AC input power is available within the programmed limits of voltage and frequency, charging will take place and AC input will be passed through to the load(s). The unit will NOT transfer to Inverting Mode if AC input fails or is outside the programmed limits of voltage and frequency *[For details, see Section 4.4.2.13.3 of EVO-RC Remote Control Manual]*.

4.9 TEMPERATURE SENSOR FOR BATTERY CHARGING

Battery Temperature Sensor Model EVO-BCTS [*Fig 2.5(a)*] has been provided to ensure optimum charging of Lead Acid/Nickel-Zinc (*Ni-Zn*) batteries by modifying the charging voltages based on temperature if the battery sees very wide temperature swings. See Section 5.5 for details. Temperature compensation can be programmed with the help of optional Remote Control EVO-RC *[See Section 4.4.2.5 of EVO-RC Remote Control Manual]*. Range is -3 to -4 mv/ °C/cell (*Default is -4 mv/ °C/cell*). Without temperature compensation, the battery life is likely to be drastically reduced because the battery will be undercharged during cold conditions (will build up sulfation) or will be overcharged during hot conditions (will boil and lose excessive water). *See Section 1.4.5 for more details on temperature compensation.*

CAUTION!

1. Lithium Ion Battery charging does not require temperature compensation. Hence, do not use EVO-BCTS Temperature Sensor when charging Lithium Ion Batteries.

2. Automatic temperature compensation using EVO-BCTS Temperature Sensor is designed for Lead Acid Batteries based on programming parameter "COMPENSATE" *[See Section 4.4.2.5 in EVO-RC Remote Control Manual]*. When charging Nickel-Zinc (*Ni-Zn*) batteries, ensure that the value of programming parameter "COMPENSATE" is set based on approximate linear compensation for the particular Ni-Zn battery.

SECTION 4 | General Description & Principles of Operations

ATTENTION!

1. *Le chargement au lithium-ion ne nécessite pas de compensation de température. Par conséquent, n'utilisez pas le capteur de température EVO-BCTS lors du chargement de batteries au lithium-ion.*

2. *La compensation automatique de température à l'aide du capteur de température EVO-BCTS est conçue pour les batteries au plomb selon le paramètre de programmation "COMPENSATE" [voir la section 4.4.2.5 du manuel de la télécommande EVO-RC]. Lors de la charge en nickel-zinc (Ni-Zn) batteries, assurez-vous que la valeur du paramètre de programmation "COMPENSATE" est définie sur la base d'une compensation linéaire approximative pour la batterie Ni-Zn concernée.*

4.10 AUTOMATIC CHARGE CURRENT ADJUSTMENT

Connecting an external charger or a load to the EXT. Charger connection (3 and 4, Fig 3.8) will utilize the Automatic Charge Current Adjustment feature of the EVO. This feature affects the maximum charge current by the EVO's internal battery charger. The battery charger works to maintain battery charge current set by the parameter "BULK CURRENT" by increasing or decreasing the EVO's charger output based on the current measured through the EXT. Charger connection (3 and 4, Fig 3.8). Refer to Section 5.4 for further details.

4.11 COOLING AND OVER TEMPERATURE PROTECTION

4.11.1 Cooling Fans

The unit is cooled by convection and by forced air cooling using 2 variable speed cooling fans. Temperature is sensed at the Power Transformer and H-Bridge Power Mosfets/Heat Sink. The fans will be switched ON at specified temperatures measured at the above sense points. The speed of the fans is increased as the temperature rises.

4.11.2 Over Temperature Protection

Refer to Fault Messages and Troubleshooting Guide at Table 7.1 of EVO-RC Remote Control Manual. The unit goes to Fault Mode and shuts down due to over temperature sensed at the Main Power Transformer and the Heat Sink for the Power Mosfets: Fault messages and temperature thresholds for shut down and auto-reset are as follows:

- **"Transformer over heat!" :** Shut down at 150 ºC / 302 ºF and auto-reset at 80 ºC / 176 ºF.
- **"Heat sink over heat!" :** Shut down at 70 ºC / 158 ºF and auto-reset at 40 ºC / 107 ºF.

4.11.3 Automatic Reduction Of Charging Current In Higher Ambient Temperatures

In order to protect against over temperature shut down when operating in higher ambient temperatures of 50 ºC to 60 ºC / 122 ºF to 140 ºF, the BULK CURRENT setting *[See Section 4.4.2.1 in the EVO-RC Remote Control Manual]* is automatically reduced as follows based on temperature sensed at the Power Transformer and at the Heat Sink for the Power Mosfets:

- **Power Transformer:** In case the temperature is >130 ºC / 266 ºF, the BULK CURRENT setting is automatically reduced by 4 A (*EVO-2212E*) / 20A (*EVO-3012E*) / 1A (*EVO-2224E*) / 5A (*EVO-4024E*) every 10 sec.
- **Heat Sink:** In case the temperature is >65ºC, the BULK CURRENT is automatically reduced by 4A (*EVO-2212E*) / 20 A (*EVO-3012E*) / 1A (*EVO-2224E*) / 5A (*EVO-4024E*) every 10 sec.

SECTION 4 | General Description & Principles of Operations

4.12 OPTIONAL REMOTE CONTROL EVO-RC FOR PROGRAMMING OF MODES OF OPERATION AND PARAMETERS

Optional Remote Control Model EVO-RC [*Fig 2.4(a)*] will be required for more advanced control and monitoring. *Please see separate Owner's Manual for EVO-RC.* The Remote Control comes with 10 M / 33 ft., RJ-45 Data Cable. The Remote plugs into RJ-45 Jack on the front panel of the unit (7, Fig 2.1). It has provision for Data Logging using SD Card of up to 32 GB (*FAT16 / FAT32*). It also has its own Real Time Clock and Super Capacitor Type of Internal Battery. The Remote Control will be required for Firmware upgrade through the SD Card.

Detailed messaging is available through its LCD display and LEDs. This remote will also be required for programming of various parameters to suit specific requirements. Each programmable parameter has a Default Value. **This unit has been shipped with the various parameters set at the Default Values.** *Programmable and Default values are shown in Tables 6.2 to 6.6.*

SECTION 5 | Battery Charging in Evolution® Series

5.1 PRINCIPLES OF OPERATION OF BATTERY CHARGING SECTION

INFO

For background information on batteries and charging process, please read Section 1.4, "General Information - Battery Related". All battery charging voltages are specified at battery temperature of 25 °C / 77 °F.

5.1.1 General Information

EVO® Series is a Low Frequency Type, Pure Sine Wave, Single Phase Inverter-Charger with a built-in Transfer Relay. It uses high performance, 100MHz DSP (*Digital Signal Processing*) type of micro-controller and Pulse Width Modulation (*PWM*) control. It is Bi-Directional i.e. it uses a *common Converter Section* consisting of Low Frequency Isolation Transformer and Mosfet based H-Bridge that can work in two directions as follows:

1) **AC to DC Charging Mode:** The common Converter Section is used to convert external AC input power from 2 sources (*Grid or Generator*) to DC output power to charge the batteries and at the same time, pass through the AC input power to the AC loads.
2) **DC to AC Inverting Mode:** The common Converter Section is used to convert DC input power from the batteries to AC output power to feed the AC loads.

INFO

Please note that as the unit is Bi-Directional with a common Converter Section as explained above, it cannot work as inverter and charger at the same time

During "Charging Mode", the internal Transfer Relay is energized when AC input power from grid/generator is within the programmed limits of voltage and frequency and the following actions are initiated:

- AC input power is fed to the Common Converter Section for conversion to DC voltage to charge the batteries
- AC input power is simultaneously passed through to the AC loads

5.1.2 Basics of PWM (Pulse Width Modulation) Based Charging Process

5.1.2.1 AC input from Grid/Generator is fed to the Primary Winding of the Isolation Transformer (*T1 in Fig 3.12*). The voltage on the Secondary of the isolation Transformer is stepped down and fed to input of H-Bridge Converter that uses four N-Channel Mosfet Switches. The output of the H-Bridge is fed to the battery/battery bank. PWM (*Pulse Width Modulation*) technique is used for the charging process. PWM frequency is 30 kHz.

5.1.2.2 The two High-Side Mosfet Switches of the H-Bridge are kept OFF and their Body Diodes are used for *full-wave rectification* of the stepped down AC input voltage. The average/mean value of battery charging current will vary between 0A and a Positive peak value in the form of *DC Wave* resembling sine wave. *The charging current displayed by the EVO-RC Remote Control will be the average/mean value of the above DC Wave*.

5.1.2.3 The two Low-Side Mosfet Switches of the H-Bridge are switched ON/OFF *together* at PWM frequency of 30 kHz with variable "Duty Cycle" proportional to the desired value of charging current. When the two Low-Side Mosfets are ON for period determined by the "Duty Cycle" set by the micro-controller, the Secondary Winding will be short circuited and magnetic field proportional to the short circuit current will be created by the winding. When the two Low-Side Mosfet Switches are switched OFF, short circuit of the winding is removed resulting in collapse of the magnetic field and generation of induced voltage pulses at PWM frequency of 30 kHz with a value = - L di/dt where "L" is the Inductance of the winding and "di/dt" is the rate of decay of Short Circuit Current. Thus, higher Duty Cycle will produce induced pulses with higher voltage. *When the voltage of the induced pulses is > the battery voltage, charging current pulses will be produced. The value of charging current pulses will be proportional to the difference of voltage between the voltage of the induced pulses and the battery voltage.*

5.1.2.4 During the Bulk Stage of charging (*Section 5.7.1.1*), the average/mean charging current set by programming parameter "BULK CURRENT" *[See section 4.4.2.1 of EVO-RC Remote Control Manual]* is held constant by controlling the "Duty Cycle" of the 30 kHz induced pulses.

INFO

When charging starts, the charging current is NOT increased to the programmed value of parameter BULK CURRENT immediately but is gradually ramped up to this value.

5.1.2.5 During Absorption Stage (*Section 5.7.2*), Float Stage (*Section 5.7.3*) and Equalization Stage (*Section 5.8.2.3*), *the battery voltage is held constant indirectly by controlling the "Duty Cycle" of the 30 kHz induced pulses*. For example, if the battery voltage increases above the value set by parameters ABSORP VOLTAGE/FLOATING VOLTAGE /EQUALIZE VOLTAGE, the PWM "Duty Cycle" is reduced that leads to lower short circuit current of the Secondary Winding. This will reduce the voltage of the induced pulses and consequently, reduce the value of the charging current pulses. Reduced value of charging current pulses will reduce the battery voltage back to the value set by ABSORP VOLTAGE/FLOATING VOLTAGE/EQUALIZE VOLTAGE.

5.1.2.6 Battery Charging Profiles

7 programmable types of 2/3/4 Stage Charging Profiles are available. Please see details under Section 5.6.

5.2 DYNAMIC AC INPUT CURRENT DIVERSION CONTROL BETWEEN AC PASS THROUGH CURRENT AND BATTERY CHARGING CURRENT

EVO® Models have very powerful Battery Charger Section that will require very high AC input current from the Grid/Generator (*See Table 5.1*).

TABLE 5.1 CHARGING CURRENTS AND PASS THROUGH LOAD CURRENTS

	Rated Charging Current		Maximum Pass Through Load Power and Current	
	Max. DC Side Charging Current	Equivalent AC Side Charging Current	Pass Through Power	Pass Through Amps
EVO-3012E	130 A	20 A	3000 VA	25 A
EVO-2212E	100 A	15 A	2200 VA	18 A
EVO-4024E	110 A	30 A	4000 VA	33 A
EVO-2224E	70 A	19 A	2200 VA	18 A

When batteries are being charged at or near the maximum value of charging current (*See TABLE 5.1*) and the pass through load current increases, the Grid/Generator supply circuit breaker may trip if the combined value of the AC side charging current (*equivalent to the DC side charging current*) and the pass through load current exceeds the grid/generator supply circuit breaker capacity. This situation is prevented by "Dynamic AC Input Current Diversion Control between AC Pass through Current and Battery Charging Current". This is accomplished through appropriate setting of programmable parameters "GRID MAX CURRENT"/"GEN MAX CURRENT". Optional Remote Control Model EVO-RC will be required for the above setting *[Please refer to Section 4.5.2.2 of the EVO-RC Remote Control Manual]*.

"GRID MAX CURRENT"/"GEN MAX CURRENT" (*Default = 30 A*) should be set equal to the Ampere rating of the external Grid/Generator supply breakers. During Battery Charging Mode, if the AC pass through load current is increased resulting in the net AC input current increasing by 1 A more than the programmed "GRID MAX CURRENT"/ "GEN MAX CURRENT" for 1 sec, the EVO® will automatically reduce the charging current to ensure that the equivalent AC Side Charging Current + Pass Through Load Current is not more than the set value of "GRID MAX/ GEN MAX CURRENT".

INFO

If the net AC input current is 1 A more than the value of GRID MAX CURRENT or GEN MAX CURRENT for 1 sec, the AC side charging current is clawed back to ensure that GRID MAX CURRENT/ GEN MAX CURRENT value is not exceeded. If the value of pass through load current increases to a value of 1 A more than the programmed value of GRID MAX CURRENT/GEN MAX CURRENT for 5 sec, input over current protection will be activated based on option to either transfer to Inverting Mode or to shut down in FAULT MODE *[Refer to details of these 2 options under parameter "INPUT OC PROTECT" at Section 4.5.2.10 in the EVO-RC Owner's Manual].*

EXAMPLE:

1) Assume EVO-2212E is connected to the Grid input with Grid input supply circuit breaker capacity of 16 A. Parameter settings are as follows:
   a) "GRID MAX CURRENT" setting = the Default value of 30 A.
   b) "BULK CURRENT" setting = 100 A (*DC*). When charging at 100 A on the DC side, the corresponding AC side input current will be 9 A (*Based on Conversion Factor of 1 A DC side charging current = 0.09 A AC side charging current*).

2) Assume that the AC pass-through load current is 10 A. The total AC input current will be 1 A, i.e. 10 A AC pass-through load current + 9 A AC input side current corresponding to 100A DC side charging current [*See 1(b) above*]. Under this condition, the EVO® will operate normally because the net AC input current of 25 A will be below 30 A Default setting for parameter "GRID MAX CURRENT".

3) If now, the AC pass-through load current is increased to 25 A for more than 5 sec, the total AC input current will be 40 A i.e. 25 A pass through load current + 15 A AC side charging current corresponding to 100 A DC side charging current [*See 1(b) above*]. As the total AC input current will be 10 A more than the "GRID MAX CURRENT" for more than 1 sec, the AC input side charging current will be clawed back from 15 A to 5 A within less than 5 sec so that the total AC input current is limited to 30 A. At reduced AC side charging current of 5 A, the corresponding DC side charging current will be 33.3 A DC (*Based on Conversion Factor of 1A DC side charging current = 0.15 A AC side charging current*).

4) If now, the AC pass-through load current is increased to 32 A for more than 5 sec, the total AC input current will be 37 A (*32 A pass through load current + 5 A AC side charging current corresponding to 33.3 A DC side charging current*) . The AC side charging current will be automatically reduced from 5 A (*corresponding to 33.3 A DC side charging current*) to 0 A (*corresponding to 0 A DC side charging current*). However, now the AC input current will be still be 32 A i.e. 2 A more than the "GRID MAX" current setting of 30 A for more than 5 sec. After 5 sec of operation under this condition, the EVO® will operate as follows based the option selected through parameter "INPUT OC PROTECT" *[See details of this parameter under Section 4.5.2.10 in EVO-RC Owner's Manual].*

   - **Parameter "INPUT OC PROTECT" set in the Default option "0=Inverter":** The EVO® will switch over to Inverter Mode to ensure that 32 A AC load is maintained. If subsequently, the load reduces to 1 A less than the 30 A setting of GRID MAX CURRENT for 5 sec, the EVO® will switch back to Charging Mode.
   - **Parameter "INPUT OC PROTECT" set for option "1= Shutdown*": EVO® will be shut down.***
     - There will be no AC output because the Transfer Relay will be de-energized, charging will be stopped and PWM drive to the Inverter Section will be switched off.
     - Fault message "Input over current" will be displayed on the LCD screen, Green LED marked "Status" will be switched off and Red LED marked "Fault" will be switched on.
       - The unit will be latched in OFF condition and will require manual reset by powering off the unit, waiting for 1 min and then powering on again.

5.3 AUTOMATIC REDUCTION OF CHARGING CURRENT IN HIGHER AMBIENT TEMPERATURES

In order to protect against over temperature shut down when operating in higher ambient temperatures of around 50 °C to 60 °C / 122 °F to 140 °F, the BULK CURRENT setting *[See section 4.4.2.1 of EVO-RC Remote Control Manual]* is automatically reduced as follows based on temperature sensed at the Power Transformer and at the Heat Sink for the Power Mosfets:

- **Power Transformer:** In case the temperature is >130 °C / 266 °F, the BULK CURRENT setting is automatically reduced by (i) 4 A every 10 sec for EVO-2212E, (ii) 20A every 10 sec for EVO-3012E, (iii) 1A every 10 sec for EVO-2224E and (iv) 5 A every 10 sec for EVO-4024E.
- **Heat Sink:** In case the temperature is >65 °C / 149 °F, the BULK CURRENT setting is automatically reduced by (i) 4 A every 10 sec for EVO-2212E, (ii) 20 A every 10 sec for EVO-3012E, (iii) 1A every 10 sec for EVO-2224E and (iv) 5 A every 10 sec for EVO-4024E.

5.4 EXT CHARGER – BIDIRECTIONAL CURRENT SENSING AND DYNAMIC DC LOAD COMPENSATION

The "EXT Charger" terminals (items 3 and 4, Fig. 3.8) have been upgraded to function as a bi-directional input-output terminals.

From firmware version 0.82 onwards, these now detect the direction of current flow to distinguish between an External Charging Source (current flowing into the battery) and an External DC Load (current flowing out of the battery). Whereas previously, it measured the current with no distinct differentiation in the direction of it.

This allows the EVO® Inverter/Charger to dynamically adjust its internal AC Charger output to maintain the target BULK CURRENT setting (See Section 4.4.2.1 of the EVO-RC Owner's Manual), regardless of whether external devices are adding power to, or draining power from the battery bank.

WARNING!

The maximum current in or out of this connection is rated for 50 A. Devices connected to these terminals, should be properly sized by the user in order to not exceed this specification.

AVERTISSEMENT !

Le courant maximal d'entrée ou de sortie de cette connexion est de 50 A. Les dispositifs raccordés à ces bornes doivent être correctement dimensionnés par l'utilisateur afin de ne pas dépasser cette valeur nominale.

5.4.1 Principle of Operation

When the EVO® is in Charging Mode (Grid or Generator input is active), the unit monitors the current at the "EXT Charger" Terminals and adjusts the internal charger output(Iinternal) in real-time based on the programmed BULK CURRENT (Iset).

Scenario A: External Solar Charging (Incoming Current)

If an external solar charge controller is connected and providing current (Isolar) to the battery, the EVO® adjusts, and reduces, its internal charging effort to prevent overcurrent flowing to the battery system.

Formula: $I_{internal} = I_{set} - I_{solar}$

Result: The net current entering the battery remains equal to the safety limit programmed in BULK CURRENT.

For example, when the BULK CURRENT is set to 40 A and 10 A are supplied by the solar charge controller, the EVO® senses this input and compensates by drawing only 30 A from the grid or generator.

Scenario B: External DC Load Compensation (Outgoing Current)
If a DC load (e.g., pumps, DC lighting, communication gear) is connected to the EXT. Charger Terminals and drawing current ( ) from the battery, the EVO® increases its internal charging effort to compensate for the load, ensuring the battery still receives the full intended charge current.

Formula: $I_{internal} = I_{set} + I_{load}$
Result: The net current charging the battery remains equal to BULK CURRENT, rather than being reduced by the DC load.

In this example, assume the bulk current is set to 40 A, while the DC loads connected to the EXT Charger Terminals of the unit, are drawing 6 A. The EVO® will automatically adjust by drawing a total of 46 A from the grid or generator to compensate. Of this total, 40 A is supplied to the battery system, and the remaining 6 A is allocated to the DC loads.

5.4.2 Hardware Limitations

The ability of the EVO® to compensate for DC loads is limited by the maximum rated current of the internal charger hardware.

Example: If you have an EVO-3012E (Max Charger Output = 130 A) and BULK CURRENT is set to 100 A:

- If the DC Load draws 20 A, the EVO increases output to 120 A (100 A for Battery + 20 A for Load). The compensation is successful.
- If the DC Load draws 50 A, the EVO attempts to output 150 A but will cap at its hardware limit of 130 A. The battery will only receive 80 A. The compensation is limited.

5.4.3 "EXT Charger" – Parameter Configuration

This parameter configures the operation of the Current Sensor located at the Bidirectional DC Terminals (items 3 and 4 of Fig. 3.8). It determines if the Internal AC Charger should adjust its output current based on the current flowing IN (from solar) or OUT (to DC loads) through these terminals.

Note: Refer to section 4.4.2.24.1 Programming Steps for Parameter "EXT. CHARGER" in the EVO-RC User Manual, to program this parameter.

Options:

- 0 = Affect (Bidirectional/Active Compensation) [Default]
- 1 = Not Affect (Ignored)

Detailed Description of Options:

1. Option "0 = Affect" (Default - Bidirectional Active)
When this option is selected, the EVO® actively monitors the direction and magnitude of current at the Bidirectional Terminals and adjusts the Internal AC Charger output (Iinternal) dynamically to ensure the battery receives the precise Net Bulk Current (Iset) programmed in the unit (refer to section 4.4.2.1 of EVO-RC User's Manual).

2. Option "1 = Not Affect" (Passive)
When this option is selected, the Internal AC Charger ignores any current flowing through the Bidirectional Terminals. The EVO® will simply output the fixed amperage programmed in the BULK CURRENT setting, regardless of external solar input or DC loads.

SECTION 5 | Battery Charging in Evolution® Series

CAUTION!

Ensure that charging voltage related parameters of EVO® like (i) ABSORP VOLTAGE, (ii) EQUALIZE VOLTAGE, (iii) FLOAT VOLTAGE and (iv) Temperature Compensation (*COMPENSATE*) are set / programmed to match the programmed parameters of the external charge controller. *[Please refer to (i) Table 6.2, Section 6 and (ii) Sections 4.4.2.2 to 4.4.2.5 of Owner's Manual for Remote Control Model EVO-RC]*.

ATTENTION !

*S'assurer que la charge de tension, les paramètres connexes d'EVO*MD *comme (i) La tension d'absorption, (ii) EQUALIZE VOLTAGE, (iii) Tension d'égaliser et (iv) La compensation de température (COMPENSATE) est réglée / programmée pour correspondre aux paramètres programmés du contrôleur de charge externe. [Veuillez consulter (i) le tableau 6.2, section 6 et (ii) les sections 4.4.2.2 à 4.4.2.5 du manuel d'utilisation de la télécommande EVO-RC].*

5.5 BATTERY TEMPERATURE COMPENSATION USING TEMPERATURE SENSOR: MODEL NO. EVO-BCTS

5.5.1 General Description – Battery Temperature Compensation

Please refer to Section 1.4.5 for general information on temperature compensation of battery charging voltages.

Battery Temperature Sensor Model EVO-BCTS [*Fig 2.5(a)*] has been provided to ensure optimum charging of Lead Acid and Nickel Zinc (*Ni-Zn*) Batteries by ***negative*** temperature compensation of the charging voltages based on the battery electrolyte temperature. The charging voltage is reduced when electrolyte temperature rises above the reference temperature of 25°C / 77°F and increased when electrolyte temperature falls below the reference temperature of 25°C / 77°F.

INFO

Charging voltages of Lithium Ion Battery are not affected by temperature and hence, Battery Temperature Sensor Model EVO-BCTS is not required to be used when Lithium Ion batteries are used.

Automatic temperature compensation will be carried out over temperature range of -20 °C to +60 °C / -4 °F to 140 °F based on the programmed value of the ***negative*** "Temperature Coefficient of Battery Charging Voltage". In EVO®, this parameter is called "COMPENSATE" and is specified in "mV/C/Cell". For programming details of this parameter, please refer to the following Sections of EVO-RC Remote Manual:

- Parameter Setup Menu Map at Fig 4.1: Screen 5 against Column "GROUP 1 CHARGE CURVE"
- Programming range and defaults: Screen No. 5 of Table 4.1
- Programming procedure: Section 4.4.2.5

In addition to compensating Absorption, Float and Equalization voltages, the voltage thresholds of parameters "LOW VOLTAGE ALARM", "BATTERY LOW VOLTAGE", "RESET VOLTAGE", "BATTERY OVER VOLTAGE" and "RESET TO BULK" are also temperature compensated.

5.5.2 Constructional Details of Battery Temperature Sensor Model EVO-BCTS and Installation

The Temperature Sensor consists of 5 meters / 16.5 ft cable with Temperature Sensor Head for the battery end [*1 in Fig 2.5(a)*] and RJ-45 Plug [*2 in Fig 2.5(a)*] for EVO® end.

Temperature Sensor Head [*1 in Fig 2.5(a)*]: The Temperature Sensor Head is installed on the Positive / Negative battery Stud [*Fig 2.5(b)*] to monitor the temperature of the battery electrolyte. The Sensor Head contains an embedded Negative Temperature Coefficient (*NTC*) Resistor with 2 internal terminals "NTC+" and "NTC -". Internal terminal "NTC+" is wired to Pin 4 of the RJ-45 Plug [*2 in Fig 2.5(a)*] and internal terminal "NTC -" is wired to Pin 5 of the RJ-45 Plug.

RJ-45 Plug [*2 in Fig 2.5(a)*]: The RJ-45 Plug is required to be plugged into the RJ-45 Jack marked "Battery Temp Sensor" on the front panel of EVO® (*6 in Fig 2.1*). Pinout of this RJ-45 Jack is shown in Fig 5.0.

RJ-45 Jack on the Front Panel of EVO® (6, Fig 2.1) for Connecting Battery Temperature Sensor

Pinout of this RJ-45 Jack marked "Battery Temp Sensor" on the front panel of EVO® (*6 in Fig 2.1*) is shown at Fig 5.0 below (*also shown at Fig 3.13*):

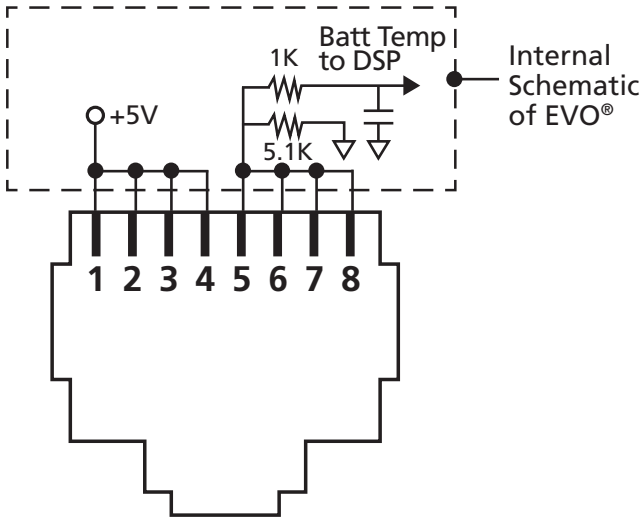


Fig 5.0 Pinout of RJ-45 Jack marked "Battery Temp Sensor" on the front panel of EVO® (*6 in Fig 2.1*).

5.6 CHARGING PROFILES

Please refer to Section 1.4.3 regarding general information on 4 stages of battery charging. Depending upon the type of batteries to be charged and its application, 2/3/4 charging stages may be used based on the appropriate Charging Profile.

When AC input within the programmed window of voltage and frequency is available, EVO® will operate as a battery charger. Option is available for 7 charging profiles as follows:

- 6 options for the following 3-Stage / 2-Stage charging profiles through programming parameter "CHARGING PROFILE" designed to cover various charging requirements for Lead Acid, Nickel-Zinc (*Ni-Zn*) and Lithium Ion Batteries.

  - 0 = 3 Stage Adaptive (*Default*)
  - 1 = 3 Stage Type 1
  - 2 = 3 Stage Type 2
  - 3 = 2 Stage Type 1
  - 4 = 2 Stage Type 2
  - 5 = 2 Stage Type 3

  Refer to the following for more details:

  - Section 5.7 for description and charging curves for 3-Stage Charging Profiles
  - Section 5.10 for description and charging curves for 2-Stage Charging Profiles
  - *Programming procedure at Section 4.4.2.21 in the EVO-RC Remote Control Manual*

- 1 option for 4-Stage Adaptive Charging Profile for Equalization for Lead Acid Batteries

  Refer to the following for more details:

  - Section 5.8 for description and charging profiles
  - *Programming procedure at Section 4.4.2.12 in the EVO-RC Remote Control Manua*

CAUTION!

The Battery Management System (*BMS*) that comes with the type of Lithium Battery being used may need to have control over charging and discharging of the battery. For this, Pins 4 and 5 of the Temperature Sensor Jack (*6, Fig 2.1; Pinout at Fig 5.0*) may be used to feed potential free contact closing signal from the BMS to "Stop Charging" or "Stop Inverting" Refer to Section 5.11.2 for details.

ATTENTION !

Le système de gestion de la batterie (BMS) qui vient avec le type de batterie au lithium utilisé aura besoin d'avoir le contrôle de charge et décharge de la batterie. Pour cela, les broches 4 et 5 du capteur de température (6, Fig. 2.1; Pinout à la Fig. 5.0) peut être utilisé pour l'alimentation contact libre de signal de fermeture de la BMS à "arrêter la charge" ou "arrêter d'inverser". Se reporter à la Section 5.11.2 pour plus de détails.

5.7 3-STAGE CHARGING PROFILE - DETAILED EXPLANATION

Refer to 3 types of 3-Stage Charging Profile options at Srls. 1 to 3 in TABLE 5.2.

Fig. 5.1 shows the voltage and current charging curves with respect to time and different charging stages associated with these profiles.

INFO

4-Stage Adaptive Charging Profile for Equalization is also available and can be activated at any time during charging taking place under these 3-stage profiles. *Procedure to activate 4-Stage Adaptive Charging Profile for Equalization is described under programming parameter "EQUALIZE-4 STAGES" at Section 4.4.2.12 in the EVO-RC Remote Control Manual.*

TABLE 5.2 3 TYPES OF CHARGING PROFILE OPTIONS FOR 3-STAGE CHARGING

Srl No.	Options under Programming Parameter "CHARGING PROFILE" *(See Section 4.4.2.21 in EVO-RC Remote Control Manual)*	Charging Stages	Battery Type
1	0 = 3 Stage Adaptive *(Displayed as "0=3 Stg Adaptiv" in programming screen)* **NOTES:** 1.This is the default, *3-Stage Adaptive Type of Charging Profile with Adaptive Time Algorithm for Absorption Stage*	1. **Stage 1 – Bulk Stage** (*See Section 5.7.1.1 for details)* • Charge at constant current (CC) = the programmed value of parameter "BULK CURRENT" **(Default value is 40 A.** *For details of programming range & procedure, refer to Section 4.4.2.1 of EVO-RC Remote Control Manual)* • Transition to Absorption Stage when voltage rises to the set value for programming parameter "ABSORP VOLTAGE" (**Default value is 14.4 V for EVO-2212E/3012E and 28.8 V for EVO-2224E/4024E.** *For details of programming range & procedure, refer to Section 4.4.2.2 of EVO-RC Remote Control Manual)* 2. **Stage 2 - Absorption Stage** *(See Section 5.7.2 for details)* • Charge at constant voltage (CV) = the programmed value for parameter "ABSORP VOLTAGE". (**Default value is 14.4 V for EVO-2212E/3012E and 28.8 V for EVO-2224E/4024E.** *For details of programming range & procedure, refer to Section 4.4.2.2 of EVO-RC Remote Control Manual)* • **Adaptive Time Algorithm:** Time in Absorption Stage is computed automatically based on time in Bulk Stage *(See Section 5.7.2 for details).* • Transition to Float Stage thereafter. 3. **Stage 3 - Float Stage** *(See Section 5.7.3 for details)* • Charge at constant voltage (CV) = the programmed value of parameter "FLOATING VOLTAGE". (***Default value is 13.5 V for EVO-2212E/3012E & 27.0 V for EVO-2224E/4024E.*** *For details of programming range & procedure, refer to Section 4.4.2.4 of EVO-RC Remote Control Manual)* • Reset to Bulk Stage under the following conditions: i. If the AC input from the Grid/Generator is disconnected and is reconnected. ii. If battery voltage falls to the programmed value of parameter "RESET TO BULK" (***Default value is 12.0 V for EVO-2212E/3012E & 24.0 V for EVO-2224E/4024E.*** *For details of programming range & procedure, refer to Section 4.4.2.15 of EVO-RC Remote Control Manual).* iii. If the charger remains in the Float Stage for 10 days	– Lead Acid: Flooded and sealed – AGM/Gel Cell – **ENSURE** that there are no other DC load(s) on the batteries. Load(s) on the battery may drain full or part of the charging current and will upset the "Adaptive Time Algorithm" for Absorption Stage time

Table continues on next page ▶

TABLE 5.2 3 TYPES OF CHARGING PROFILE OPTIONS FOR 3-STAGE CHARGING (Continued)			
2	1 = 3 Stage Type 1	1. **Stage 1 – Bulk Stage** (*See Section 5.7.1.1 for details)* • Charge at constant current (CC) = the programmed value of parameter "BULK CURRENT" **(Default value is 40 A.** *For details of programming range & procedure, refer to Section 4.4.2.1 of EVO-RC Remote Control Manual)* • Transition to Absorption Stage when voltage rises to the set value for programming parameter "ABSORP VOLTAGE" **(Default value is 14.4 V for EVO-2212E/3012E and 28.8 V for EVO-2224E/4024E**. *For details of programming range & procedure, refer to Section 4.4.2.2 of EVO-RC Remote Control Manual)* 2. **Stage 2 - Absorption Stage** *(See Section 5.7.2 for details)* • Charge at constant voltage (CV) = the programmed value for parameter "ABSORP VOLTAGE". **(Default value is 14.4 V for EVO-2212E/3012E and 28.8 V for EVO-2224E/4024E**. *For details of programming range & procedure, refer to Section 4.4.2.2 of EVO-RC Remote Control Manual)* • Remain in Absorption Stage for time duration = programmed value of parameter "ABSORP TIME" **(Default value is 60 min.** *For details of programming range & procedure, refer to Section 4.4.2.19 of EVO-RC Remote Control Manual)* • Transition to Float Stage thereafter. 3. **Stage 3 - Float Stage** *(See Section 5.7.3 for details)* • Charge at constant voltage (CV) = the programmed value of parameter "FLOATING VOLTAGE". **(Default value is 13.5 V for EVO-2212E/3012E & 27.0 V for EVO-2224E/4024E**. *For details of programming range & procedure, refer to Section 4.4.2.4 of EVO-RC Remote Control Manual)* • Reset to Bulk Stage under the following conditions: i. If the AC input from the Grid/Generator is disconnected and is reconnected. ii. If battery voltage falls to the programmed value of parameter "RESET TO BULK" **(Default value is 12.0 V for EVO-2212E/3012E & 24.0 V for EVO-2224E/4024E.** *For details of programming range & procedure, refer to Section 4.4.2.15 of EVO-RC Remote Control Manual).* iii. If the charger remains in the Float Stage for 10 days	– Lead Acid: Flooded and sealed – AGM/Gel Cell – Lithium *(See Section 5.11 for details)*
3	2 = 3 Stage Type 2	1. **Stage 1 – Bulk Stage** (*See Section 5.7.1.1 for details)* • Charge at constant current (CC) = the programmed value of parameter "BULK CURRENT" **(Default value is 40 A.** *For details of programming range & procedure, refer to Section 4.4.2.1 of EVO-RC Remote Control Manual)* • Transition to Absorption Stage when voltage rises to the set value for programming parameter "ABSORP VOLTAGE" **(Default value is 14.4 V for EVO-2212E/3012E and 28.8 V for EVO-2224E/4024E.** *For details of programming range & procedure, refer to Section 4.4.2.2 of EVO-RC Remote Control Manual)* 2. **Stage 2 - Absorption Stage** *(See Section 5.7.2 for details)* • Charge at constant voltage (CV) = the programmed value for parameter "ABSORP VOLTAGE". **(Default value is 14.4 V for EVO-2212E/3012E and 28.8 V for EVO-2224E/4024E.** *For details of programming range & procedure, refer to Section 4.4.2.2 of EVO-RC Remote Control Manual)* • Remain in Absorption Stage till the current reduces to value = the programmed value of parameter "ABSORP EXIT AMPS" **(Default value is 4 A.** *For details of programming range & procedure, refer to Section 4.4.2.20 of EVO-RC Manual)* • Transition to Float Stage thereafter. 3. **Stage 3 - Float Stage** *(See Section 5.7.3 for details)* • Charge at constant voltage (CV) = the programmed value of parameter "FLOATING VOLTAGE". **(Default value is 13.5V for EVO-2212E/3012E & 27.0 V for EVO-2224E/4024E**. *For details of programming range & procedure, refer to Section 4.4.2.4 of EVO-RC Remote Control Manual)* • Reset to Bulk Stage under the following conditions: i. If the AC input from the Grid/Generator is disconnected and is reconnected. • If battery voltage falls to the programmed value of parameter "RESET TO BULK" **(Default value is 12.0 V for EVO-2212E/3012E & 24.0 V for EVO-2224E/4024E.** *For details of programming range & procedure, refer to Section 4.4.2.15 of EVO-RC Remote Control Manual)* ii. If the charger remains in the Float Stage for 10 days	– Lead Acid: Flooded and sealed – AGM/Gel Cell – Lithium *(See Section 5.11 for details)*

5.7.1.1 STAGE 1 – Bulk Charge Stage

Refer to Fig 5.1 and Srl No. 1 of TABLE 5.2

During the 1st Bulk Charge Stage, the Duty Cycle of the boosted high frequency PWM voltage pulses (*Section 5.1.2*) is adjusted continuously to charge the battery at constant current (*CC*) = the programmed value of parameter "BULK CURRENT" designated as"Io"(**Default value is 40 A**. *For details of programming range & procedure for parameter "BULK CURRENT", refer to Section 4.4.2.1 of EVO-RC Remote Control Manual*)

NOTE: The current will slowly ramp up to the programmed value of "BULK CURRENT"

This current is delivered to the batteries until the battery voltage approaches its Gassing Voltage i.e. Absorption Voltage which is typically around 14.4 volts for 12 volt batteries and 28.8 volts for 24 volt batteries. The desired value can be programmed using the optional Remote Control EVO-RC *[Refer to parameter "ABSORP VOLTAGE" in Table 6.2 and at Section 4.4.2.2 of EVO-RC manual]*. The Bulk Charge Stage restores about 75% of the battery's charge. The Gassing Voltage is the voltage at which the electrolyte in the battery begins to break down into Hydrogen and Oxygen gases. Under normal circumstances, a battery should not be charged at a voltage above its Gassing Voltage since this will cause the battery to lose electrolyte and dry out over time.

This stage is displayed as "X-CC" in the 1st line, right corner of the Charging Mode screens in the Remote Control EVO-RC. Refer to the screens shown under column – "GROUP 3: CHARGING MODE" in Fig 3.2 of EVO-RC Remote Control Manual. Character "X" denotes code for the Charging Profile that is active. (For details of codes, please see Table 3.2 under Section 3.6.2 of EVO-RC Remote Control Manual).

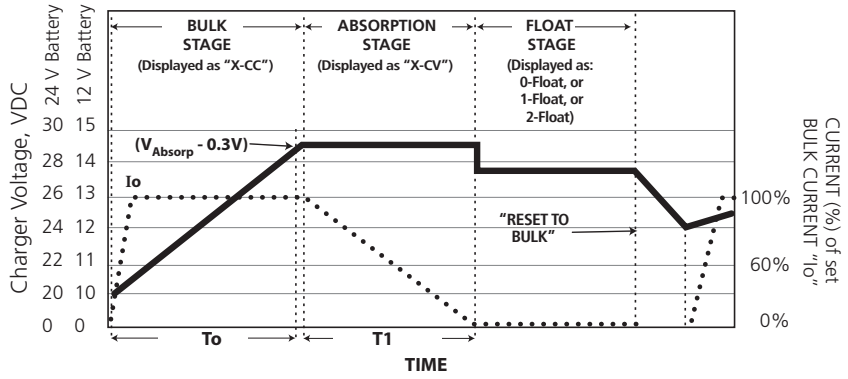


Fig 5.1 Charging Curves for 3-Stage Charging Profile

LEGEND for Fig 5.1	
———	Voltage (V) Curve
•••••	Current (I) Curve
Io	Bulk Stage Current. *Please see Section 5.7.1.1*
To	Bulk Stage Time. *Please see Section 5.7.1.1*
T1	Time in Absorption Stage. *Please see Section 5.7.2*
X-CC, X-CV, X-FLOAT	This coded information relates to the active Charging Profile and Charging Stage and is displayed in the right corner of the Charging Mode Display Screens of EVO-RC Remote Control. *Please see Table 3.2 under Section 3.6.3 of EVO-RC Remote Control Manual*
RESET TO BULK	At this point, the charger is forced to reset automatically from the operating charging stage and restart the selected CHARGING PROFILE from the 1st Stage i.e. from the Bulk Stage. *Please see Section 5.7.4*

NOTES for Fig 5.1
1. Voltage (V) and Current (I) curves show the battery voltage and current. 2. The Voltage (V) and Current (I) curves shown are based on the following operating conditions: a) The battery is being charged exclusively by the Battery charging Section of EVO® and that there is NO external charging source that is charging the battery / battery bank b) There is no external DC load on the battery / battery bank (*the entire current delivered by the Charging Section of EVO® is being used to charge the battery / battery bank*)

The value of the "BULK CURRENT" ("Io") depends upon the total Ampere Hour (Ah) capacity of the battery or bank of batteries. A battery should never be charged at very high charging current as very high rate of charging will not return the full 100 percent capacity as the Gassing Voltage rises with higher charging current. As a general rule of thumb, the BULK CURRENT "Io" for Lead Acid Batteries should be limited to 10% to 20% of the Ah capacity of the battery [Ah capacity at C-rate of discharge = C/20 (or, 0.05C)]. Higher charging current may be used for Lead Acid Batteries if permitted by the battery manufacturer. Lithium ion & nickel zinc batteries may be charged at higher rates of up to 50% to 100% of their Ah capacity.

Programming range and Default values of "BULK CURRENT" ("Io") are shown in Table 6.2 and *also at Table 4.1 under Section 4.4.1 of EVO-RC Remote Control Manual*. The units are shipped with the "BULK CURRENT" set at the Default Value of 40A. *For programming information for this parameter, please refer to Section 4.4.2.1 of EVO-RC Remote Control Manual*.

When the unit enters Charging Mode, it starts working as a battery charger and the charger will ramp up to full programmed "BULK CURRENT" until the charger reaches the programmed threshold of "ABSORP VOLTAGE". NOTE: The charging current will slowly ramp up to the programmed value of BULK CURRENT.

For Adaptive Charging Profile Option "0=3 Stage Type 0" (*See Srl. No. 1 in Table 5.2*), a software timer will measure the time taken from the instant the unit enters the Bulk Charging Stage until the instant the battery voltage reaches 0.3 V below the programmed "ABSORP VOLTAGE", then registers this time as Bulk Charge Time "To" and computes Absorption Time "T1" as 10 times the Bulk Charge Time "To" in the internal "T1 Timer" i.e. T1 = To x 10 (*Minimum value of "T1" is 1 Hr and max value is 12 Hrs*). The "T1 Timer" is used to determine the time the charging will take place in the next Absorption Stage (*Section 5.7.2*).

5.7.1.2 Automatic Adjustments of Internal AC Charger Current When External Solar Charge Controller is Also Charging in Parallel

Please note that if an external Solar Charge Controller is also used to charge the batteries at the same time in parallel with the internal AC charger of the unit, the charging current of the internal AC charger will be controlled so that the total charging current of the external Solar Charge Controller and the internal charger is = the programmed "BULK CURRENT ("Io").

For example, if the programmed "BULK CURRENT (*"Io"*) is say 40 A and the charging current of the external Solar Charge Controller is 30 A, the internal AC charger will output only 10 A (*Programmed setting of 40 A – external charging current of 30 A = 10 A*). Similarly, if the programmed setting is say 30 A and the current supplied by the external Solar Charge Controller is say 50 A, the internal AC charger will NOT provide any charging current. Please refer to Section 5.4 for more details.

5.7.2 STAGE 2 – Absorption Stage

During the Absorption Stage, the Duty Cycle of the boosted high frequency PWM voltage pulses (*Section 5.1.2*) is adjusted continuously to keep the battery at constant voltage (*CV*) = the programmed value of parameter "ABSORP VOLTAGE" to ensure that the battery is further charged to the full capacity without overcharging. Programming range and Default values of "ABSORP VOLTAGE" are shown in Table 6.2. Default value is 14.4V for EVO-2212E/EVO-3012E and 28.8V for EVO-2224E/EVO-4024E. *For programming details of parameter "ABSORP VOLTAGE", refer to Section 4.4.2.2 of the EVO-RC Manual*. The Absorption Stage restores the remaining 25% of the battery's charge. The time the charger remains in the Absorption Stage is proportional to the depth of discharge of the battery. When the battery is more discharged, it will take longer time in the Bulk Charge Stage to reach the Gassing/Absorption Voltage.
For 3-Stage Adaptive Charging Profile Option "0=3 Stage Adaptive" (*See Srl. No. 1 in Table 5.2*), T1 Timer (*explained under Bulk Stage in Section 5.7.1.1 and Fig 5.1*) computes the time of charging in this stage as follows:

- Absorption Time "T1" = Bulk Charge Time "To" x 10 (*"To" = Time from entering Bulk Charge Stage till battery voltage rises to 0.3V below Absorption Voltage*).
- The "T1 Timer" has minimum time of 1 hour and a maximum time of 12 hours.
- When the "T1 Timer" runs out, the charger will enter the next Float Stage.
- Programming range and Default values of Absorption Voltage are shown in Table 6.2.

For the other 3-Stage Charging Profiles, "Stage 2 - Absorption Stage" is controlled as follows:

- Option "1 = 3 Stage Type 1" (*See Srl. 2 of Table 5.2*)
- Option "2 = 3 Stage Type 2" (*See Srl. 3 of Table 5.2*)

This stage is displayed as "X-CV" in the 1st line, right corner of the Charging Mode screens in the Remote Control EVO-RC. *[Refer to the screens shown under column "GROUP 3: CHARGING MODE" in Fig 3.2 of EVO-RC Remote Control Manual. Character "x" denotes code for the Charging Profile that is active. For details of codes for the Charging Profiles, please see Table 3.2 under Section 3.6.2 of Owner's Manual for EVO-RC.]*

5.7.3 STAGE 3 – Float Stage

Float Stage is a maintenance stage in which the Duty Cycle of the boosted high frequency PWM voltage pulses (*Section 5.1.2*) is adjusted continuously to keep the battery voltage at level = the programmed parameter "FLOATING VOLTAGE", typically about 13.5 V for 12 V models and 27.0 V for 24 V models to maintain the battery's charge without losing electrolyte through gassing and also, prevent corrosion of Positive plate by maintaining proper Positive Plate Polarization Voltage. Programmable range of values of "FLOATING VOLTAGE" are shown in Table 6.2. Default value is 13.5V for EVO-2212E/EVO-3012E and 27.0V for EVO-2224E/EVO-4024E. *For programming of parameter "FLOATING VOLTAGE", refer to Section 4.4.2.4 of EVO-RC Remote Control Manual.*

This stage is displayed as "X-FLOAT" in the 1st line, right corner of the Charging Mode screens in the Remote Control EVO-RC *[Refer to the screens shown under column "GROUP 3: CHARGING MODE" in Fig 3.2 of EVO-RC Remote Control Manual at Appendix A]. Character "x" denotes code for the Charging Profile that is active. [For details of the codes, please see Table 3.2 under Section 3.6.2 of Owner's Manual for EVO-RC.*

5.7.4 Automatic Resetting of Charging Cycle

The charging cycle will be reset to the Bulk Stage *[Section 5.8.2.1]* as follows:

a) If the AC input from the Grid/Generator is disconnected and is reconnected
b) If battery discharges and its voltage falls to the voltage level set by programming parameter "RESET TO BULK" *[For details, refer to Section 4.4.2.15 of EVO-RC Remote Control Manual].* Programming range for this parameter is:
   i. 10 to 13VDC for EVO-2212E/EVO-3012E (*Default value is 12.0VDC*)
   ii. 20 to 26VDC for EVO-2224E/EVO-4024E (*Default value is 24.0VDC*)
   c) If the charger remains in the Float Stage for 10 days

5.8 4 STAGE ADAPTIVE CHARGING PROFILE - EQUALIZATION

CAUTION!

4-Stage Adaptive Charging Profile - Equalization should be used only for vented, flooded (*non-sealed or "wet"*) batteries and not on sealed AGM/Gel Cell/Nickel-Zinc (*Ni-Zn*)/Lithium batteries and only as often as recommended by the battery manufacturer.

ATTENTION !

Profil de charge adaptative en 4 étapes - L'égalisation ne doit être utilisée que sur des batteries ventilées (non scellées ou «humides») et non sur des batteries scellées AGM/Gel/Nickel-Zinc (Ni-Zn)/Lithium et seulement aussi souvent que recommandé par le fabricant de batteries.

5.8.1 Brief Description:

4-Stage Adaptive Charging Profile for Equalization is used to equalize Flooded/Wet Cell Lead Acid Batteries. Equalization is carried out periodically – normally once per month for battery under heavy duty service and every 2 to 4 months for battery under light duty service. During the Equalization Stage, the battery is intentionally over-charged/boiled for a specified time period to equalize voltage of individual cells. Other benefits include reduction in sulfation and stirring up of the electrolyte to remove stratification. This results in maintaining the peak capacity of the battery.

INFO

Please read Section 1.4.4 regarding more details on necessity of equalizing batteries.

This 4-Stage Adaptive Charging Profile can be activated as follows:

- Using optional Remote Control Model EVO-RC. Programming Parameter "EQUALIZE-4STAGES" is required to be set at "1=Yes". *Refer to Section 4.4.2.12 of EVO-RC Manual.*
- If Remote Control EVO-RC is not available, by pressing ON/OFF Push Button on the front panel of the EVO® (*11, Fig 2.1*) for 1 sec. The cycle can be stopped prematurely by pressing the ON/OFF Push Button for 1 sec. Please refer to Section 5.9 for more details.

5.8.2 4-Stage Adaptive Charging Profile for Equalization – Charging Curves

Fig 5.2 shows the voltage and current curves during the 4 stages under this profile. Details are explained below:
As part of this **Adaptive Equalization Algorithm**, the charging process in the Equalization Stage is based on time **"To"** which is the time the charger remains in the initial Constant Current Bulk Charging Stage. In the Bulk Charging Stage, charging takes place at constant current (*referred to as "CC" at programmed value of parameter "BULK CURRENT"*) *[See Section 4.4.2.1 of EVO-RC Remote Control Manual]*. The charger will remain in the initial Bulk Charging Stage for a longer duration when the battery is deeply discharged and for a shorter duration if the battery has a shallow discharge.

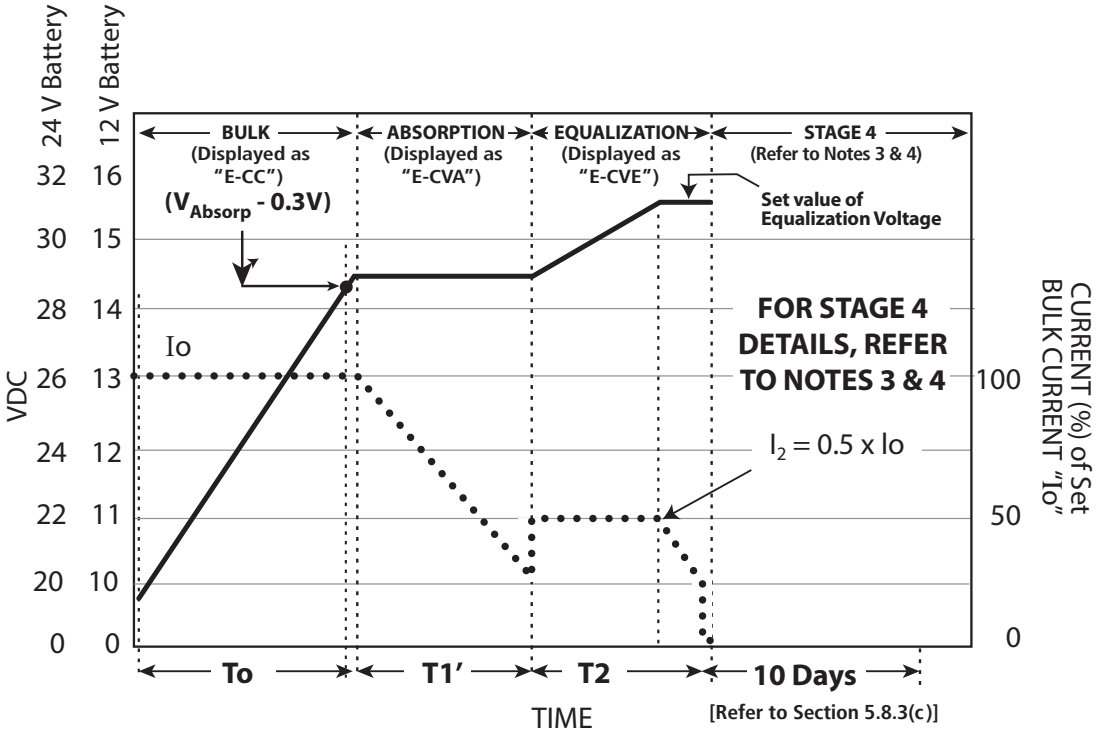


Fig 5.2 Charging Curves for 4-Stage Adaptive Charging Profile for Equalization

LEGEND for Fig 5.2	
———	Voltage (V) Curve
•••••	Current (I) Curve
Io	Bulk Stage Current. *Please see Section 5.7.1.1*
To	Bulk Stage Time. *Please see Section 5.7.1.1*
T1'	Adaptive Time in Absorption Stage. *Refer to Section 5.8.2.1.2(a)*
T2	Adaptive Time in Equalization Stage. *Refer to Section 5.8.2.1.2(b)*
E-CC, E-CVA, E-CVE	This coded information relates to the active Charging Profile and Charging Stage and is displayed in the right corner of the Charging Mode Display Screens of EVO-RC Remote Control. *Please see Table 3.2 under Section 3.6.3 of EVO-RC Remote Control Manual*

NOTES for Fig 5.2

1. Voltage (V) and Current (I) curves show the battery voltage and current.
2. Voltage (V) and Current (I) curves shown are based on the following operating conditions:
   a) The battery is being charged exclusively by the Battery charging Section of EVO® and that there is NO external charging source that is charging the battery/battery bank
   b) There is no external DC load on the battery/battery bank (the entire current delivered by the Charging Section of EVO® is being used to charge the battery/battery bank)
3. The 4th Stage will be the same as the last stage of the parameter CHARGING PROFILE *[See Section 4.4.2.21 in the EVO-RC Remote Control Manual]* from where Equalization was started. See Section 5.8.2.4 for details.
4. See Section 5.8.3 regarding conditions under which the charger will be forced to reset automatically and restart charging in the 1st Stage i.e. from the Bulk Stage of the programmed parameter CHARGING PROFILE *[See Section 4.4.2.21 in the EVO-RC Remote Control Manual]*

5.8.2.1 Stage 1 – Bulk Charge Stage under 4-Stage Adaptive Charging Profile – Equalization
Refer to Section 1.4.3.1 for general information on Bulk Charge Stage and to Fig 5.2 for voltage and current curves during this stage.

5.8.2.1.1 During the 1st "Bulk Charge Stage", the batteries will be charged at constant current (*CC*) = the programmed value of parameter "BULK CURRENT" (*"Io"*) *[Default value of Parameter "BULK CURRENT" is 40 A. See programming range at Table 6.2 and programming procedure at Section 4.4.2.1 in the EVO-RC Remote Control Manual*]. The value of programmed parameter "BULK CURRENT" (*"Io"*) should normally be limited to 10% to 20% of the Ah capacity of the battery [*Ah capacity at C-rate of discharge = C/20 (or, 0.05C)*]. Higher current may be used if permitted by the battery manufacturer. The Bulk Charge Stage is displayed as "E-CC" in the right corner of the 1st line of Charging Mode Screens of EVO-RC Remote Control. *[Please refer to codes / abbreviations in Table 3.2 under Section 3.6.2 of EVO-RC Remote Control Manual].*

5.8.2.1.2 A Software Timer is used to measure the time taken from the time the unit enters Bulk Stage to the time the battery voltage reaches 0.3 V below the programmed value of parameter "ABSORP VOLTAGE" *[Default value of parameter "ABSORP VOLTAGE" is 14.4 V for EVO-2212E/3012E and 28.8 V for EVO-2224E/4024E. See programming range at Table 6.2, Section 6 and programming procedure at Section 4.4.2.2 in the EVO-RC Remote Control Manual]*. This time is registered as Bulk Stage Time "To". ***As part of Adaptive Algorithm, the following times are computed based on the Bulk Stage Time "To"***

- ***a) Absorption Stage Time T1' =*** To x 0.5
- ***b) Equalization Stage Time T2:***
  - i. T2 = T1' + 1 Hr = (To x 0.5) +1 Hr ; if T1' is <2 Hrs
  - ii. T2 = T1' + 2 Hrs = (To x 0.5) +2 Hr ; if T1' is > 2 Hrs but <4 Hrs
  - iii. T2 = T1' + 4 Hrs = (To x 0.5) +4 Hr ; if T1' is > 4 Hrs

5.8.2.1.3 When the battery voltage rises to the programmed value of parameter "ABSORP VOLTAGE", the charging stage transitions to the next Stage 2 – Absorption Stage described at Section 5.8.2.2 below *[Default value of parameter "ABSORP VOLTAGE" is 14.4 V for EVO-2212E/3012E and 28.8 V for EVO-2224E/4024E. See programming range at Table 6.2, Section 6 and programming procedure at Section 4.4.2.2 in the EVO-RC Remote Control Manual]*.

5.8.2.1.4 Automatic Adjustment of Internal AC Charger Current when External Solar Charge Controller is also Charging in Parallel: Please note that if an external solar charge controller is also used to charge the batteries at the same time in parallel with the internal AC charger of the unit, the charging current of the internal AC charger will be controlled so that the total charging current of the external charger and the internal charger is = the

programmed "BULK CURRENT (*"Io"*) *[See Section 4.4.2.1 of EVO-RC Remote Control Manual].*

For example, if the programmed value of parameter "BULK CURRENT" (*"Io"*) is say 40 A and the charging current from the external Solar Charge Controller is say 30 A at any given instant, the internal AC charger will output only 10A (*Programmed value of 40 A minus external charging current of 30A = 10 A*). Now, if the charging current from the External Charge Controller rises to say 50 A, the internal AC charger will be reduced to 0 A.

5.8.2.2 Stage 2 – Adaptive Absorption Stage under 4-Stage Adaptive Charging Profile – Equalization
Refer Section 1.4.3.2 for general information on Absorption Stage and to Fig 5.2 for voltage and current curves during this stage.

5.8.2.2.1 During the 2nd "Absorption Stage", the batteries will be charged at constant voltage (*CV*) = the programmed value of parameter "ABSORP VOLTAGE" *[Default value of parameter "ABSORP VOLTAGE" is 14.4 V for EVO-2212E/3012E and 28.8 V for EVO-2224E/4024E. See programming range at Table 6.2, Section 6 and programming procedure at Section 4.4.2.2 in the EVO-RC Remote Control Manual]*. The Absorption Stage is displayed as "E-CV" in the right corner of the 1st line of Charging Mode Screens of EVO-RC Remote Control. *[Please refer to codes/abbreviations detailed at Table 3.2 under Section 3.6.2 of EVO-RC Remote Control Manual at Appendix A]*. The charger remains in this stage for computed Time ***T1'*** [*Refer to Section 5.8.2.1.2(a)*] and then transitions to Stage 3 – Equalization Stage described at Section 5.8.2.3 below

5.8.2.3 Stage 3 –Adaptive Equalization Stage:

Refer Section 1.4.3.4 for general information on Equalization Stage and to Fig 5.2 for voltage and current curves during this stage

In this stage, charging takes place at constant voltage at value = the programmed value of parameter "EQUALIZE VOLTAGE" *[Default value is 14.40 V for EVO-2212E / 3012E and 28.80 V for EVO-2224E/4024E. Please see programming range at Table 6.2 and programming procedure at Section 4.4.2.3 in EVO-RC Remote Control Manual]*. It remains in this stage for computed time "T2" [*Refer to Section 5.8.2.1.2(b)*] and then transitions to Stage 4 described at Section 5.8.2.4 below

5.8.2.4 Stage 4 – Last Stage of 4-Stage Charging Profile for Equalization:

Stage 4 of the 4-Stage Charging Profile for Equalization will be the same as the last stage of the charging profile that was active when the 4-Stage Charging Profile for Equalization was switched on. See details at Table 5.2.1 below:

Table 5.2.1 Stage 4 of 4-Stage Adaptive Charging Profile for Equalization

Charging Profile that was active when Equalization was started (1)	**Last Stage of Charging Profile at Column (1) from where Equalization was started (2)**	**EVO-RC display at 1st line, right corner (*See Note 1*) (3)**
0=3 Stage Adaptive	FLOAT: Charge at constant voltage = "FLOATING VOLTAGE" • Exit to BULK STAGE when: - Voltage drops to "RESET TO BULK", or - After 10 days in Float Stage	0-FLOAT
1=3 Stage Type 1		1-FLOAT
2= 3 Stage Type 2		2-FLOAT

Table continues on next page ▶

Table 5.2.1 Stage 4 of 4-Stage Adaptive Charging Profile for Equalization		
3= 2 Stage Type 1	OFF	3-OFF
4= 2 Stage Type 2	Absorption Stage	4-CV
5= 2 Stage Type 3	Off	5-OFF

NOTE 1:

This portion of display is shown in the 1st line, right hand corner of GROUP 3: CHARGING MODE screens *[Column 4 of Fig 3.2 in EVO-RC Remote Control Manual]*.

- Numerals 0 to 5 indicate the specific Charging Profile *(Column 1)* that is active
- FLOAT / CV indicates the charging stage *(CV stands for "Constant Voltage Absorption Stage)*
- OFF indicates that charging is OFF

EXAMPLE BASED ON TABLE 5.2.1

Assume that 4-Stage Charging Profile for Equalization was switched on when 3-Stage Adaptive Charging Profile option "0= 3 Stage Type 0" was active [*Column (1), Table 5.2.1*]. In this Charging Profile, the last i.e. the 3rd Stage is FLOAT [*Column (2), Table 5.2.1*]. After completing the 3rd Stage of Equalization, the 4th Stage will, therefore, be FLOAT [*Column (3), Table 5.2.1*]. The right-hand corner display "0-FLOAT" [*Column (3), Table 5.2.1*] indicates:

- "0" for the parameter CHARGING PROFILE set at Option "0=3 Stage Type 0"
- "FLOAT" indicates the last FLOAT Stage of 3-Stage Adaptive CHARGING PROFILE Option "0=3 Stage Type 0"

5.8.3 Automatic Resetting of 4-Stage Adaptive Charging Profile

The 4-Stage Adaptive Charging Profile explained at Section 5.8.2 above will be reset to the First Stage i.e. the Bulk Stage *[Section 5.8.2.1]* as follows:

a) If the AC input fails and is restored or, it is disconnected and is reconnected
b) If battery discharges and its voltage falls to the voltage level set by programming parameter "RESET TO BULK" *[For details, refer to Section 4.4.2.15 of EVO-RC Remote Control Manual]*. Programming range for this parameter is:
   i. 10 to 13 VDC for EVO-2212E/EVO-3012E (*Default value is 12.0 VDC*)
   ii. 20 to 26 VDC for EVO-2224E/EVO-4024E (*Default value is 24.0 VDC*)
c) If the charger remains in the Float Stage for 10 days

5.9 SWITCHING ON AND SWITCHING OFF PROCEDURE FOR 4-STAGE ADAPTIVE CHARGING PROFILE FOR EQUALIZATION

The default charging profile is "3-Stage Type 0" i.e. 3-Stage Adaptive *[Refer to (i) Srl. No 1, Table 5.2 and (ii) Section 4.4.2.21 in the EVO-RC Remote Control Manual]*. 4-Stage Adaptive Charging Profile for Equalization is required to be activated manually as follows:

- **Initiating 4-Stage Adaptive Charging Profile for Equalization using ON/Off Push Button (11, Fig 2.1) on the Front Panel (only if the Remote Control EVO-RC is not connected to the EVO® Inverter Charger or, is not available):** When the unit is in Charging Mode (*qualified Grid / Generator Input is available*), the Green LED marked "ON" (*12, Fig 2.1*) will be blinking once in 1 sec interval. Press the ON/OFF Button (*11, Fig 2.1*) for 1 second. The ongoing Charge Profile will be terminated and Adaptive Equalization will be initiated. The Green LED marked

"ON" (*12, Fig 2.1*) will start blinking twice in 1 sec interval to show that the 4-Stage Adaptive Charging Profile for Equalization is active. The unit will complete Equalization and terminate in the last stage of the charging profile that was active at the time the Equalization Profile was activated (*Section 5.8.2.4*). Henceforth, charging will continue in the initial charging profile that was active before equalization was initiated. At the same time, the Charging Profile Setting will again be reset to the original and the Green LED marked"ON" (*12, Fig 2.1*) will return to 1 blink in 1 sec interval. **To terminate Equalization Profile prematurely before its completion, press the ON/OFF Push Button for 1 second.**

If the unit was in Inverting Mode *[Green LED marked "ON" (12, Fig 2.1) steady]* and the Charging Profile is set to 4-Stage Adaptive Charging Profile for Equalization as above by pressing the ON/OFF Push Button for 1 second, the unit will initiate Equalization Profile *whenever qualified AC input is available from Grid/Generator.* To terminate Equalization Profile prematurely before its completion, press the ON/OFF Push Button for 1 second.

NOTE: Procedure described above is to be used when the optional Remote Control EVO-RC has NOT been plugged into the RJ-45 Remote Control Jack (*7, Fig 2.1*). **Please note if the Remote Control has been plugged into the RJ-45 Jack, the above procedure cannot be activated and the ON/OFF of Equalization Profile will be controlled by the Remote Control EVO-RC.**

5.10 2-STAGE CHARGING PROFILES

2-Stage Charging Profile may be used for charging lead acid, lithium Ion and Nickel-Zinc (*Ni-Zn*) types of batteries.

In 2-Stage Charging Profile, the battery is charged in Bulk Stage first and then in Absorption Stage or Float Stage. There is no 3rd Stage.

INFO

The 2nd Stage i.e. Absorption Stage may also be referred to as Float Stage in some applications like charging Lead Acid Battery with load (*battery backup application like in Telecom battery charging, Emergency Lighting etc.*). In this application, the voltage setting of the 2nd Absorption Stage is lowered to the level corresponding to the Float Stage. Please note that under this condition, the battery will not charge fully but only to around 80%.

The following 3 programming options are available for 2-Stage Charging:

1) *Option 3 = 2 Stage Type 1:* Please refer to Srl. 1 of Table 5.3 for detailed description and Fig 5.3 for Voltage - Current (V-I) Curves
2) *Option 4 = 2 Stage Type 2:* Please refer to Srl. 2 of Table 5.3 for detailed description and Fig 5.4 for Voltage – Current (V-I) Curves
3) *Option 5 = 2 Stage Type 3:* Please refer to Srl. 3 of Table 5.3 for detailed description and Fig 5.5 for Voltage – Current (V-I) Curves

INFO

Please refer to Section 5.11 for more details regarding protections available in EVO® Series when using 2-Stage Charging Profiles for charging Lithium Ion Battery Packs in association with their Battery Management System (*BMS*).

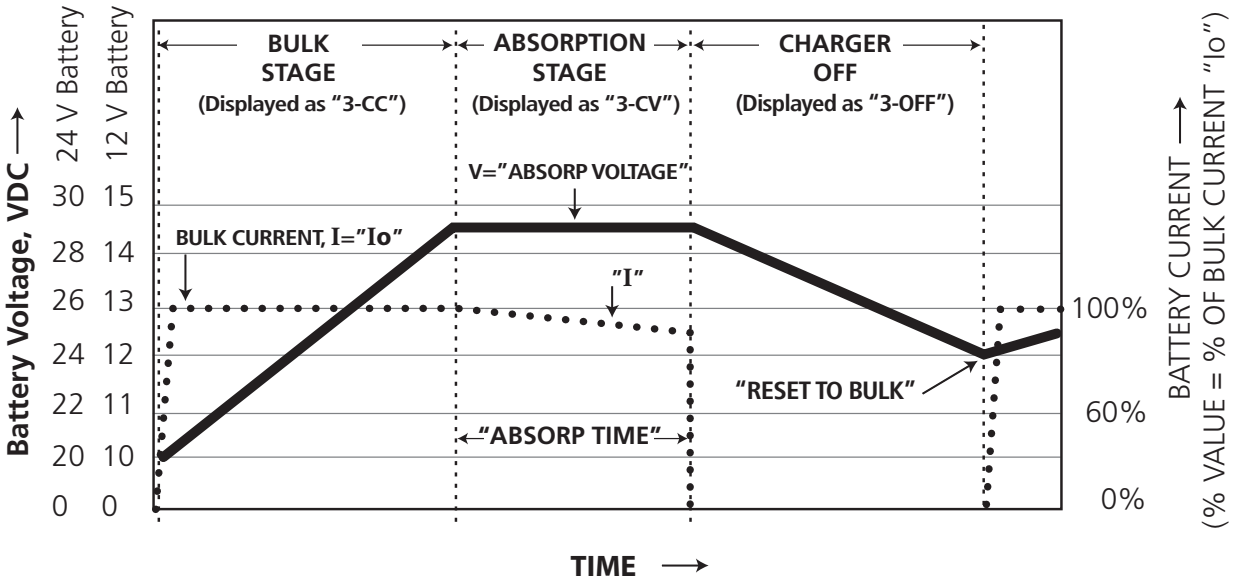


Fig 5.3 Voltage – Current (V-I) Curves for "2-Stage Type 1" Charging Profile

LEGEND for Fig 5.3	
———	Voltage (V) Curve
•••••	Current (I) Curve
Io	Bulk Stage Current. *Please see Section 5.7.1.1*
3-CC, 3-CV, 3-OFF	This coded information relates to the active Charging Profile and Charging Stage and is displayed in the right corner of the Charging Mode Display Screens of EVO-RC Remote Control. *Please see Table 3.2 under Section 3.6.3 of EVO-RC Remote Control Manual*

NOTES for Fig 5.3

1. *Please see Srl. 1 of Table 5.3 for details of charging process*
2. Voltage (V) and Current (I) curves show the battery voltage and current.
3. The Voltage (V) and Current (I) curves shown are based on the following operating conditions:
   a) The battery is being charged exclusively by the battery charging Section of EVO® and that there is NO external charging source that is charging the battery/battery bank
   b) There is no external DC load on the battery/battery bank *(the entire current delivered by the Charging Section of EVO® is being used to charge the battery/battery bank)*

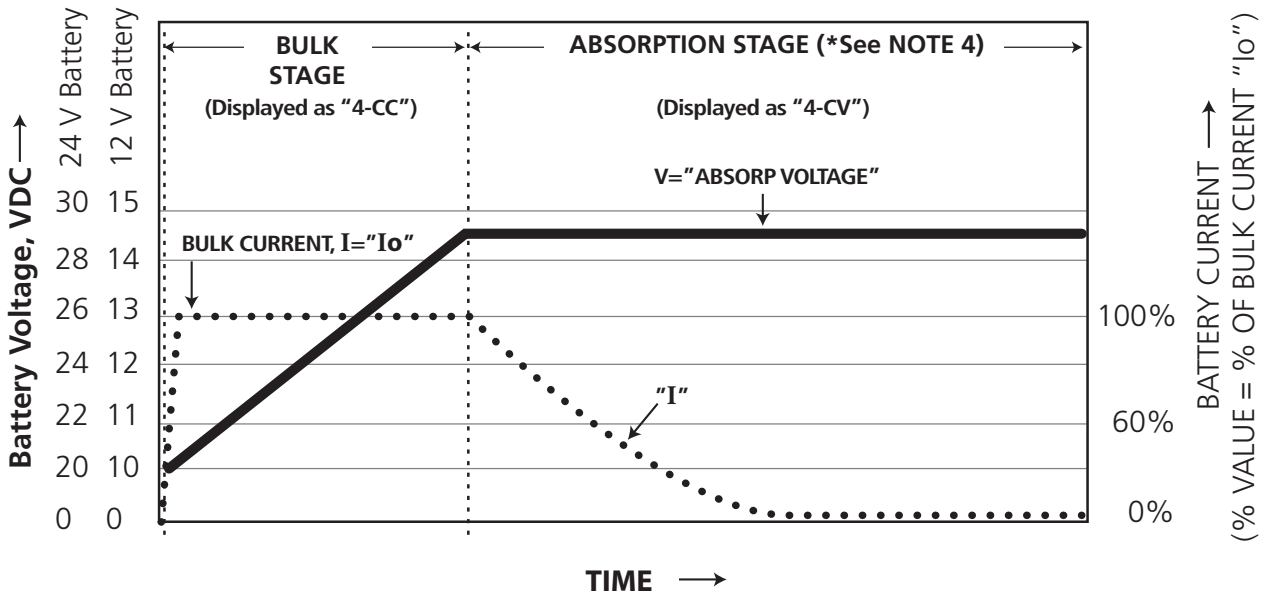


Fig 5.4 Voltage – Current (V-I) Curves for "2-Stage Type 2" Charging Profile

LEGEND for Fig 5.4	
———	Voltage (V) Curve
•••••	Current (I) Curve
Io	Bulk Stage Current. *Please see Section 5.7.1.1*
4-CC, 4-CV	This coded information relates to the active Charging Profile and Charging Stage and is displayed in the right corner of the Charging Mode Display Screens of EVO-RC Remote Control. *Please see Table 3.2 under Section 3.6.3 of EVO-RC Remote Control Manual*

NOTES for Fig 5.4

1. *Please see Srl. 1 of Table 5.3 for details of charging process*
2. Voltage (V) and Current (I) curves show the battery voltage and current.
3. The Voltage (V) and Current (I) curves shown are based on the following operating conditions:
   a) The battery is being charged exclusively by the battery charging Section of EVO® and that there is NO external charging source that is charging the battery/battery bank
   b) There is no external DC load on the battery/battery bank (*the entire current delivered by the Charging Section of EVO® is being used to charge the battery/battery bank*)
4. *Please see Section 5.7.4* regarding conditions under which the charger will be forced to reset automatically and restart charging from the 1st Stage i.e. Bulk Stage of the programmed CHARGING PROFILE

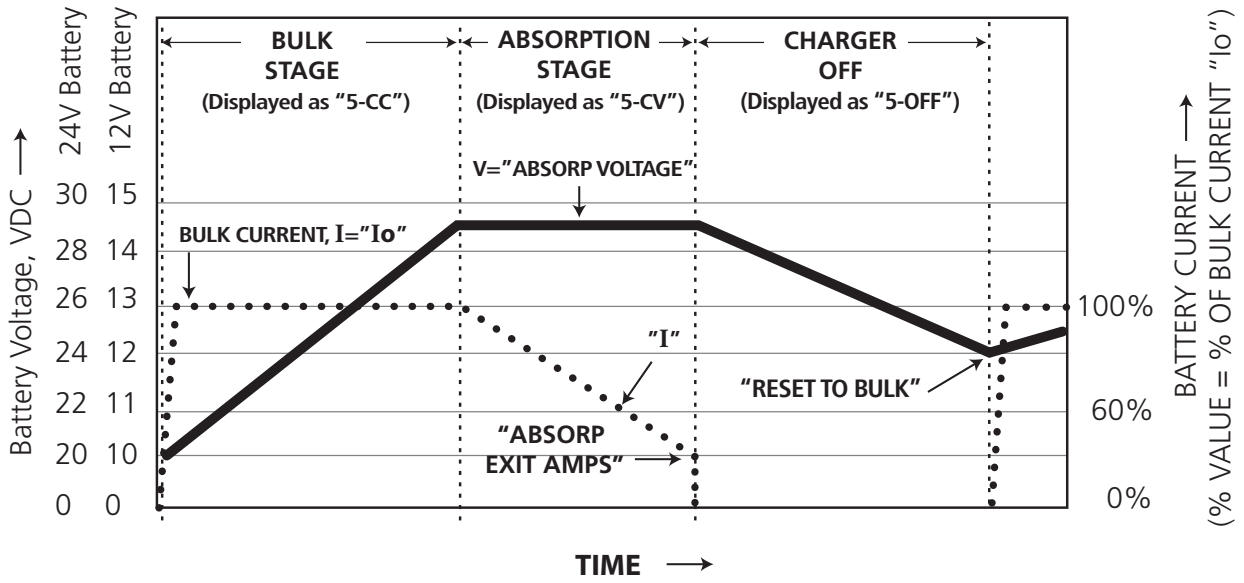


Fig 5.5 Voltage – Current (V-I) Curves for "2-Stage Type 3" Charging Profile

LEGEND for Fig 5.5	
———	Voltage (V) Curve
•••••	Current (I) Curve
Io	Bulk Stage Current. *Please see Section 5.7.1.1*
5-CC, 5-CV, 5-OFF	This coded information relates to the active Charging Profile and Charging Stage and is displayed in the right corner of the Charging Mode Display Screens of EVO-RC Remote Control. *Please see Table 3.2 under Section 3.6.3 of EVO-RC Remote Control Manual*
RESET TO BULK	At this point, the charger is forced to reset automatically from the operating charging stage and restart the selected CHARGING PROFILE from the 1st Stage i.e. from the Bulk Stage. *Please see Section 5.7.4*
ABSORP EXIT AMPS	When charging current in Absorption Stage drops to value set by programming parameter "ABSORP EXIT AMPS", the charger is switched off *[The default value of parameter "ABSORP EXIT AMPS" is 4A. For details of programming range or programming procedure, refer to Section 4.4.2.20 of the EVO-RC Remote Control Manual]*

NOTES for Fig 5.5

1. *Please see Srl. 3 of Table 5.3 for details of charging process*
2. Voltage (V) and Current (I) curves show the battery voltage and current.
3. The Voltage (V) and Current (I) curves shown are based on the following operating conditions:
   a) The battery is being charged exclusively by the Battery charging Section of EVO® and that there is NO external charging source that is charging the battery/battery bank
   b) There is no external DC load on the battery/battery bank (*the entire current delivered by the Charging Section of EVO® is being used to charge the battery/battery bank*)

TABLE 5.3 3 TYPES OF CHARGING PROFILE OPTIONS FOR 2-STAGE CHARGING

Srl No.	Options under Programming Parameter "CHARGING PROFILE" *(See Section 4.4.2.21 in EVO-RC Remote Control Manual)*	Charging Stages	Battery Type
1	3=2Stage Type1 *REFER TO FIG 5.3 FOR VOLTAGE-CURRENT (V-I) CURVES*	1. **Stage 1 – Bulk Stage (See Section 5.7.1.1)** • Charge at constant current = the programmed value of parameter "BULK CURRENT" **(Default value is 40 A.** *For details of programming range & procedure, refer to Section 4.4.2.1 of EVO-RC Remote Control Manual* • Transition to Absorption Stage when voltage rises to the set value for programming parameter "ABSORP VOLTAGE" (**Default value is 14.4 V for EVO-2212E/3012E and 28.8 V for EVO-2224E/4024E.** *For details of programming range & procedure, refer to Section 4.4.2.2 of EVO-RC Remote Control Manual)* 2. **Stage 2 - Absorption Stage (See Section 5.7.2)** • Charge at constant voltage = the programmed value for parameter "ABSORP VOLTAGE". (**Default value is 14.4 V for EVO-2212E/3012E and 28.8 V for EVO-2224E/4024E.** *For details of programming range & procedure, refer to Section 4.4.2.2 of EVO-RC Remote Control Manual)* • Remain in Absorption Stage till the time in Absorption Stage is = the programmed value of parameter "ABSORP TIME" **(Default value is 60 min.** *For details of programming range & procedure, refer to Section 4.4.2.19 of EVO-RC Remote Control Manual).* • Switch off charging after expiry of programmed value of parameter "ABSORP TIME" **(Default value is 60 min.** *For details of programming range & procedure, refer to Section 4.4.2.19 of EVO-RC Remote Control Manual).* • Reset to Bulk Stage under the following conditions: i. If the AC input from the Grid/Generator is disconnected and is reconnected. ii. If battery voltage falls to the programmed value of parameter "RESET TO BULK" **(Default value is 12.0 V for EVO-2212E/3012E & 24.0 V for EVO-2224E/4024E.** *For details of programming range & procedure, refer to Section 4.4.2.15 of EVO-RC Remote Control Manual).*	• Lithium *(See Section 5.11)* • Nickel Zinc *(See Section 5.10)*

Table continues on next page ▶

TABLE 5.3 3 TYPES OF CHARGING PROFILE OPTIONS FOR 2-STAGE CHARGING (Continued)

2	4=2Stage Type2 *REFER TO FIG 5.4 FOR VOLTAGE-CURRENT (V-I) CURVES*	1. **Stage 1 – Bulk Stage (See Section 5.7.1.1)** • Charge at constant current = the programmed value of parameter "BULK CURRENT" **(Default value is 40 A.** *For details of programming range & procedure, refer to Section 4.4.2.1 of EVO-RC Remote Control Manual)* • Transition to Absorption Stage when voltage rises to the set value for programming parameter "ABSORP VOLTAGE" **(Default value is 14.4 V for EVO-2212E/3012E and 28.8 V for EVO-2224E/4024E**. *For details of programming range & procedure, refer to Section 4.4.2.2 of EVO-RC Remote Control Manual)* 2. **Stage 2 - Absorption Stage (See Section 5.7.2)** • Charge at constant voltage (CV) = the programmed value for parameter "ABSORP VOLTAGE". **(Default value is 14.4 V for EVO-2212/3012 and 28.8 V for EVO-2224/4024**. *For details of programming range & procedure, refer to Section 4.4.2.2 of EVO-RC Remote Control Manual)* • Remain in Absorption Stage • Reset to Bulk Stage under the following conditions: i. If the AC input from the Grid/Generator is disconnected and is reconnected. ii. If battery voltage falls to the programmed value of parameter "RESET TO BULK" **(Default value is 12.0 V for EVO-2212E/3012E & 24.0 V for EVO-2224E/4024E.** *For details of programming range & procedure, refer to Section 4.4.2.15 of EVO-RC Remote Control Manual).*	• Lithium *(See Section 5.11)*
3	5=2Stage Type3 *REFER TO FIG 5.5 FOR VOLTAGE-CURRENT (V-I) CURVES*	1. **Stage 1 – Bulk Stage (See Section 5.7.1.1)** • Charge at constant current = the programmed value of parameter "BULK CURRENT" **(Default value is 40 A.** *For details of programming range & procedure, refer to Section 4.4.2.1 of EVO-RC Remote Control Manual)* • Transition to Absorption Stage when voltage rises to the set value for programming parameter "ABSORP VOLTAGE" **(Default value is 14.4 V for EVO-2212E/3012E and 28.8 V for EVO-2224E/4024E.** *For details of programming range & procedure, refer to Section 4.4.2.2 of EVO-RC Remote Control Manual)* 2. **Stage 2 - Absorption Stage (See Section 5.7.2)** • Charge at constant voltage = the programmed value for parameter "ABSORP VOLTAGE". **(Default value is 14.4 V for EVO-2212E/3012E and 28.8 V for EVO-2224E/4024E.** *For details of programming range & procedure, refer to Section 4.4.2.2 of EVO-RC Remote Control Manual)* • Remain in Absorption Stage till the current reduces to value = the programmed value of parameter "ABSORP EXIT AMPS" **(Default value is 4 A.** *For details of programming range & procedure, refer to Section 4.4.2.20 of EVO-RC Remote Control Manual)* • Switch off charging after the current reduces to value = the programmed value of parameter "ABSORP EXIT AMPS" **(Default value is 4 A.** *For details of programming range & procedure, refer to Section 4.4.2.20 of EVO-RC Remote Control Manual)* • Reset to Bulk Stage under the following conditions: i. If the AC input from the Grid/Generator is disconnected and is reconnected. ii. If battery voltage falls to the programmed value of parameter "RESET TO BULK" **(Default value is 12.0 V for EVO-2212E/3012E & 24.0 V for EVO-2224E/4024E**. *For details of programming range & procedure, refer to Section 4.4.2.15 of EVO-RC Remote Control Manual).*	• Lithium *(See Section 5.11)* • Nickel Zinc *(See Section 5.10)*

5.11 CHARGING LITHIUM ION BATTERIES

CAUTION!

The Battery Management System (*BMS*) that comes with the Lithium Ion Battery being used may need to have control over charging and discharging of the battery. For this, any of Pins 1/2/3/4 and any of Pins 5/6/7/8 of the Temperature Sensor Jack (*6, Fig 2.1; Pinout at Fig 3.13*) may be used to feed potential free contact closing signal from the BMS to "Stop Charging" or "Stop Inverting. See Section 5.11.2 below for details.

ATTENTION!

Le système de gestion de la batterie (BMS) qui vient avec la batterie au lithium-ion utilisé peut avoir besoin d'avoir le contrôle de charge et décharge de la batterie. Pour cela, n'importe lequel des broches 1/2/3/4 et 5/6/7/8 de la prise de capteur de température (6, Fig. 2.1; Pinout à la Fig. 3.13) peut être utilisé pour l'alimentation contact libre de signal de fermeture de la BMS à "arrêter la charge" ou "arrêter d'inverser". Se reporter à la Section 5.11.2 pour plus de détails.

5.11.1 Charging Profiles for Lithium Batteries

Programming parameter "CHARGING PROFILE" is used to select up to 5 programming options for 2/3-Stage charging profiles for Lithium Ion Batteries. Details are given in Table below:

Srl. No. Table 5.2	Srl. No. of Table 5.3	Option under Parameter "CHARGING" Profile (Section 4.4.4.2.21 of EVO-RC Remote Control Manual
2	—	"1 = 3-Stage Type 1"
3	—	"2 = 3-Stage Type 2"
—	1	"3 = 2-Stage Type 1"
—	2	"4 = 2-Stage Type 2"
—	3	"5 = 2-Stage Type 3"

INFO

Charging of Lithium Ion Batteries is not affected by temperature and hence, Battery Temperature Sensor Model EVO-BCTS [*Fig 2.5(a)*] is not required to be used

5.11.2 Stop Charging and Stop Inverting Protections when Charging Lithium Batteries

For background information, refer to Section 4.4.2.22.2 in the EVO-RC Remote Control Manual. For protection against over-voltage/over-temperature/over-discharge, Lithium Ion Battery Management Systems (*BMS*) will normally have capability of providing potential free relay contact closure signal that could be fed to Inverter Charger to stop charging or stop inverting. For this, the BMS will normally use miniature, Normally Open (*1-Form-A*), Open Drain Opto-Isolated DC Solid-State Relay (*SSR*). The Solid-State Relay output terminals in the BMS are normally marked "+" (*Drain of Mosfet Switch*) and "-" (*Source of Mosfet Switch*). Example of this type of relay is IXYS Part No. "CPC1002N" (*60 V, 700 mA rating*).

SECTION 5 | Battery Charging in Evolution® Series

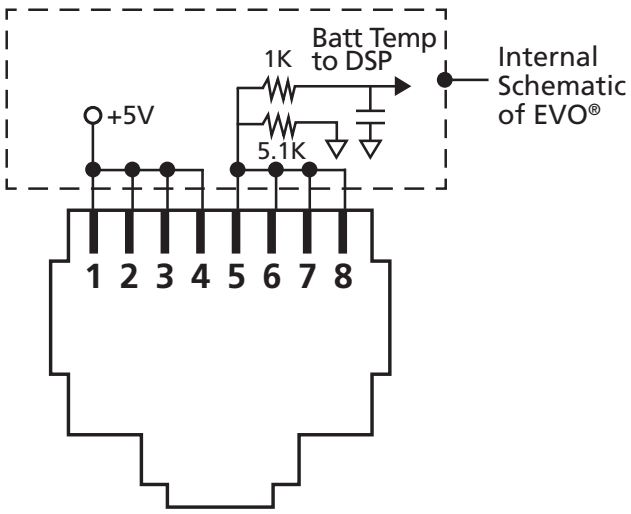
The following 2 types of signals are normally used by the BMS for ON/OFF control of charging and inverting operation of the Inverter-Charger:

- **"Stop Charging" Signal:** In case of (i) over voltage of individual cell/overall battery pack, or (ii) over temperature of individual cell or overall battery pack, the signal will be "enabled" and SSR contacts will close (*Drain (+) and Source (-) Terminals will be shorted*).
- **"Stop Inverting" Signal:** In case of deep discharge of the battery to the level of Low Battery Cut Off Voltage, the signal will be "enabled" and the SSR contacts will close (*Drain (+) and Source (-) Terminals will be shorted*).

If the above two protection functions of the BMS i.e. *"Stop Charging"* and *"Stop Inverting"* are to be used for ON/OFF control of charging and inverting operations of EVO® Inverter-Charger, the following actions will be required to be undertaken:

a) Programming parameter **"BATTERY TYPE"** must be changed from Option 1 - "0=Lead Acid" (*Default setting*) to Option 2 - "1=Lithium" (*See Section 4.4.2.22 of EVO-RC Remote Control Manual)*. With this setting, the function of front panel RJ-45 Jack marked "Battery Temp. Sensor: (6, Fig 2.1) will change from accepting and processing battery temperature signal from the Battery Temperature Sensor EVO-BCTS to accepting and processing potential free relay contact closure signal from the Solid-State Relay from the BMS to stop charging /inverting.

b) **Wiring Connection:** Output from the SSR Terminals on the Lithium Battery BMS should be wired to the RJ-45 Jack marked "Battery Temp. Sensor" (*6, Fig 2.1*) as follows:
- Connect terminal marked "+" on the SSR (*Drain of Mosfet switch inside SSR*) to any of pins 1/2/3/4 of RJ-45 Jack (*Pinout shown below*)
- Connect terminal marked "-" on the SSR (*Source of Mosfet switch inside SSR*) to any of pins 5/6/7/8 of RJ-45 Jack (*Pinout shown below*)



Pinout of RJ-45 Jack marked "Battery Temp. Sensor" on the Front Panel of EVO® (*6, Fig 2.1*)

When the Drain-Source terminals of the BMS close, Pins 1/2/3/4 and 5/6/7/8 of RJ-45 Jack will be shorted. The following actions will be activated in EVO:

- **EVO® in Charging Mode:** Charging will stop (*Internally, the EVO® will be in Charging Mode, but the charging current will be reduced to 0A*). The 1st Line of the Overall Operating Mode Display Screens shown under Column 4 for "GROUP 3: CHARGING MODE" display Screens *[Fig 3.2 in EVO-RC Manual]* will show "CHR STOP BY BMS" as shown in example below:

  Example of Screen No. 1 of 19 Screens under Column 4 for GROUP 3: CHARGING MODE"
  [Fig 3.2 in EVO-RC Remote Control Manual]

  ```
  CHGR STOP BY BMS
  OUTPUT  120.00 V
  ```

- **EVO® in Inverting Mode:** Inverting will stop (*Internally, the EVO® will enter Standby Mode*). The 1st Line of the Operating Mode Screens shown in the Menu Map for GROUP 1: STANDBY MODE" display Screens *[Fig 3.2 in EVO-RC Manual]* will show "INV STOP BY BMS" as shown in example below:

  Example of Screen No. 1 of 7 Screens under Column 1 for GROUP 1: STANDBY MODE"
  [Fig 3.2 in EVO-RC Remote Control Manual]

  ```
  INV STOP BY BMS
  BATTERY 12.000 V
  ```

5.12 OPERATING MODE OPTION - "CHARGER ONLY"

In Off-grid DC powered homes, for efficiency consideration, all lighting and other loads/appliances are normally powered from 12 V batteries that are primarily charged through solar/wind power. Generator backup is used for powering AC to DC battery charger for charging the batteries during extended periods of cloudy/no wind conditions. To meet this requirement, the EVO® can be programmed to operate as a battery charger ONLY i.e. when AC input power is available within the programmed limits of voltage and frequency, charging will take place and AC input will be passed through to the load(s). The unit will not transfer to Inverting Mode if AC input fails or is outside the programmed limits of voltage and frequency. *For further details refer to Section 4.4.2.13.3 in EVO-RC Remote Control Manual.*

CAUTIONS!

a) Please ensure that all safety instructions at Section 1 of this manual are read and understood before operating the unit.
b) Please ensure that the unit has been installed properly as per instructions at Section 3 of this manual.

ATTENTIONS!

a) Veuillez vous assurer que toutes les instructions de sécurité de la Section 1 de ce manuel sont lues et comprises avant d'utiliser l'appareil.
b) Veuillez vous assurer que l'appareil a été installé correctement conformément aux instructions de la section 3 de ce manuel.

SECTION 6 | Operation, Protections and Troubleshooting

INFO

Please ensure that charged battery has been connected to the DC Input Terminals (*1 and 2 in Fig2.1*). This unit will NOT operate if specified battery voltage as shown below is not available at the DC Input terminals:

a) 12 V units i.e. EVO-2212E/3012E…….. ≥ 9.1 VDC
b) 24 V units i.e. EVO-2224E/4024E…….. ≥ 18.1 VDC

6.1 POWERING ON/POWERING OFF USING FRONT PANEL ON/OFF BUTTON (11, FIG 2.1)

NOTE: *For power on/power off Sequence when using the optional Remote Control EVO-RC Owner's Manual*

6.1.1 Manual Power on Sequence when AC Input is in Switched Off Condition/Not Connected:

To power ON the unit, press and hold the ON/OFF Button on the front panel (*11, Fig 2.1*) for around 3 seconds until completion of sequence shown below:

- Green LED marked "ON" (*12, Fig 2.1*) will blink 3 times, will go off momentarily and will then be steady Green. Now, release the ON/OFF Button. Subsequently, the lighting pattern of this LED will be controlled by various operating conditions given in Table 6.1

NOTE: *For Power ON/OFF sequence when using the optional Remote Control EVO-RC, please refer to Section 3.2 of EVO-RC Remote Control Manual.*

6.1.2 Automatic Power on Sequence when AC Input Power is in Switched on Condition:

Automatic "Power on Sequence" will be initiated if:

i. AC input power > 140 ± 10 VAC is made available at the Grid/Generator Input Terminals and,
ii. The battery voltage is > 12 V for EVO-2212E/3012E and > 24 V for EVO-2224E/4024E. If no fault condition(s) is detected, the unit enters "Charging Mode" if AC input power is within the programmed limits of voltage and frequency or Inverting Mode if AC input power is NOT within the programmed limits of voltage and frequency.

NOTE: *For power on/power off Sequence when using the optional Remote Control EVO-RC, please refer to Section 3.2 of EVO-RC Remote Control Manual.*

6.1.3 Power off Sequence:

6.1.3.1 Power off Sequence when AC Input is in Switched off Condition/Not Connected:

When the AC input is in switched off condition/not connected and the unit is in ON condition, the unit will be operating in Inverting Mode and the Green LED marked "ON (*12, Fig 2.1*) will be in steady ON condition.
To power OFF the unit, press and hold the ON/OFF Button (*11, Fig 2.1*) for around 5 seconds. Wait for the Green LED marked "ON" (*12, Fig 2.1*) and Red LED marked "FAULT / ALARM" (*13, Fig 2.1*) to light steady and then release the ON/OFF Button. The unit will power OFF after the ON/OFF Button is released. *[**NOTE**: "Power off Sequence" will complete ONLY when the Power ON/OFF Button is released!]*

NOTE: *For Power ON/OFF Sequence when using the optional Remote Control EVO-RC, please refer to Section 3.2 of EVO-RC Remote Control Manual)*.

6.1.3.2 Power off Sequence when AC Input Power is in Switched on Condition (AC Input Voltage > 140 ± 10 VAC)
Please note that as long as AC input voltage > 1400 ± 10 VAC is available at the Grid/Generator Input Terminals, the unit ***CANNOT BE POWERED OFF*** using the ON/OFF Button on the front panel of the unit or the ON/OFF Key on the optional Remote Control EVO-RC *[See Section 3.2.2 of EVO-RC Remote Control Manual]*. ***Switch off the AC input power first if the unit is required to be powered off.*** However, if the unit is in "Fault Mode", it will be possible to power off the unit with the help of ON/OFF Button on the front panel of the unit or the ON/OFF Key on the optional Remote Control EVO-RC.

NOTE: *For Power ON/OFF Sequence when using the optional Remote Control EVO-RC, please refer to Section 3.2 of EVO-RC Remote Control Manual*.

6.2 POWERING ON/OFF BY FEEDING EXTERNAL +12 V SIGNAL TO TERMINALS MARKED "REMOTE ON/OFF" ON THE FRONT PANEL

The unit can be switched ON/OFF remotely by feeding specified format of +12 VDC (*+9 to15 VDC, < 10 mA*) signal to terminals marked "Remote ON/OFF" on the Front Panel (*15, Fig 2.1*). The specified +12 V signal format has 2 options – "Button Type" or "Switch Type". These 2 signal format options can be programmed using the optional Remote Control EVO-RC. These options are available under programmable parameter called "REMOTE SWITCH" grouped under Parameter Menu Map for Parameter Group 5: OTHER FUNCTION". *Please refer to the following Sections of the EVO-RC Remote Control Manual:*

- *Section 4.1, Fig 4.2: Screen No. 4 under column "SELECT GROUP – OTHER FUNCTION"*
- *Section 4.8.1, Table 4.7: Srl No. 4 "REMOTE SWITCH"*
  - *0=Button Type (Default); 1=Switch Type*
- *Section 4.8.2.4: Detailed explanation of programmable parameter REMOTE SWITCH*

6.2.1 Button Type ON/OFF Control Using +12 V Signal (Default)

This type of external +12 V signal format is used when the signal is fed through an external series connected Push Button *[+12 V will be fed as long as the Push Button is kept pressed]*. Control logic used is as follows:

- When the EVO® is in OFF condition, momentary feeding of +12 V signal through the external Push Button for > 2 sec will turn the unit ON. The EVO™ will remain ON even when the Push Button is released
- When the EVO® is in ON condition, momentary feeding of +12 V signal through the external Push Button for > 5 sec will turn the EVO® OFF.

NOTE: *If the external Push Button is pressed for < 5 sec, the unit will NOT switch OFF*

6.2.2 Switch Type ON/OFF Control Using +12 V Signal

This type of external +12 V signal format is used when the +12 V signal (*+9 to 15 VDC, < 10 mA*) is fed through an external, series connected ON/OFF Toggle/Rocker Switch or Relay contact (*+12 V signal will be fed continuously when the switch in ON condition/Relay contact is closed and +12 V signal will be removed when the external ON/OFF switch is in OFF condition or the Relay contact is open*). Example of this type of Remote ON/OFF control signal format is the ignition switch in a vehicle. When the ignitionswitch is ON, 12 V from the vehicle battery will be available. When the ignition switch is OFF, 12 V will be switched OFF. Control logic used is as follows:

- When the external ON/OFF Switch is turned ON or when the Relay contact is closed, continuous +12 V control signal will be made available and the EVO® will turn ON. EVO® will remain ON as long +12 V control signal is available through the ON condition of the external ON/OFF Switch or the closed Relay contact
- When the external ON/OFF Switch is turned OFF or if the Relay contact opens, the +12 V signal will be removed and the EVO® will switch OFF

CAUTION!

When "Switch Type" of ON/OFF control described at Section 6.2.2 above is selected, the ON/OFF button on the front panel of the unit (*12, Fig 2.1*) should NOT be used to turn ON or turn OFF the unit. The front panel ON/OFF push button will now follow the above "Switch Type" control logic wherein the unit will remain ON only as long as the button is kept pressed and will turn OFF in 2 seconds after it is released.

ATTENTION!

Lorsque « Switch Type » de ON/OFF contrôle décrit ci-dessus est sélectionnée, le bouton ON/OFF sur le panneau avant de l'unité (12, Fig 2.1) ne devraient pas servir à allumer ou éteindre l'appareil. La façade, bouton poussoir ON/OFF suivra désormais la logique de contrôle ci-dessus « Switch Type » dans lequel l'appareil demeurera allumé aussi longtemps que la touche est maintenue enfoncée et s'éteint après 2 secondes après que qu'il est libéré.

6.3 OPERATIONAL INFORMATION THROUGH LEDS AND BUZZER

Table 6.1 shows the operational states of the unit indicated by the following LEDs on the front panel of the unit and Buzzer:

- Green LED marked "ON" *(12, Fig 2.1)*
- Red LED marked "Fault" *(13, Fig 2.1)*

Optional Remote Control Model EVO-RC will be required for more detailed messaging that is available through its LCD display and LEDs. *This remote will also be required for programming of various parameters to suit specific requirements.*

TABLE 6.1 FRONT PANEL LED AND BUZZER INDICATIONS

Status	Green LED marked "ON" (12, Fig 2.1)	Red LED marked "Fault" (13, Fig 2.1)	Buzzer (See NOTE 1 Below)
Seen during Power-On Sequence (*Refer to Section 6.1.1*)	Blink 3 times & then off	OFF	OFF
Seen during Power-Off Sequence (*Refer to Section 6.1.2*)	ON	ON	OFF
Normal charging	Blink once in 1 sec interval	OFF	OFF
Equalization charging	Blink twice in 1 sec interval	Off	Off

Table continues on next page ▶

TABLE 6.1 FRONT PANEL LED AND BUZZER INDICATIONS (Continued)			
Inverting (*Discharging*)	ON	OFF	Beep once in 3 sec interval
Low battery alarm	ON	Blink once in 1 sec interval	Beep once in 1 sec interval
Power saving	Blink once in 3 sec interval	OFF	OFF
Standby	Blink once in 5 sec interval	OFF	OFF
Fault	OFF	ON	ON
NOTE 1: The buzzer can be switched on or off through programming parameter "BUZZER" *[Refer to Section 4.8.2.7 of EVO-RC Manual. The default setting is "1 = On"].*			

6.4 OPTIONAL REMOTE CONTROL EVO-RC FOR PROGRAMMING OF MODES OF OPERATION AND PARAMETERS

Optional Remote Control Model EVO-RC [*Fig 2.4(a)*] will be required for more advanced control and monitoring. Please see separate Owner's Manual for EVO-RC. The Remote Control comes with 10 M / 33 ft., RJ-45 Data Cable. The Remote plugs into RJ-45 Jack on the front panel of the unit (*7, Fig 2.1*). It has provision for Data Logging using SD Card of up to 32 GB (*FAT16 / FAT32*). It also has its own Real Time Clock and Super Capacitor Type of Battery.

Detailed messaging is available through its LCD display and LEDs. This remote will also be required for programming of various parameters to suit specific requirements. Each programmable parameter has a Default Value. This unit has been shipped with the various parameters set at the Default Values.

6.4.1 Programmable & Default Values of Programming Parameters

Programmable and Default values are shown in Tables 6.2 to 6.7.

TABLE 6.2 PROGRAMMABLE AND DEFAULT PARAMETERS: PARAMETER GROUP NO.1 "CHARGING CURVE"

For programming details of parameters shown in this Table, refer to Section 4.4 of the Owner's Manual for Remote Control Model EVO-RC.

Parameter	Programming Range (Programming requires optional Remote Control Model EVO-RC)				Default			
	EVO-2212E	EVO-3012E	EVO-2224E	EVO-4024E	EVO-2212E	EVO-3012E	EVO-2224E	EVO-4024E
"BULK CURRENT" (See NOTE 1) (*Bulk Charge Current "Io"*)	0-100 A	0-130 A	0-70 A	0-110 A	40 A			
"ABSORP VOLTAGE" (*Absorption Voltage*)	12.00 V - 16.00 V		24.00 V - 32.00 V		14.40 V		28.80 V	
"EQUALIZE VOLTAGE" (*Equalization Voltage*)	14.00 V - 16.50 V		28.00V - 33.00 V		14.40 V		28.80 V	

Table continues on next page ▶

TABLE 6.2 PROGRAMMABLE AND DEFAULT PARAMETERS: PARAMETER GROUP NO.1 "CHARGING CURVE" (Continued)								
"FLOATING VOLTAGE" (*Float Voltage*)	12.00 V - 15.00 V		24.00 V - 30.00 V		13.50 V		27.00 V	
"COMPENSATE" (*Temperature Compensation*)	3 mV to 5 mV /C/Cell				4 mV /C/Cell			
"BATT OVER VOLT" (*Battery Over Voltage Shutdown*)	14.00 V - 17.50 V		28.00 V - 35.00 V		16.00 V		32.00 V	
"RESET VOLTAGE" (*Reset voltage for "BATT LOW VOLTAGE" condition*)	12.00 V - 17.50 V		24.00 V - 35.00 V		14.00 V		28.00 V	
"LV DETECT TIME" (*Time to qualify "BATT LOW VOLTAGE" condition*)	0 - 600 sec				10 sec			
"LV CUT OFF TIME" (*Time in "BATT LOW VOLTAGE" condition to trigger complete shutdown*)	0 - 7200 sec				1200 sec			
"EQUALIZE-4STAGES" (*4 Stage Adaptive Equalization On / Off*)	0 = No (3-Stage / 2-Stage) 1 = Yes (4-Stage Equalization)				0 = No (3-Stage / 2-Stage)			
"MODE"	0 = Normal…Grid/Gen priority (Off-Line) 1 = On-Line…Inverter priority 2 = Charger Only…Charging & AC bypass only, no inverting				0 = Normal			
Parameter	**Programming Range (Programming requires optional Remote Control Model EVO-RC)**				**Default**			
	EVO-2212E	**EVO-3012E**	**EVO-2224E**	**EVO-4024E**	**EVO-2212E**	**EVO-3012E**	**EVO-2224E**	**EVO-4024E**
"ONLINE OPTION" (*Available only when parameter "MODE" is set to option "1=On-Line"*)	0 = Option 1 1 = Option 2				0 = Option 1			
"RESET TO BULK"	10.00 V to 13.00 V		20.00 V to 26.00 V		12.00 V		24.00 V	
"GS DETECT TIME"	0 - 600 sec				10 sec			
"GEN ON TIME"	0 - 240 min				60 min			
"GEN OFF DELAY"	0 - 240 min				60 min			
"ABSORP TIME"	0 - 600 min				60 min			
"ABSORP EXIT AMPS"	0 - 20 A				4 A			

Table continues on next page ▶

TABLE 6.2 PROGRAMMABLE AND DEFAULT PARAMETERS: PARAMETER GROUP NO.1 "CHARGING CURVE" (Continued)		
"CHARGING PROFILE"	0 = 3 Stage Adaptive 1 = 3 Stage Type 1 2 = 3 Stage Type 2 3 = 2 Stage Type 1 4 = 2 Stage Type 2 5 = 2 Stage Type 3	0 = 3 Stage Adaptive
"BATTERY TYPE"	0 = Lead Acid 1 = Lithium	0 = Lead Acid
"SAFE CHARGING"	0 - 300 min	0 min

NOTE 1:
"BULK CURRENT" value may automatically reduce in higher ambient temperatures of around 50 ° - 60 °C / 122 ° - 140 °F if Power Transformer temperature exceeds 130 °C / 266 °F or Heat Sink temperature exceeds 65 °C / 149 °F. *(See Section 4.11.3)* The BULK CURRENT value, could also automatically change due to connections made on the EXT. Charger Terminals (See Section 5.4 of this user manual, for detailed information).

TABLE 6.3 PROGRAMMABLE AND DEFAULT PARAMETERS: PARAMETER GROUP NO.2 "INPUT SETTING"
For programming details of parameters shown in this Table, refer to Section 4.5 of the Owner's Manual for Remote Control Model EVO-RC.

Group	Parameter name	Programming Range				Default value			
		EVO-2212E	EVO-3012E	EVO-2224E	EVO-4024E	EVO-2212E	EVO-3012E	EVO-2224E	EVO-4024E
INPUT SETTING	**DEFAULT FREQ**	0 = 50Hz 1 = 60Hz				0 = 50 Hz			
	GRID MAX CURRENT	5.00 A to 20.00 A	5.00 A to 25.00 A	5.00 A to 20.00 A	5.00 A to 35.00 A	16.00 A			
	GEN MAX CURRENT	5.00 A to 20.00 A	5.00 A to 25.00 A	5.00 A to 20.00 A	5.00 A to 35.00 A	16.00 A			
	HIGH CUT OFF	50 – 70 Hz				55 Hz			
	HIGH RESET	50 – 70 Hz				54 Hz			
	LOW CUT OFF	40 – 60 Hz				45 Hz			
	LOW RESET	40 – 60 Hz				46 Hz			
	SYNC GRID	0 = Fine ; 1 = Coarse				0 = Fine			
	SYNC GEN	0 = Fine ; 1 = Coarse				1 = Coarse			
	INPUT OC PROTECT	0 = INV Mode ; 1 = Shutdown				0 = INV Mode			
	INPUT RECOVERY	0 = Buffered ; 1 = Direct				0 = Buffered			

TABLE 6.4 PROGRAMMABLE AND DEFAULT PARAMETERS: PARAMETER GROUP NO.3 "INPUT LOW LIMIT"
For programming details of parameters shown in this Table, refer to Section 4.6 of the Owner's Manual for Remote Control Model EVO-RC.

Group	Parameter name	Setting range				Default value			
		EVO-2212E	EVO-3012E	EVO-2224E	EVO-4024E	EVO-2212E	EVO-3012E	EVO-2224E	EVO-4024E
INPUT - LOW LIMIT	RESET VOLTAGE	140.0 – 200.0 V				190.0 V			
	CUT OFF VOLT 1	60.0 – 200.0 V				180.0 V			
	DETECT TIME 1	0 – 2000 cycle				300 cycle			
	CUT OFF VOLT 2	140.0 – 200.0 V				170.0 V			
	DETECT TIME 2	0 – 2000 cycle				60 cycle			
	CUT OFF VOLT 3	140.0 – 200.0 V				160.0 V			
	DETECT TIME 3	0 – 2000 cycle				1 cycle			

TABLE 6.5 PROGRAMMABLE AND DEFAULT PARAMETERS: PARAMETER GROUP NO.4 "INPUT HIGH LIMIT"
For programming details of parameters shown in this Table, refer to Section 4.7 of the Owner's Manual for Remote Control Model EVO-RC.

Group	Parameter name	Setting range				Default value			
		EVO-2212E	EVO-3012E	EVO-2224E	EVO-4024E	EVO-2212E	EVO-3012E	EVO-2224E	EVO-4024E
INPUT - HIGH LIMIT	RESET VOLTAGE	200.0 – 280.0 V				125.0 V			
	CUT OFF VOLT 1	200.0 – 280.0 V				265.0 V			
	DETECT TIME 1	0 – 2000 cycle				60 cycle			
	CUT OFF VOLT 2	200.0 – 280.0 V				270.0 V			
	DETECT TIME 2	0 – 2000 cycle				15 cycle			
	CUT OFF VOLT 3	200.0 – 280.0 V				275.0 V			
	DETECT TIME 3	0 – 2000 cycle				1 cycle			

TABLE 6.6 PROGRAMMABLE AND DEFAULT PARAMETERS: PARAMETER GROUP NO.5 "OTHER FUNCTIONS"
For programming details of parameters shown in this Table, refer to Section 4.8 of the Owner's Manual for Remote Control Model EVO-RC.

Parameter name	Setting range				Default Value			
	EVO-2212E	EVO-3012E	EVO-2224E	EVO-4024E	EVO-2212E	EVO-3012E	EVO-2224E	EVO-4024E
"POWER SAVING"	1 = Enable 0 = Disable				0 = Disable			
"ENTER POINT"	4 – 50 W				6 W	8 W	6 W	8 W
"WAKE UP POINT"	5 – 50 W				7 W	10 W	7 W	10 W

Table continues on next page ▶

TABLE 6.6 PROGRAMMABLE AND DEFAULT PARAMETERS: PARAMETER GROUP NO.5 "OTHER FUNCTIONS" (Continued)

"REMOTE SWITCH" • For ON /OFF control through external 12 V signal fed to Remote ON/OFF terminals on the Front Panel (*15, Fig 2.1)*	**0 = Button Type**: 12 V signal is fed through Push Button Type of Switch: • Pressing of Push Button > 2 sec will switch the unit ON • When ON, pressing Push Button > 5 sec will turn the unit OFF **1 = Switch Type:** 12 V signal is fed through contacts of Toggle Type of Switch or relay contact: • ON condition (*contacts closed*) will turn the unit ON • OFF condition (*contacts open*) for 2 sec will switch the unit OFF	**0 =** Button Type **CAUTION!** ON/OFF Logic also controls the operation of the ON/OFF Button on the front panel (*11, Fig 2.1*). The fefault setting is "Button Type". If the ON/OFF Control is changed to external "Remote Switch", it will not be possible to switch ON/OFF the EVO® Inverter/Charger from the front panel ON/OFF push button because it will work with Switch Type Logic. It will be ON only as long as the Push Buttom is kept pressed and will switch OFF when released.

Parameter name	Setting range				Default Value			
	EVO-2212E	EVO-3012E	EVO-2224E	EVO-4024E	EVO-2212E	EVO-3012E	EVO-2224E	EVO-4024E
"RELAY FUNCTION" (*for Status Relay*)	**0 = Charge/Other** • OFF in "Charging" Mode • ON in other Modes i.e. "Inverting", "Power Saving" or "Standby" **1 = Normal/Fault** • OFF in normal operating conditions • ON in Fault Modes **2 = Generator 0** • ON when batteries drop to "LOW VOLT ALARM" or lower for period = "GS DETECT TIME" - Initiates Generator start • OFF after batteries are charged till the end point of the programmed option under parameter "CHARGING PROFILE" *[See Section 4.8.2.5.2.1 of EVO-RC Remote Control Manual]*. When the relay switches OFF, it initiates Generator Stop. **3 = Generator 1** • ON when batteries drop to "LOW VOLT ALARM" or lower for period = "GS DETECT TIME" - initiates Generator start • OFF when batteries are charged to "RESET VOLTAGE" for period = "GEN OFF TIME" - initiates Generator stop **4 = Generator 2** • ON when batteries drop to "LOW VOLT ALARM" or lower for period = "GS DETECT TIME" - initiates Generator start • OFF after period = "GEN ON TIME" from the time relay switched ON - initiates Generator stop				**2** = Generator 0			

Table continues on next page ▶

TABLE 6.6 PROGRAMMABLE AND DEFAULT PARAMETERS: PARAMETER GROUP NO.5 "OTHER FUNCTIONS" (Continued)		
"COMM ID" (*Communication ID for optional Remote Control EVO-RC*)	1 - 255	1
"BUZZER"	0 = OFF ; 1 = ON	1 = ON
"DISCHARGE BEEP" (*Beeping in "Discharging/Inverter Mode"*)	0 = OFF ; 1 = ON	0 = OFF
"DEFAULT RESET"	0 = No ; 1 = Yes	0 = No
DATA LOG TIME (*For Optional Remote Control EVO-RC*)	0 = Disable 3 = 30 sec 6 = 10 min 1 = 1 sec 4 = 1 min 2 = 10 sec 5 = 5 min	1 = 1 sec
PARAMETER SAVE (*For Optional Remote Control EVO-RC*)	0 = No 1 = Yes	0 = No
TEMP UNIT	0 = C 1 = F	0 = C
PASSWORD DISABLE	0 = No 1 = Yes	0 = No

6.5 PROTECTIONS, FAULT MESSAGES AND TROUBLESHOOTING GUIDE

The front panel of the unit has a Red LED marked "FAULT" (*13, Fig 2.1*). This LED will light up (*steady*) when the unit registers any of the **FAULT MODE** situations shown in Table 7.1 of EVO-RC Remote Control Manual at Appendix A.

Table 7.1 of EVO-RC Remote Control Manual at Appendix A shows details of protections and associated Fault/Error Messages that will be displayed on the LCD screen of the optional Remote Control EVO-RC.

NOTE: If the optional Remote Control EVO-RC is not used, it may be difficult to narrow down the probable cause of the fault.

6.6 POWERING OFF THE UNIT IN FAULT MODE

If the unit is in "Fault Mode", it will be possible to power OFF the unit with the ON/OFF Push Button on the front panel of EVO® (*11, Fig 2.1*).

As explained under Section 6.1.3, as long as AC input voltage > 140 ± 10 VAC is present, the unit CANNOT BE POWERED OFF using the ON/OFF Button on the front panel of the unit or on the optional Remote Control EVO-RC *[See Section 3.2.2 of EVO-RC Remote Control Manual at Appendix A]*. In order to power off using the Power ON/Off Button, switch OFF the AC input first.

6.7 12 V, 100 MA CAPACITY DC SOURCE FOR SIGNALING

A 12 V, 100 mA capacity DC source has been provided (*16, Fig 2.1*). This voltage may be routed through the contacts of the Status Relay (*14, Fig 2.1*) to feed 12 V ON/OFF control signal to drive circuits of remote monitoring control of the programmable conditions of operation of the unit *[Refer to Section 4.8.2.5.1 of EVO-RC Remote Control Manual]*.

Table continues on next page ▶

6.8 STANDBY MODE

When the EVO® is in Standby Mode, it will stop inverting or charging/pass through.

6.8.1 General Information

INFO

1. Standby Mode may also be used to temporary halt normal operation of the Inverter Charger without switching OFF the unit completely.
2. EVO-RC Remote Control is required for switching ON/ switching OFF Standby Mode. Switching ON/OFF of Standby Mode CANNOT be carried out from the ON/ OFF button on the front panel of EVO® unless EVO-RC Remote Control has been connected to the EVO® unit.

For the Standby Mode to be switched ON, the EVO™ should be in ON condition and should be operating in one of the 3 Operating Modes – "Inverting" or "Charging" or "Power Save" *[See Fig 3.2 of EVO-RC Manual]*. When Standby Mode is switched ON, the EVO™ will exit its Operating Mode.

6.8.2 Procedure to Enter and Exit Standby Mode/Status Display in Standby Mode

For procedure to enter and exit Standby Mode, please refer to Section 3.4.1 of EVO-RC Remote Control.

SECTION 7 | Specifications

Models	EVO-2212E	EVO-3012E	EVO-2224E	EVO-4024E
INVERTER SECTION				
Output Waveform	Pure Sine Wave			
Input Battery Voltage Range	9.1 - 17 VDC		18.1 - 34 VDC	
Nominal AC Output Voltage	230 VAC ± 5%; Single Phase			
Output Frequency	50 Hz / 60Hz ± 0.1 Hz (Default 50 Hz ± 0.1 Hz)			
Total Harmonic Distortion of Pure Sine Wave Form (THD)	< 5%			
Continuous Output Power	2200 VA	3000 VA	2200 VA	4000 VA
Continuous AC Output Current	10 A	13 A	10 A	18 A
Surge Power for 1 msec	300% (6600 VA, 28 A)	300% (9000 VA, 39 A)	300% (6600 VA, 28 A)	300% (12,000 VA, 52 A)
Surge Power for 100 msec	200% (4400 VA, 19 A)	200% (6000 VA, 26 A)	200% (4400 VA, 19 A)	200% (8000 VA, 34 A)
Power Boost for 5 sec	150% (3300 W)	150% (4500 W)	150% (3300 W)	150% (6000 W)
Power Boost for 30 sec	140% (3080 W)	140% (4200 W)	140% (3080 W)	140% (5600 W)
Power Boost for 5 min	120% (2640 W)	120% (3600 W)	120% (2640 W)	120% (4800 W)
Power Boost for 30 min	110% (2420 W)	110% (3300 W)	110% (2420 W)	110% (4400 W)
Maximum Continuous DC Input Current	266 A	373 A	133 A	266 A
Inverter Efficiency (Peak)	90%	90%	93%	94%
No Load Power Consumption in Standby Mode (Inverting/ charging are suspended)	< 5 W			
No Load Power Consumption in Power Saving Mode	< 8 W			
No Load Power Consumption in Normal Mode (120 VAC Output, Typical)	30 watts		25 watts	
AC INPUT FROM GRID/GENERATOR				
AC Input Voltage	230 VAC (140-280 VAC ± 5% selectable)			
AC Input Frequency	50 Hz / 60 Hz (40 Hz - 70 Hz selectable)			
Maximum Programmable (Default) AC Input Current	5-20 A (Default 16 A)	5-25 A (Default 16 A)	5-20 A (Default 16 A)	5-35 A (Default 16 A)
TRANSFER CHARACTERISTICS				
Transfer Relay Type and Capacity	SPDT, 40 A	SPDT, 40 A	SPDT, 40 A	SPDT, 40 A
Transfer Time – Inverter to AC Input Source	< 1 ms (Synchronized transfer at zero crossing)			
Transfer Time – AC Input Source to Inverter	Up to 16 ms (Synchronized transfer at zero crossing)			

SECTION 7 | Specifications

Models	EVO-2212E	EVO-3012E	EVO-2224E	EVO-4024E
OPERATING MODES				
Normal (Off-Line) Mode	**Grid/Generator Priority (Default)** • Grid/Generator supplies AC loads and charges batteries • Inverter is for backup			
On-Line Mode	**Battery/Inverter Priority (Programmable)** • Inverter supplies AC loads even if Grid/Generator is available • Grid/Generator takes over when batteries are discharged to "LOW VOLT ALARM" to charge batteries and to power AC loads. AC loads are transferred back to Inverter under various programmed conditions			
Charger Only Mode	• Charging & AC Bypass only. • No Inverting			
INTERNAL BATTERY CHARGER SECTION				
AC Input Voltage Range	230 VAC (140 to 280 VAC ± 5% selectable); 50 Hz / 60 Hz (40 -70 Hz selectable); Single Phase			
Rated Continuous AC Input Current	9 A, AC	12 A, AC	10 A, AC	18 A, AC
AC Input Power Factor	> 0.95			
Programmable Bulk Charging Current and Voltage	0 - 100 A, DC 12 - 16.5 VDC	0 - 130 A, DC 12 - 16.5 VDC	0 - 70 A, DC 24 - 33 VDC	0 - 110 A, DC 24 - 33 VDC
Charger Efficiency	75%		86%	85%
Charging Profiles & Control	7 types of charging profiles to cover Lead Acid, Lithium Ion & Nickel-Zinc types of batteries: • Three, 3-Stage Profiles (1 with Adaptive Control) • Three, 2-Stage Profiles • One, 4-Stage Equalization Profile (with Adaptive Control)			
Battery Temperature Compensation	• Battery Temperature Sensor included • Compensation Range from -20 °C to 60 °C (-4 °F to 140 °F)			
EXTERNAL BATTERY CHARGER SECTION (Solar Charge Controller)				
Charging Voltage Range	13 - 16.5 VDC	13 - 16.5 VDC	26 - 33 VDC	26 -33 VDC
Maximum Flowing Current	50 A			
COOLING, PROTECTIONS AND ALARMS				
Cooling	2 Fans – Temperature Controlled, Variable Speed			
Protections and Alarms	Battery Low Voltage Alarm and Low/Over Voltage Shut Down			
	Shut Down under Input Over Current, Output Over Current, Output Overload and Output Short			
	Transformer and Heat Sink Overheat Shut Down			
	Immunity Against Conducted Electrical Transients in Vehicles			
OPTIONAL REMOTE CONTROL				
Model No.	Compatible with EVO-RC (see Appendix A) and EVO-RC-PLUS			
Specifications	• Advanced Features for programming various parameters and modes of operation • Up to 32 GB SD Card Slot for Data Logging • Comes with 10 M / 33 ft RJ-45 Data Cable			

SECTION 7 | Specifications

Models	EVO-2212E	EVO-3012E	EVO-2224E	EVO-4024E
COMPLIANCE				
Safety Compliance	• Intertek-ETL listed: Conforms to ANSI/UL STD. 1741 • Intertek-ETL listed: Certified to CAN/CSA STD. C22.2 No. 107.1-01 • Intertek-ETL listed: Conforms to ANSI/UL STD. 458 with Marine Supplement*			
EMI/EMC Compliance	• Certified to FCC Part 15(B), Class A			
Environmental Compliance	• CE marked			
ENVIRONMENTAL SPECIFICATIONS				
Operating Temperature	-20 °C to +60 °C (-4 °F to 140 °F)			
Storage Temperature	-40 °C to +70 °C (-40 °F to 158 °F)			
Operating Humidity	0 to 95% RH non condensing			
WEIGHTS AND DIMENSIONS				
Dimensions: W x D x H	325 x 426 x 207 mm; 12.79 x 16.77 x 8.15 in			
Weights:	27 Kg / 59 lb.	29 kg / 64 lb.	26 Kg / 57 lb.	29 Kg / 64 LB

NOTES:

(1) All AC power ratings in the Inverter Section are specified at Power Factor = 0.95
(2) All specifications given above are at ambient temperature of 25 °C / 77 °F unless specified otherwise
(3) Specifications are subject to change without notice
(4) *Marine Supplement is valid when installed using Drip Shield. Please see Figs 3.1(a), 3.2(b), 3.3(b) and 3.4(b).

SECTION 8 | Warranty

3 YEAR LIMITED WARRANTY

EVO® Series Inverter/Chargers manufactured by Samlex America, Inc. (the "Warrantor") are warranted to be free from defects in workmanship and materials under normal use and service. The warranty period is 3 years for the United States and Canada, and is in effect from the date of purchase by the user (the "Purchaser").

Warranty outside of the United States and Canada is limited to 6 months. For a warranty claim, the Purchaser should contact the place of purchase to obtain a Return Authorization Number.

The defective part or unit should be returned at the Purchaser's expense to the authorized location. A written statement describing the nature of the defect, the date of purchase, the place of purchase, and the Purchaser's name, address and telephone number should also be included.

If upon the Warrantor's examination, the defect proves to be the result of defective material or workmanship, the equipment will be repaired or replaced at the Warrantor's option without charge, and returned to the Purchaser at the Warrantor's expense. (Contiguous US and Canada only) using a carrier of the warrantor's choice.

Warranty service shall be performed only by the Warrantor. Any attempt to remedy the defect by anyone other than the Warrantor shall render this warranty void. The warranty does not apply to units with a serial number that has been altered, removed or modified in any way.

There is no warranty for defects or damages to equipment or parts caused by:

- Installation, alternation, inspection or removal
- Normal wear and tear
- Abuse or misuse of the equipment including exposure to excessive heat, salt or fresh water spray, or water immersion
- Corrosion, fire, lightening, biological infestations or Acts of God
- Repairs attempted by anyone other than the Warrantor
- Improper use, contrary to operational instructions provided in product manual
- Shipping or transport

No other express warranty is hereby given and there are no warranties which extend beyond those described herein. This warranty is expressly in lieu of any other expressed or implied warranties, including any implied warranty of merchantability, fitness for the ordinary purposes for which such goods are used, or fitness for a particular purpose, or any other obligations on the part of the Warrantor or its employees and representatives.

There shall be no responsibility or liability whatsoever on the part of the Warrantor or its employees and representatives for injury to any persons, or damage to person or persons, or damage to property, or loss of income or profit, or any other consequential or resulting damage which may be claimed to have been incurred through the use or sale of the equipment, including any possible failure of malfunction of the equipment, or part thereof. The Warrantor assumes no liability for incidental or consequential damages of any kind.

Samlex America Inc. (the "Warrantor")
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NOTES:

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