samlexpower®

# Solar Charge Controller

MSK-10A

Owner's Manual

Please read this manual BEFORE using your Charge Controller

# OWNER'S MANUAL | Index

# SECTION 1 | Safety Instructions

## IMPORTANT SAFETY INSTRUCTIONS

**PLEASE READ THE FOLLOWING SAFETY INSTRUCTIONS BEFORE USING THE CHARGE CONTROLLER. FAILURE TO ABIDE BY THE RECOMMENDATIONS MAY CAUSE PERSONAL INJURY / DAMAGE TO THE CONTROLLER.**

The following safety symbols will be used in this manual to highlight safety and 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.

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**WARNINGS**  **CAUTIONS!**

1. This Charge Controller is not waterproof (Ingress Protection Rating is IP-30). PLEASE ENSURE THAT THE UNIT IS INSTALLED IN DRY, COOL AND WELL VENTILATED ENVIRONMENT.
2. Ground the Negative of the battery as follows:
   - to Earth Ground in shore installations
   - to Chassis Ground in Negative grounded mobile installations
3. There are no user serviceable parts inside the controller. Do not disassemble or attempt to repair it.
4. Install external fuses / breakers as required.
5. Disconnect the PV Panel(s) and fuse / breakers near to battery before installing or adjusting the controller.
6. Confirm that power connections are tightened to avoid excessive heating from loose connection.
7. The charge controller has been set to optimally charge 12V / 24V Lead Acid Batteries (Sealed/AGM)
8. Comply with battery manufacturer's recommendations.
9. Avoid charging damaged, defective or old battery.
10. Ensure correct polarity is maintained when connecting the Charge Controller to the battery - Connect the Positive output terminal to the Positive Battery Post and the Negative output terminal to the Negative Battery Post.
11. When charging, removal of the battery from the vehicle is not necessary provided the battery is being charged in a well-ventilated area.

12. Batteries contain very corrosive diluted Sulphuric Acid as electrolyte. Precautions should be taken to prevent contact with skin, eyes or clothing. If battery acid makes contact with skin or clothing, flush immediately with water. See a doctor immediately.
13. Batteries generate Hydrogen and Oxygen during charging resulting in evolution of explosive gas mixture in non-sealed batteries. Care should be taken to ventilate the battery area when non-sealed batteries are used and follow battery manufacturer's recommendations.
14. Ensure there are no flammable substances, explosive gases, flames, smoke or spark near the battery or the PV Panel(s).
15. 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.
16. 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.
17. 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.
18. PV Panel(s) generate electrical power when exposed to sunlight. Place a dark cover over the panels when handling panels that have bare, un-insulated output wires. Accidental shorting of panel terminals or wiring connected to the panels can result in spark causing personal injury or a fire hazard.
19. It is important that the battery gets fully charged frequently (at least once per week). Otherwise, the battery can become permanently damaged due to under charging. Partially charged batteries can quickly sulfate internally which is an irreversible condition. It is good practice to prevent a battery from being discharged below 50%. Deeper discharging severely shortens battery life.
20. Keep the surface of PV Panel(s) clean from dust. Clean with a soft cloth. Do not walk on the panels.
21. Installation and wiring must comply with the local and National Electrical Codes and must be done by a certified electrician.

# SECTION 2 | General Information, Features & Layout

## 2.1 GENERAL INFORMATION

MSK-10A is a 10A rated, Series Type of PWM (Pulse Width Modulation) Charge Controller. It is based on an advanced design using a microcontroller for digital accuracy and fully automatic operation. It can be used for 12V or 24V battery systems.

## 2.2 FEATURES

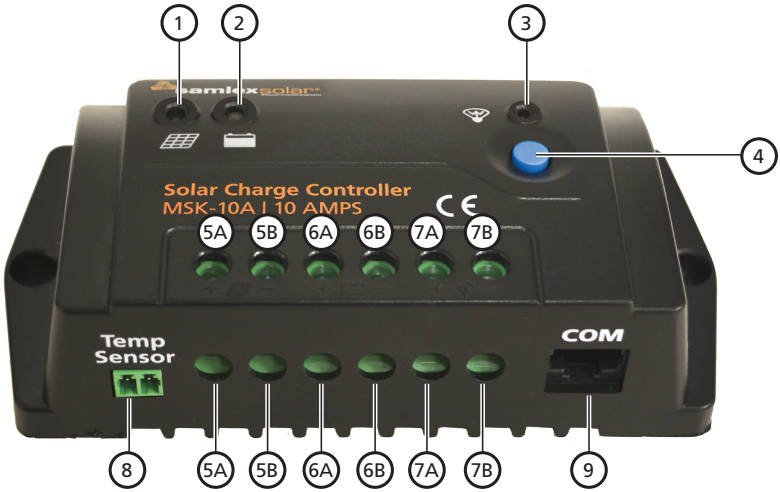
- Advanced microcontroller based, high performance design for digital accuracy and fully automatic and intelligent operation
- Series Type PWM (Pulse Width Modulation) charging for low loss, higher efficiency charging and longer battery life
- Up to 50V Open Circuit Voltage (Voc) and up to 10A Short Circuit Current (Isc) of PV Panel(s) - enables use of up to 150W of 12V Nominal panels for 12V battery and up to 300W, 24V Nominal panels for 24V Nominal battery.
- Dual voltage capability – can be used with 12V / 24V Nominal PV Panel(s) / batteries. 12V / 24V Nominal Battery System is detected automatically: Battery voltage < 18V is detected as 12V Nominal battery and >18V is detected as 24V Nominal battery
- 4 stages of charging for 100% return of capacity and for longer battery life
  - **Normal**: Bulk Stage →Absorption Stage →Float Stage
  - **Once every 28 days or, if battery voltage drops to 11.1/22.2V**: Bulk Stage →Equalization Stage →Float Stage
- Set for charging sealed/AGM Lead Acid Battery
- User friendly LED display for monitoring of operation and self diagnostics for troubleshooting
- Integrated or optional external Temperature Sensor for temperature compensation to ensure improved charging of batteries that experience wider temperature variations during the year
- MOSFET based reverse current blocking for night-time battery discharge prevention. This allows much lower losses as compared to Diode based blocking
- **Protections:** (i) PV over current (ii) PV short circuit (iii) PV reverse polarity (iv) PV over voltage (v) High voltage transients on PV input (vi) Battery reverse polarity (vii) Battery over voltage (viii) Battery over discharge (ix) Controller / battery overtemperature (x) Over voltage, overload and short circuit protections on Load Terminals

## 2.3 APPLICATIONS

- Recreational / Service Vehicles
- Off grid
- Portable Charging Kits
- Boats and marine crafts
- Field work / mobile offices
- Telecommunications

# SECTION 2 | General Information, Features & Layout

## 2.4 LAYOUT




| LEGEND FOR FIG 2.1 | | | |
|---|---|---|---|
| **Item No.** | **Description** | **Item No.** | **Description** |
| 1 | PV Status LED | 6A | Battery Terminal (+) |
| 2 | Battery Status LED | 6B | Battery Terminal (–) |
| 3 | Load Status LED | 7A | Load Terminal (+) |
| 4 | Load On/Off Button<br>Also used for clearing fault | 7B | Load Terminal (–) |
| 5A | PV Input Terminal (+) | 8* | Connector for optional remote battery temperature sensor "MSK-TS" |
| 5B | PV Input Terminal (–) | 9 | RS-485 Communication Port (NOT USED) |

* If the temperature sensor is short-circuited or damaged, the controller will charge or discharge at the default temperature setting of 25°C.

**Fig 2.1: Layout of Charge Controller MSK-10A**

# SECTION 3 | Installation

## 3.1 SAFETY

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

**PLEASE READ ALL THE SAFETY INSTRUCTIONS GIVEN IN SECTION 1 BEFORE INSTALLING AND OPERATING THE CONTROLLER. FAILURE TO ABIDE BY THE RECOMMENDATIONS MAY CAUSE PERSONAL INJURY / DAMAGE TO THE KIT.**

**DO NOT USE THE UNIT IN WET ENVIRONMENT**

- **Please note that this unit is not waterproof (its Ingress Protection Rating is IP-30). Hence, please ensure that the unit is installed in dry environment.**

**GROUNDING**

- **Ground the Negative terminal of the battery to Earth Ground in shore installation and to the Chassis Ground in Negative grounded mobile installations.**

**BATTERY TYPES**

- **The unit has been set to optimally charge 12/24V, sealed (AGM) Lead Acid Batteries**

**MISE EN GARDE!** **ATTENTION!**

**VEUILLEZ LIRE TOUTES LES INSTRUCTIONS DE SÉCURITÉ DONNÉES DANS LA SECTION 1 AVANT D'INSTALLER ET D'UTILISER LE CONTRÔLEUR. NON-RESPECT DE LA LES RECOMMANDATIONS PEUVENT PROVOQUER DES BLESSURES OU ENDOMMAGER LE KIT.**

**N'UTILISEZ PAS L'APPAREIL DANS UN ENVIRONNEMENT HUMIDE**

- **Veuillez noter que cet appareil n'est pas étanche (son indice de protection d'entrée est ip-30). Par conséquent, veuillez vous assurer que l'unité est installée dans un environnement sec.**

**MISE À LA TERRE**

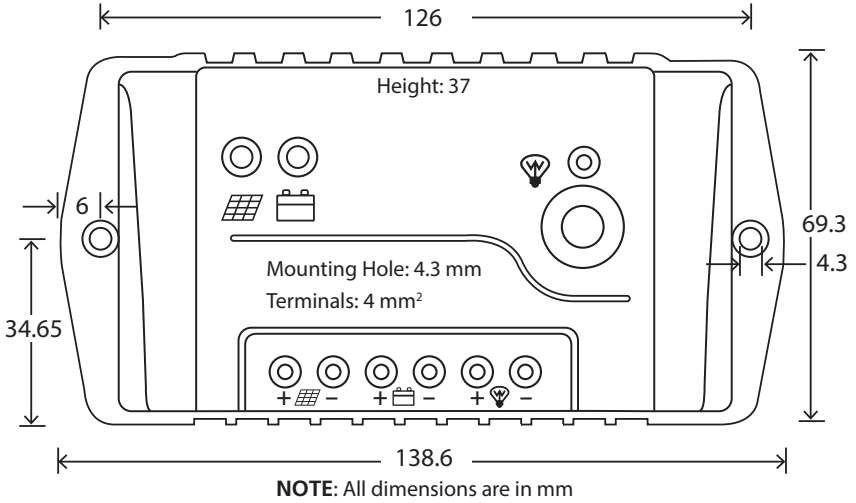
- **Mettez à la terre la borne négative de la batterie à la terre à la terre dans l'installation à terre et à la masse du châssis dans les installations mobiles à la terre négative.**

**TYPES DE BATTERIE**

- **L'unité a été réglée pour charger de manière optimale des batteries au plomb scellées (AGM) de 12/24V**

## 3.2 DIMENSIONAL DRAWING

Dimensional drawing is given at Fig 3.1 below:




**NOTE**: All dimensions are in mm

**Fig 3.1: Dimensional Drawing of Charge Controller MSK-10A**

## 3.3 MOUNTING

Refer to Fig 3.2

When mounting the controller, ensure free air through the ventilation slots at the bottom of the unit. There should be at least 6 inches (150 mm) of clearance above and below the controller to allow for cooling. If mounted in an enclosure, forced air ventilation is highly recommended.

**WARNING!**

**RISK OF EXPLOSION! NEVER INSTALL THE CONTROLLER IN A SEALED ENCLOSURE WITH FLOODED BATTERIES! DO NOT INSTALL IN A CONFINED AREA WHERE BATTERY GASSES CAN ACCUMULATE.**

**MISE EN GARDE!**

**RISQUE D'EXPLOSION! N'INSTALLEZ JAMAIS LE CONTRÔLEUR DANS UN BOÎTIER SCELLÉ AVEC DES BATTERIES INONDÉES! NE PAS INSTALLER DANS UNE ZONE CONFINÉE OÙ DES GAZ DE BATTERIE PEUVENT S'ACCUMULER.**

### 3.3.1 Step 1: Choose Mounting Location
Locate the controller in area protected from direct sun, high temperature, and water. Make sure there is good ventilation.

### 3.3.2 Step 2: Check For Clearance
Place the controller in the location where it will be mounted. Verify that there is sufficient room to run wires and that there is sufficient room above and below the controller for airflow.

### 3.3.3 Step 3: Mark Holes
Use a pencil or pen to mark the 2 mounting hole locations on the mounting surface, (Refer to the dimensional drawing in Fig 3.1)

### 3.3.4 Step 4: Drill Holes
Remove the controller and drill 2 holes in the marked locations. Use drill size #29 for #8 self tapping screws.

### 3.3.5 Step 5: Secure Controller
Place the controller on the surface and align the mounting holes with the drilled holes in Step 3.3.4. Secure the controller in place using 2, #8 self tapping screws.

## 3.4 CONNECTIONS

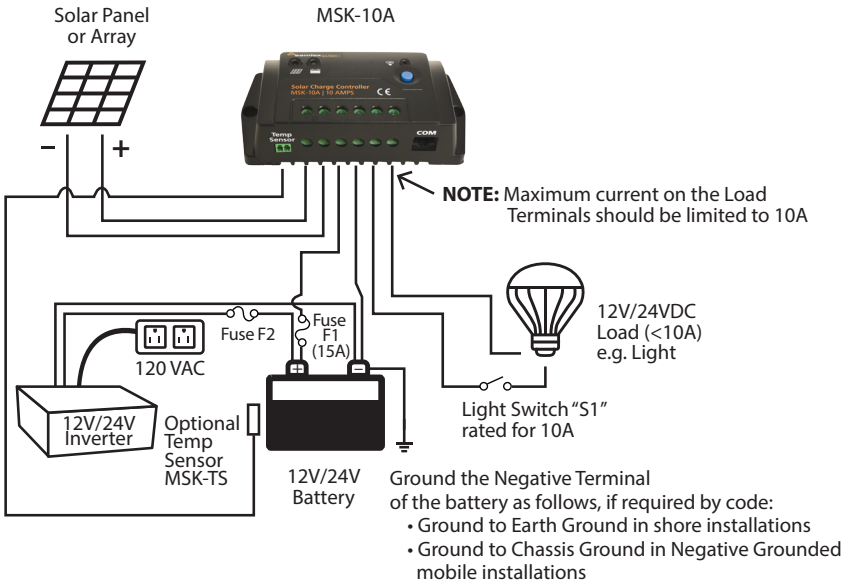



**Fig 3.2: Wiring Diagram**

### 3.4.1 Step1: Battery Connection

**WARNING!**

**RISK OF EXPLOSION OR FIRE! NEVER SHORT CIRCUIT BATTERY POSITIVE (+) AND NEGATIVE (-).**

**MISE EN GARDE!**

**RISQUE D'EXPLOSION OU D'INCENDIE! NE COURT-CIRCUITEZ JAMAIS LA BATTERIE POSITIF (+) ET NÉGATIF (-).**

Refer to Fig 3.2

Before the battery is connected, make sure that battery voltage is greater than 8V so as to start up the controller. If the battery system voltage is 24V, make sure the battery voltage is not less than 18V to ensure that battery system voltage is correctly sensed as 24V (auto sensing feature for battery system voltage will erroneously sense voltage < 18V as 12V battery system). Battery system voltage will be sensed automatically when the controller starts up for the first time. 15A fuse "F1" is used to protect the cable run from the battery to the charge controller against short circuit. Install the fuse not more than 7" from the battery Positive terminal. Do not insert the fuse at this time.

### 3.4.2 Step 2: Load Connection through Load Terminals (Limited to 10A)

Refer to Fig 3.2

The Load Terminals of the controller can be connected to such electrical devices as lights and other devices with load current of up to 10A. Controller provides power to the load(s) through the battery.

When load(s) are fed from the Load Terminals, the controller will provide the following protections on the load side:

**Protect the battery as follows:**

- *Battery Low Voltage Alarm (≤12V/24V)*: Battery Status LED (2, Fig 2.1) will be steady ORANGE. Output will still be available at Load Terminals. This condition will be auto reset at 12.2 / 24.4V

**WARNING!**

**CURRENT OUTPUT ON THE LOAD TERMINALS IS LIMITED TO A MAXIMUM OF 10A. IF HEAVIER LOADS DRAWING MORE THAN 10A LIKE INVERTER ETC. ARE REQUIRED TO BE POWERED, CONNECT THEM DIRECTLY TO THE BATTERY THROUGH APPROPRIATE FUSE "F2" THAT SHOULD MATCH THE DC INPUT CURRENT OF THE INVERTER. THIS FUSE SHOULD ALSO BE INSTALLED WITHIN 7" OF THE BATTERY (+) TERMINAL.**

**MISE EN GARDE!**

**LA SORTIE DE COURANT SUR LES BORNES DE CHARGE EST LIMITÉE À UN MAXIMUM DE 10A. SI DES CHARGES PLUS LOURDES DE PLUS DE 10 A COMME L'ONDULEUR, ETC. DOIVENT ÊTRE ALIMENTÉES, CONNECTEZ-LES DIRECTEMENT À LA BATTERIE VIA LE FUSIBLE APPROPRIÉ "F2" QUI DOIT CORRESPONDRE AU COURANT D'ENTRÉE CC DE L'ONDULEUR. CE FUSIBLE DOIT ÉGALEMENT ÊTRE INSTALLÉ À MOINS DE 7 "DE LA BORNE (+) DE LA BATTERIE.**

- *Battery Over Voltage (≥16V/32V)*:
  - Battery Status LED (2, Fig 2.1) will be blinking GREEN (4 Hz)
  - Load will be disconnected. This condition will be automatically reset at 15.0 / 30.0V.
- *Battery is Over Discharged (≤11.1V/22.2V)*: Battery Status LED (2, Fig 2.1) will be steady RED. Output to Load Terminals will be disconnected. This condition will be auto reset at 12.6/ 25.2V

**Protect the load as follows:**

- *Overload or short circuit in the load connected to the Load Terminals*: Output to Load Terminals will be disconnected (Refer to Sections 5.1.4 & 5.1.5 for details)

Connect the Positive (+) and Negative (-) of load(s) to controller Load Terminals as shown in Fig 3.2.

An in-line Switch "S1" may be wired in series in the load Positive (+) wire as show in Fig 3.2. This switch may be placed near the load to turn on and turn off the load locally.

If the Load Terminals of the controller are fed to a distribution panel for further distribution to the loads, each load circuit may be fused separately. Ensure that the maximum total running / start up current draw of the load(s) is less than 10A.

### 3.4.3 Step 3: Solar Panel / Array Connection

**WARNING!**

**RISK OF ELECTRIC SHOCK! EXERCISE CAUTION WHEN HANDLING SOLAR CONNECTIONS. HIGH VOLTAGE OUTPUT FROM THE PV PANEL(S)/ARRAY MAY CAUSE SHOCK OR INJURY. COVER THE PV PANEL(S)/ARRAY FROM THE SUN BEFORE INSTALLING SOLAR WIRING.**

**MISE EN GARDE!**

**RISQUE DE CHOC ELECTRIQUE! FAITES PREUVE DE PRUDENCE LORS DE LA MANIPULATION DE L'ÉNERGIE SOLAIRE CONNEXIONS. LA SORTIE HAUTE TENSION DES PANNEAUX PHOTOVOLTAÏQUES PEUT PROVOQUER DES CHOCS OU DES BLESSURES. COUVREZ LES PANNEAUX PHOTOVOLTAÏQUES DU SOLEIL AVANT D'INSTALLER LE CÂBLAGE SOLAIRE.**

The controller can accept 12V (36 cell) or 24V nominal (72 cell) PV panel(s) with maximum Open Circuit Voltage of up to 50V. Continuous voltage > 50V will damage the input section of the controller due to short circuiting of the Transient Voltage Suppressor (TVS) connected across the PV input terminals.

### 3.4.4 Step 4: Battery Temperature Sensing & Compensation

The controller has internal battery temperature sensing that will provide approximate battery temperature sensing in cases where the controller is located very close to the battery.

Optional Battery Temperature Sensor Model MSK-TS (with 3m/10ft cable) may be ordered if the battery is installed up to 3m/10ft away from the controller. Insert the female connector into the Jack marked "Temp Sensor" (8, Fig 2.1). Attach the cylindrical sensor half way down the vertical side of the warmest battery in the battery bank so that the sensor picks up the temperature of the electrolyte. Use 1 mil PVC Pipe Wrap to tape the sensor to the battery (pre-clean the battery surface with rubbing alcohol prior to placing the tape).

Battery Temperature Coefficient is -18mV/°C for 12V battery & -36mV/°C for 24V battery.

### 3.4.5 Step 5: Install Fuse

Install 15A fuse "F1" in the battery circuit.

### 3.4.6 Step 6: Confirm Power ON

When battery power is applied, the controller will start operating. Refer to Table 4.1 under Section 4.7 for operational information through the PV / Battery / Status LEDs (1, 2 & 3 in Fig 2.1).

# SECTION 4 | Operation

## 4.1 PRINCIPLE OF OPERATION OF SOLAR CHARGING WITH SERIES TYPE PULSE WIDTH MODULATION (PWM) CONTROL

The design and operation of MSK-10A is based on Series Type PWM (Pulse Width Modulation) control at PWM frequency of 25 Hz.

## 4.2 PWM EXPLANATION

The output of the PV Panel(s)/Array is connected to the battery in series with a Mosfet Switch inside the controller. A Micro-controller controls the ON / OFF operation of the Mosfet Switch to control the charging current and consequently, the State of Charge of the battery.

A PV Panel/Array is a current source that outputs constant current equal to its Short Circuit Current (Isc) over a wide voltage range (provided Irradiance Level, Spectrum and Cell Temperature remain constant). For example, at STC, a typical 12V nominal, 45W PV Panel may provide constant Short Circuit Current (Isc) of around 3A over voltage range from 0V to around 15V.

PWM consists of repetitive cycles of controlled duration of ON and OFF states of the Series Connected Mosfet Switch inside the controller. The sum of ON and OFF times of one cycle is called the Pulse Period. In PWM control, the duration of the Pulse Width (ON time) is varied (modulated) and is defined by "Duty Cycle" which is the ratio of the "ON Time" to the "Pulse Period ". Duty Cycle is normally specified in %. Thus, 0% Duty Cycle will mean that the switch is constantly OFF (will output 0A) and 100% Duty Cycle will mean that the switch is constantly ON and will output the full instantaneous Short Circuit Current "Isc" of the panel. For Duty Cycles > 0% and < 100%, the switch will alternate between ON and OFF states in a controlled manner in every cycle and will output variable average current within a range of 0A to the full Short Circuit Current Isc. Thus, through PWM control, the Mosfet Switch inside the controller converts constant Short Circuit Current (Isc) of the PV Panel(s) to controlled average charging current at its output by varying the Duty Cycle. The average value of the charging current is equal to the instantaneous input value of Short Circuit Current (Isc) of the panel multiplied by the Duty Cycle.

## 4.3 PWM CHARGING IN MSK-10A

Battery charging is a current based process. Current fed to the battery results in re-charging of the cells and consequent rise in battery voltage. Controlling the current will control battery voltage. For 100% return of capacity, and for prevention of excessive gassing and sulfation, the battery charging voltage is required to be controlled at the specified Voltage Regulation Set Points for Absorption, Float and Equalization Charging Stages for different battery types. Battery can, thus, be charged at the specified Voltage Regulation Set Points by PWM of the charging current through control of Duty Cycle as explained above. The controller checks the battery voltage and updates the Duty Cycle regularly at a very fast rate. The Duty Cycle is proportional to the difference between the sensed battery voltage and the Voltage Regulation Set Point. Once the specified Voltage Regulation Set Point is reached, it is kept steady - rise in voltage is compensated

by reducing the average current by reducing the Duty Cycle and fall in voltage is compensated by raising the average current by raising the Duty Cycle. These fast updates on battery voltage measurements and Duty Cycle corrections ensure charging of the battery at the specified Voltage Regulation Set Point with minimum voltage deviation.

### 4.3.1 Optimum PWM Frequency

The PWM frequency can range from tens of Hz to around 1000 Hz. At higher frequencies, the time period between the cycles is lesser and is not sufficient to complete the electro-chemical reactions. At lower frequencies, the rise times of the charging pulses are lower which results in higher gas bubble formation resulting in lowering of active surface area and increase of internal impedance. In
MSK-10A, frequency of 25 Hz is used for optimum charging performance.

### 4.3.2 Benefits of pulsing nature of charging current during PWM

During PWM voltage regulated stages of Absorption, Float and Equalization, Duty Cycle is lower and the charging current is in the form of pulses. Pulsing charging current allows some Oxygen and Hydrogen generated during charging chemical reactions to be chemically combined again and then absorbed. This eliminates concentration polarization and ohm polarization and reduces the internal pressure of the battery. Consequently, charging process is smoother and more capacity is returned to the battery. Further, pulsing current provides more time to react, which reduces the gassing volume and improves the absorption rate of charging current.

## 4.4 CHARGING PROFILES

The controller has been set for the following 2 Charging Profiles:

(a) *3-Stage Normal Profile*: See Fig 4.1A & Section 4.4.1 for details
(b) *3-Stage Equalization Profile*: See Fig 4.1B & Section 4.4.2 for details

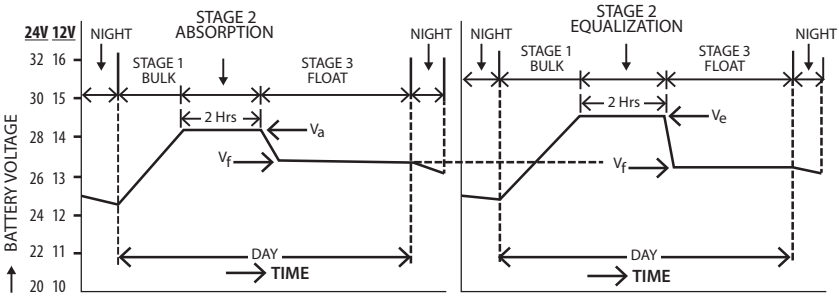



**Fig 4.1A 3-Stage Normal Profile**
**Bulk → Absorption → Float**

**Fig 4.1B 3-Stage Equalization Profile**
**Bulk → Equalization → Float**

**LEGEND FOR FIG 4.1A & FIG 4.1B:**

Va - Absorption Stage PWM Voltage Regulation Set Point
Ve - Equalization Stage PWM Voltage Regulation Set Point
Vf - Float Stage PWM Regulation Voltage Set Point

**Figs 4.1A & 4.1B Charging Profiles**

### 4.4.1 Normal Charging Profile

Please refer to Fig 4.1A

This charging cycle is carried out for normal day to day charging. Charging is sequential: Stage 1: Bulk Stage (Maximum available Current = Instantaneous Short Circuit Current "Isc" of the panel (Current) ⟶ Stage 2: Absorption Stage (Constant Voltage) ⟶ Stage 3: Float Stage (Constant Voltage).

#### 4.4.1.1 Stage 1 - Bulk Stage

Please refer to Fig 4.1A

This is almost a constant current stage. During this stage, the Mosfet Switch is kept at 100% Duty Cycle (ON continuously) and hence, maximum current equal to the available instantaneous Short Circuit Current "Isc" of the panel is fed to the battery and the battery voltage starts rising. When the voltage rises to the Absorption Transition Voltage Set Point "Va", the controller transitions to Absorption Stage. At the end of the Bulk Stage, the battery is charged to around 80% capacity. The balance of 20% capacity is restored in the next Absorption Stage.

#### 4.4.1.2 Stage 2 - Absorption Stage

Please refer to Fig 4.1A

The controller enters this stage from the previous Bulk Stage when the battery voltage rises to the Absorption Transition Voltage Set Point "Va" which is internally set as follows:

- "Va" for 12V battery: 14.4V for Sealed Lead Acid (AGM - Absorbed Glass Mat)
- "Va" for 24 V battery: 28.8V for Sealed Lead Acid (AGM - Absorbed Glass Mat)

This stage is timed for 2 Hrs - either continuous or cumulative.

This is a constant voltage stage and the Mosfet Switch operates under PWM control by feeding pulsing Short Circuit Current "Isc" with constantly reducing Duty Cycle (< 100% to > 0%) / average current to keep the battery voltage constant at the Absorption Transition Voltage Set Point "Va". This is an intentional, controlled over voltage condition for the battery for 2 Hrs. This is necessary to return the balance 20% of the capacity. At this voltage, the battery starts gassing (evolution of Hydrogen and Oxygen due to electrolysis of water in the electrolyte) and hence, it is necessary to exit this stage as soon as 100% capacity is restored. If this over voltage condition is allowed to continue after 100% recharging, the battery will be damaged due to effects of overcharging like overheating, loss of water (flooded batteries), corrosion of the Positive plates and excessive build up of pressure resulting in acid spillage due to opening of pressure activated relief valves (sealed batteries). The balance of 20% of the battery capacity is restored in this stage. As the battery capacity rises from 80% to 100%, the PWM control tapers the current by continuously reducing the Duty Cycle from < 100% to > 0%.

Change over to the next Float Transition Voltage Set Point "Vf" (13.8V for 12 V battery and 27.6V for 24V battery) is possible only after the battery voltage is held at the selected Absorption Transition Voltage Set Point "Va" for continuous or cumulative period of 2 Hours. If Absorption Transition Voltage Set Point "Va" cannot be maintained continuously / cumulatively for 2 Hr, transition to Float Stage **WILL NOT** take place.

#### 4.4.1.3 Stage 3 - Float stage

Please refer to Fig 4.1A

The controller enters this stage from the previous Absorption Stage after the battery voltage is held at the selected Absorption Transition Voltage Set Point "Va" for continuous or cumulative period of 2 Hours.

This is also a constant voltage stage and the Mosfet Switch operates under PWM control by feeding pulsing, instantaneous Short Circuit Current "Isc" with very low Duty Cycle of > 0% to < 10% to keep the battery voltage constant at the Float Transition Voltage Set Point "Vf" (13.8V for 12V battery and 27.6V for 24V battery). During this stage, the battery is 100% charged and a very low "Trickle Charge" of around 0.1% of the Ah Capacity is required to be fed to the battery to compensate for self-discharge. The battery can be left at this stage for prolonged period of time.

**NOTE: During Float Stage, if the load current is more than the current from the PV Panel(s), the battery voltage will drop. If the battery voltage drops to 13.2V for 12V battery and 26.4V for 24V battery, the controller reverts to Stage 2: Absorption Stage.**

## 4.5 EQUALIZATION OF LEAD ACID BATTERIES - GENERAL INFORMATION

**WARNING!**

**RISK OF EXPLOSION AND EQUIPMENT DAMAGE!**

- Equalizing flooded battery can produce explosive gases. Ensure proper ventilation of the battery box
- Equalization may increase battery voltage to the level that can damage sensitive DC loads. Ensure that DC input voltage of all DC loads is greater than the Equalizing Charging Set Point. DC loads not matching Equalization Voltage Set Point, Ve (Fig 4.1B) should be disconnected.

**CAUTION!**

- Top up the electrolyte with distilled water after completion of equalization.
- Excessive overcharging and gassing too vigorously can damage the battery plates and cause shedding of active material from the plates. An equalization that is too high or for too long can be damaging. Review the requirements for the particular battery being used in your system.

**MISE EN GARDE!**

**RISQUE D'EXPLOSION ET DE DOMMAGES MATÉRIELS!**

*• L'égalisation de la batterie inondée peut produire des gaz explosifs. Assurer une bonne ventilation du boîtier de batterie*

*• L'égalisation peut augmenter la tension de la batterie au niveau qui peut endommager les charges CC sensibles. Assurez-vous que la tension d'entrée CC de toutes les charges CC est supérieure au point de consigne de charge d'égalisation. Les charges CC ne correspondant pas au point de consigne de tension d'égalisation doivent être déconnectées.*

**ATTENTION!**

*• Remplissez l'électrolyte avec de l'eau distillée une fois l'égalisation terminée.*

*• Une surcharge excessive et un gazage trop vigoureux peuvent endommager les plaques de la batterie et provoquer une perte de matière active des plaques. Une égalisation trop élevée ou trop longue peut être dommageable. Passez en revue les exigences de la batterie particulière utilisée dans votre système.*

Equalization is intentional overcharging of the battery for controlled period of time. Routine equalization cycles are often vital to the performance and life of a battery – particularly in a solar system where peak sun hours per day are limited and variable and may not be sufficient to keep the battery in a fully charged condition. Periodic equalization is carried out for proper health and long life of a Lead Acid battery to prevent / reduce the following undesirable effects:

### 4.5.1 Sulfation

If the charging process is not complete due to inability of the charger to provide the required voltage levels or if the battery is left uncharged for a long duration of time, soft Lead Sulfate crystals on the Positive and Negative plates that are formed during discharging / self discharge are not fully converted back to Lead Dioxide 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 non-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 crystals. Voltages 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. Sulfation may be reduced partially by the stirring / mixing action of the electrolyte due to gassing and bubbling because of intentional overcharging during the Equalization Stage.

### 4.5.2 Electrolyte Stratification

Electrolyte stratification can occur in all types of flooded batteries. As the battery is discharged and charged, concentration of Sulphuric 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.

### 4.5.3 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 the 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.

## 4.6 EQUALIZATION CHARGING PROFILE

Please refer to Fig 4.1B

Equalization charging profile is carried out automatically every 28 days whenever the battery is over discharged and the battery voltage drops to 11.1V for 12V battery and 22.2V for 24V battery.

### 4.6.1 Stage 1 Bulk Stage

Please refer to Fig 4.1B

This is the same as the Bulk Stage in the Normal Charging Cycle (See Section 4.4.1.1)

### 4.6.2 Stage 2 Equalization Stage

Please refer to Fig 4.1B

The controller enters this stage from the previous Bulk Stage when the battery voltage rises to the Equalization Transition Voltage Set Point “Ve” which is internally set as follows:

- “Ve” for 12V battery: 14.6V for Sealed Lead Acid (AGM - Absorbed Glass Mat)
- “Ve” for 24V battery: 29.2V for Sealed Lead Acid (AGM - Absorbed Glass Mat)

This stage is timed for 2 Hrs - either continuous or cumulative

This is a constant voltage stage and the Mosfet Switch operates under PWM control by feeding pulsing Short Circuit Current "Isc" with constantly reducing Duty Cycle (< 100% to > 0%) / average current to keep the battery voltage constant at the Equalization Transition Voltage Set Point "Ve". This is an intentional, controlled over voltage condition for the battery for 2 Hrs. This is necessary for equalization requirements.
Change over to the next Float Transition Voltage Set Point "Vf" (13.8V for 12V battery and 27.6V for 24V battery) is possible only after the battery voltage is held at the selected Equalization Transition Voltage Set Point "Ve" for continuous or cumulative period of 2 Hours. If Equalization Transition Voltage Set Point "Ve" cannot be maintained continuously / cumulatively for 2 Hr, transition to Float Stage **WILL NOT** take place.

### 4.6.3 Stage 3 - Float stage

Please refer to Fig 4.1B

The controller enters this stage from the previous Equalization Stage after the battery voltage is held at the selected Equalization Transition Voltage Set Point "Ve" for continuous or cumulative period of 2 Hours.

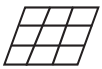
This stage is the same as the Float Stage in the Normal Charging Cycle (See Section 4.4.1.3).

**NOTE: During Float Stage, if the load current is more than the current from the PV Panel(s), the battery voltage will drop. If the battery voltage drops to 13.2V for 12V battery and 26.4V for 24V battery, the controller reverts to Stage 2: Absorption**

## 4.7 LED INDICATIONS

LED indications for operational status are shown at Table 4.1.

**TABLE 4.1 LED INDICATIONS FOR OPERATIONAL STATUS**

| Item No. (Fig 2.1) | Description | Color of LED | LED Lighting Pattern | Operational Status |
|---|---|---|---|---|
| 1 | PV Status LED  | Green | On Steady | Low solar irradiance due to poor sunlight. PV panel/array voltage is more than 8V but less than the battery voltage and hence, there will be no charging. |
| | | Green | Slow Blinking (1Hz) | PV Voltage is > battery voltage. Charging is taking place. |
| | | Green | Fast Flashing (4Hz) | PV Reverse Polarity |
| | | Green | OFF | PV Voltage is <5V (Night time or PV is disconnected) |
| 2 | Battery Status LED  | Green | On Steady | Normal Battery Voltage is >12.4V / 24.8V |
| | | Green | Slow Blinking (1Hz) | Battery is fully charged |
| | | Green | Fast Blinking (4Hz) | Battery over voltage: 16V / 32V<br>• Auto reset at 15.0V / 30.0V |
| | | Orange | On Steady | Battery under voltage warning: 12V / 24V<br>• Auto reset at 12.2V / 24.4V |
| | | Red | On Steady | Battery is over discharged to 11.1 / 22.2V.<br>• Auto reset at 12.6V / 25.2V |
| | | Red | Slow Blinking (1Hz) | Battery over heated to >65°C. Charging is stopped. (Optional Battery Temperature Sensor MSK-TS has been connected)<br>• Auto reset at <55°C |
| 3 | Load Status LED  | Red | On Steady | Battery power to Load Terminals is ON |
| | | Red | Off | Battery power to Load Terminals is OFF |
| | | Red | Slow Flashing (1Hz) | Overload on the Load Terminals. Battery power to Load Terminals is OFF |
| | | Red | Fast Flashing (4Hz) | Short circuit at Load Terminals. Battery power to Load Terminals is OFF |
| 1,2,3 | All 3 LED Indicators are blinking:<br>• PV Status LED (1) = Blinks Green<br>• Battery Status LED (2) = Blinks Orange<br>• Load Status LED (3) = Blinks Red | | | - Internal hot spot is >85°C<br>• Input and output are disconnected<br>- Auto reset at < 75°C |
| 1,2,3 | All 3 LED Indicators are blinking:<br>• PV Status LED (1) = Blinks Green<br>• Battery Status LED (2) = Blinks Red<br>• Load Status LED (3) = Blinks Red | | | System voltage error. Battery voltage does not match the controller voltage. Check battery voltage is 12V/24V. Press Load On/ Off Button (4, Fig 2.1) to clear the malfunction. |

## 4.8 LOAD ON/OFF CONTROL

When the controller is powered ON, press the Load On/Off Button (4, Fig 2.1) to toggle the load ON and OFF. When load is ON, Load Status LED (3, Fig 2.1) will turn ON - RED.

## 4.9 BATTERY TEMPERATURE SENSING & COMPENSATION

Refer to Section 3.4.4 for details.

# SECTION 5 | Protections & Troubleshooting

## 5.1 PROTECTIONS

### 5.1.1 PV Input Over Current
If the PV array output current exceeds 10A rating of the controller, the charging current will be limited to the rated current of 10A.

### 5.1.2 PV Array Short Circuit
If PV array short circuit occurs, remove the short circuit to resume normal operation automatically. The controller will not be damaged due to short circuit on the PV input side.

### 5.1.3 PV Reverse Polarity
Fully protected against PV reverse polarity. PV Status LED (1, Fig 2.1) will fast blink Green @ 4Hz. The controller will not be damaged. Correct polarity of the connection to resume normal operation.

### 5.1.4 Overload in the Load(s) Connected to Load Terminals
When the load is within the rated current of 10A, Load Status LED (3, Fig 2.1) will be steady RED. When the load rises to ≥ 1.05 times (10.5A) for around 3 sec, overload protection is activated as follows:

1. Load will be disconnected for 5 sec – Load Status LED will slow blink 5 times @ 1Hz
2. Load will be reconnected – Load Status LED will be steady
3. If overload ≥ 10.5A continues for 3 sec, the load will be disconnected for 10 sec and the Load Status LED will blink 10 times @ 1Hz
4. Load will be reconnected – Load Status LED will be steady
5. If overload ≥ 10.5A continues for 3 sec, the load will be disconnected for 15 sec and the Load Status LED will slow blink 15 times @ 1Hz
6. Load will be reconnected – Load Status LED will be steady
7. If overload ≥ 10.5A continues for 3 sec, the load will be disconnected for 20 sec and the Load Status LED will blink 20 times @ 1Hz
8. Load will be reconnected – Load Status LED will be steady
9. If overload ≥ 10.5A continues for 3 sec, the load will be disconnected for 25 sec
10. Load will be reconnected – Load Status LED will be steady
11. If overload ≥ 10.5A continues for 3 sec, *the load will be disconnected permanently and the Load Status LED will slow blink continuously @ 1Hz*
    - To reset, remove overload and press the Load On/Off Button (4, Fig 2.1) for around 8 sec

### 5.1.5 Load Short Circuit
Short circuit condition is detected if the output current is ≥ 2 times (20A) momentarily. The protection is activated and reset as follows:

1. If load current ≥ 20A is detected momentarily, the load will be disconnected immediately and the Red Load Status LED will fast blink @ 4Hz for 5 sec
2. After 5 sec, the load will be reconnected. If short circuit condition continues, the load will be disconnected immediately and the Red Load Status LED will continue to fast blink @ 4Hz for 10 sec.
3. After 10 sec., the load will be reconnected. If the short circuit condition continues, the load will be disconnected immediately and the Red Load Status LED will continue to fast blink @ 4Hz for 15 sec.
4. After 15 sec., the load will be reconnected. If the short circuit condition continues,

the load will be disconnected immediately and the Red Load Status LED will continue to fast blink @ 4Hz for 20 sec.

5. After 20 sec., the load will be reconnected. If the short circuit condition continues, the load will be disconnected immediately and the Red Load Status LED will continue to fast blink @ 4Hz for 25 sec.
6. After 25 sec., the load will be reconnected. If the short circuit condition continues, *the load will **NOT** be reset and the Red Load Status LED will continue to fast blink @ 4Hz until the short circuit condition is removed and manual reset is carried out by pressing the Load On/Off Button (4, Fig 2.1) for 8 sec.*

### 5.1.6 Battery Reverse Polarity

Fully protected against battery reverse polarity. The controller will not be damaged. Correct polarity of wiring to resume normal operation.

### 5.1.7 Battery Over Voltage

At 16V/32V battery voltage, charging will be stopped. Battery Status LED (2, Fig 2.1) will be fast blinking Green @ 4Hz. Automatic reset at 15V/30V.

### 5.1.8 Battery Over Discharge

At battery voltage of 11.1/22.2V, the load connected to Load Terminals (6A, 6B in Fig 2.1) will be disconnected. Battery Status LED (2, Fig 2.1) will be Steady Red. Automatic reset at 12.6/25.2V. (**NOTE:** Loads directly connected to the battery will continue to discharge the battery.)

### 5.1.9 Overtemperature Protection – Battery

If the battery temperature exceeds 65°C, battery charging is stopped. Battery Status LED (2, Fig 2.1) will slow blink Green @ 1Hz. Automatic reset at < 55°C.

**NOTE:** For this protection, optional Battery Temperature Sensor MSK-TS will be required to be connected (See Section 3.4.4)

### 5.1.10 Overtemperature Protection – Controller

If the temperature of the controller's heat sink exceeds 85°C, the input and output will be disconnected. Connection will be resumed at 75°C.

### 5.1.11 Damaged Temperature Sensor

If the optional external battery temperature sensor Model MSK-TS (Section 3.4.4) is short-circuited or damaged, the controller will charge or discharge at the default temperature of 25°C.

### 5.1.12 High Voltage Transients

Battery is protected against high voltage transients. In lightning prone areas, additional external lightning protection is recommended.

## 5.2 TROUBLESHOOTING

Troubleshooting Guide is shown at Table 5.1. Please refer to LED indications at Section 4.7, Table 4.1 for supplementary information.

**TABLE 5.1 TROUBLESHOOTING GUIDE**

| Symptom | Possible Cause | Remarks / Remedy |
|---|---|---|
| PV Status LED (1, Fig 2.1) is not lighted although solar panel(s) are exposed to sunlight | • Energy from solar panel(s) is not available at the Solar Panel Input Terminals of the controller.<br>• Voltage > 8V is not available simultaneously at the Battery Terminals of the controller. | • Check solar panel(s) wiring<br>• Check battery connection and series fuses and ensure voltage > 8V is available at the battery terminals of the controller |
| PV Status LED (1, Fig 2.1) is Steady ON | Low solar irradiance due to poor sunlight. PV panel/array voltage is > 8V but < the battery voltage & hence, no charging | Ensure that PV panel/array is exposed to unobstructed and bright sunlight with no clouds/shading |
| PV Status LED (1, Fig 2.1) is fast blinking Green @ 4Hz | • PV polarity is reversed<br>• No charging | Correct polarity of PV connection. |
| Battery Status LED (2, Fig 2.1) is Green - fast flashing @ 4Hz and there is no output at the Load Terminals | Battery Over Voltage Disconnect Protection has been activated due to high voltage of ≥ 16V / 32V at the battery output terminals. Solar Panel(s) and Load have been disconnected | Disconnect the Solar panel(s) and discharge the battery |
| Battery Status LED (2, Fig 2.1) is steady Orange. Output is available at the Load Terminals | Battery Under Voltage Warning Indication has been activated at ≤ 12V / ≤ 24V. Output is still available at the Load Terminals | Charge the battery. Reduce / switch OFF load to allow the battery voltage to rise<br><br>Will be reset automatically when voltage rises to 12.2V / 24.4V and LED will go back to steady Green from steady Orange |
| Battery Status LED (2, Fig 2.1) is steady Red. No output voltage at the Load Terminals | Protection against over discharge of battery has been activated at ≤ 11.1V / ≤ 22.2V and the load has been disconnected. | Charge the battery. Reduce / switch off load to allow the battery voltage to rise:<br>- Load will be reconnected automatically at 12.6V / 25.2V and the LED will go back to steady Green from steady Red |

**…Continued on page 25**

# SECTION 5 | Protections & Troubleshooting

| TABLE 5.1 TROUBLESHOOTING GUIDE | | |
|---|---|---|
| **Symptom** | **Possible Cause** | **Remarks / Remedy** |
| Load Status LED (3, Fig 2.1) is slow blinking Red @ 1Hz.<br><br>Load has been disconnected. | Load has been disconnected due to overload in the load circuit connected to the Load Terminals:<br>- Read Section 5.1.4 for details | Remove the cause of overload:<br>- Reset by manually pressing the Load On/ Off Button (4, Fig 2.1) for 8 to 10 sec<br>- Read Section 5.1.4 for details |
| Load Status LED (3, Fig 2.1) is fast blinking Red @ 4Hz.<br><br>Load has been disconnected. | Load has been disconnected due to short circuit<br>- Read Section 5.1.5 for details | Remove the cause of short circuit.<br>- Reset by manually pressing Load On/Off Button (4, Fig 2.1) for 8 to 10 sec.<br>- Read Section 5.1.5 for details. |
| • PV Status LED (1, Fig 2.1) is blinking Green<br>• Battery Status LED (2, Fig 2.1) is blinking Orange<br>• Load Status LED (3, Fig 2.1) is blinking Red<br><br>Controller has stopped working. | Heat sink of the controller > 85°C | Check reasons for overheating. Improve ventilation and ensure proper cool airflow over heat sink surface<br>- Will reset automatically when the unit cools down and temperature drops to < 75°C |
| • PV Status LED (1, Fig 2.1) is blinking Green<br>• Battery Status LED (2, Fig 2.1) is blinking Red<br>• Load Status LED (3, Fig 2.1) is blinking Red<br><br>Controller has stopped working. | Battery temperature has exceeded 65°C | Check reasons for overheating of the battery.<br>- Will reset automatically when the battery temperature drops to below 55°C<br><br>**NOTE:**<br>This protection will be activated only when optional Battery Temperature Sensor Model MSK-TS has been installed (See Section 3.4.4) |
| No LED indications | Battery voltage is < 8V | Charge the battery to voltage > 8V using another AC charger. |

# SECTION 6 | Specifications

## 6.1 GENERAL

| PARAMETER | | SPECIFICATIONS | |
|---|---|---|---|
| | | 12V | 24V |
| **CHARGE CONTROLLER** | | | |
| Type of Charging Control | | Series Type, PWM control, PWM Frequency: 25Hz | |
| Battery Type | | Optimized for Sealed Lead Acid, AGM | |
| Battery System Voltage | | 12V / 24V Nominal; Auto Sensing (<18V sensed as 12V / >18V sensed as 24V) | |
| Working Voltage Range of Charge Controller | | 8V to 32V | |
| Rated Battery Charging Current | | Up to 10A | |
| Rated Current on Load Terminals | | 10A | |
| Charge Circuit Voltage Drop | | ≤ 0.28V | |
| Discharge Circuit Voltage Drop | | ≤ 0.20V | |
| Self Consumption | | ≤ 8.4mA for 12V battery / 7.8mA for 24V battery | |
| Charging Stages | | Bulk, Absorption, Equalization, Float | |
| Charging Profiles | | *Normal Charging Profile:*<br>• Bulk Stage →Absorption Stage →Float Stage<br><br>*Equalization Profile: Executed every 28 days or if battery voltage drops to 11.1V/22.2V:*<br>• Bulk Stage →Equalization Stage →Float Stage | |
| Bulk Stage Current | | Equal to Instantaneous Short Circuit Current Isc of the PV Panel(s) / Maximum 10A | |
| Absorption Stage Voltage | | 14.4V | 28.8V |
| Absorption Stage Duration | | 2 Hrs | |
| Float Stage Voltage | | 13.8V | 27.6V |
| Equalization Stage Voltage | | 14.6V | 29.2V |
| Equalization Stage Duration | | 2 Hrs | |
| Automatic Reset to Absorption Stage | | 13.2V | 26.4V |
| Charging Limit Voltage | | 15.5V<br>Reset: 15.0V | 31.0V<br>Reset: 30.0V |
| Discharging Limit Voltage | | 10.6V | 21.2V |
| Over Voltage Disconnect Voltage | | 16.0V<br>Auto Reset at 15.0V | 32.0V<br>Auto Reset at 30.0V |
| Under Voltage Warning | | 12.0V<br>Auto Reset at 12.2V | 24.0V<br>Auto Reset at 24.4V |
| Low Voltage Disconnect | | 11.1V<br>Auto Reset at 12.6V | 22.2V<br>Auto Reset at 25.2V |
| Battery Temperature Compensation | Built-in Temp Sensor | -18mV/°C | -36mV/°C |
| | External Temp Sensor Model MSK-TS (Optional) | | |

**…Continued on page 27**

# SECTION 6 | Specifications

| PARAMETER | SPECIFICATIONS | |
|---|---|---|
| | 12V | 24V |
| **INPUT – PV PANEL(S) / ARRAY** | | |
| Maximum Open Circuit Voltage | 50V | |
| Maximum Short Circuit Current | 10A | |
| **INPUT / OUTPUT CONNECTIONS** | | |
| Type of connectors | Moving Cage Type for 4mm$^2$ / Up to AWG #12 wire size | |
| **PROTECTIONS** | | |
| Protections | PV over current; PV short circuit; PV reverse polarity; PV over voltage; High voltage transients on PV input; Battery reverse polarity; Battery over voltage; Battery over discharge; Controller / Battery overtemperature; Over voltage, overload and short circuit protections on Load Terminals | |
| **COMPLIANCE** | | |
| Electro Magnetic Compatibility | CE Marked | |
| **ENVIRONMENTAL** | | |
| Operating Temperature | -35°C to +50°C | |
| Storage Temperature | -35°C to +80°C | |
| Humidity | ≤ 95% Non Condensing | |
| Ingress Protection (IP) Rating of Enclosure | IP-30 (NOT waterproof) | |
| **MECHANICAL** | | |
| Overall Dimensions | 138.6 x 69.3 x 37mm | |
| Weight | 0.13 kg | |

**NOTES:**

1. Battery charging & protection voltages are at 25ºC
2. Specifications are subject to change without notice

# SECTION 7 | Warranty

## 3 YEAR LIMITED WARRANTY

MSK-10A Solar Charge Controller 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)

No refund of the purchase price will be granted to the Purchaser, unless the Warrantor is unable to remedy the defect after having a reasonable number of opportunities to do so. 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. There shall be no warranty for defects or damages caused by faulty installation or hook-up, abuse or misuse of the equipment including exposure to excessive heat, salt or fresh water spray, or water immersion.

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")**
**www.samlexamerica.com**

# Notes

# Notes

# Notes

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