



Morningstar's **SunSaver** is the world's leading small solar controller for both professional and consumer applications.

SunSaver's technology provides:

- Exceptional Reliability
- PWM Battery Charging
- Consistent High Quality

The SunSaver's advanced design delivers outstanding performance and value. The SunSaver's low cost is made possible by Morningstar's unique approach to design and manufacturing:

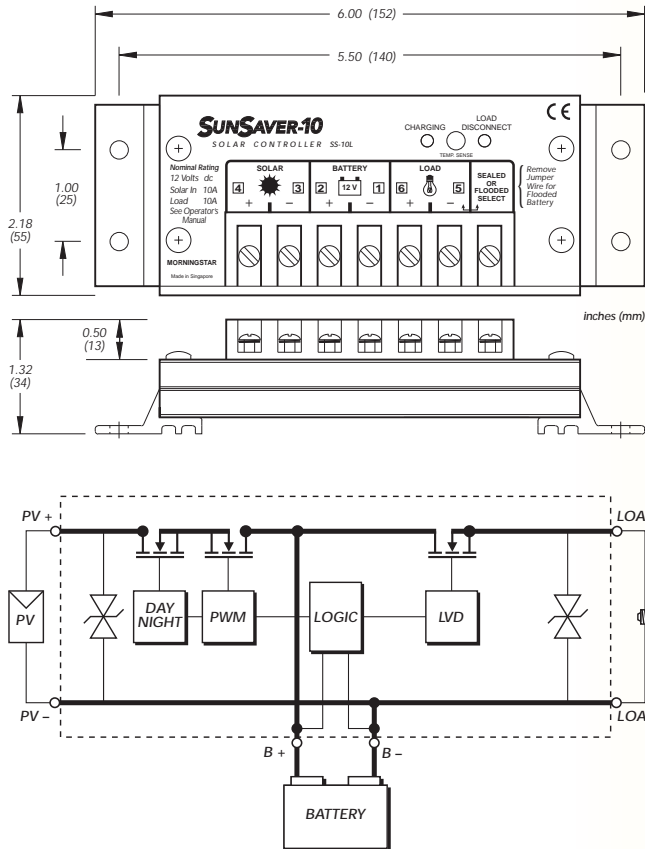
- Automated production
- ISO 9002 quality programs
- Latest power electronic technologies
- Latest control and logic technologies
- High volume manufacturing

Features:

- Eight versions available (see back)
 - 12 and 24 volts
 - 6, 10 and 20 amps
- 100% solid state
- Series design (not shunt)
- True 0 to 100% PWM duty cycle
- Setpoint accuracy to 35 mV
- Rated for 25% overloads
- Fully encapsulated in epoxy potting
- Marine rated terminals / anodized case
- Temperature compensation
- Sealed / Flooded battery select
- No need to derate
- Parallel for 40 amps or more
- Green charging / Red LVD indicators

SunSaver Model Selection Chart

MODEL NUMBER	SOLAR RATING (Amps)			LOAD RATING (Amps)			LVD	12V	24V
	0	10	20	0	10	20			
• SS-6	Blue	Yellow	Blue	Blue	Yellow	Blue	Yellow	Blue	Yellow
• SS-6L	Blue	Yellow	Blue	Blue	Yellow	Blue	Blue	Blue	Yellow
• SS-10	Blue	Yellow	Blue	Blue	Yellow	Blue	Yellow	Blue	Yellow
• SS-10L	Blue	Yellow	Blue	Blue	Yellow	Blue	Blue	Blue	Yellow
• SS-10-24V	Blue	Yellow	Blue	Blue	Yellow	Blue	Yellow	Blue	Blue
• SS-10L-24V	Blue	Yellow	Blue	Blue	Yellow	Blue	Blue	Blue	Blue
• SS-20L	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
• SS-20L-24V	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue



Mechanical Specifications

Wire size #10 AWG (5.2 mm²)
 Anodized aluminum case
 Marine rated terminals
 Epoxy encapsulated
 Weight is 8 oz (0.23 kg)

Electrical Specifications

	12 Volt	24 Volt
Rated Solar Input	6.5/10/20 A	
Rated Load	6/10/20 A	
25% Current Overload	5 min.	5 min.
Regulation Voltage:		
Sealed Battery	14.1 V	28.2 V
Flooded Battery	14.4 V	28.8 V
Load Disconnect	11.5 V	23.0 V
LVD Reconnect	12.6 V	25.2 V
Temp. Comp. (mV/°C)	-28	-56
Self-consumption	6 to 10 mA	
Operating Temp.	-40 to +85°C	

WARRANTY: Five year warranty period. Contact Morningstar or your authorized distributor for complete terms.

AUTHORIZED MORNINGSTAR DISTRIBUTOR:



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SUNSAVER

PHOTOVOLTAIC SYSTEM CONTROLLERS

OPERATOR'S MANUAL

SUNSAVER MODELS INCLUDED IN THIS MANUAL

- **SS-6 / SS-6L** 6A / 12V
 - **SS-10 / SS-10L** 10A / 12V
 - **SS-10-24V / SS-10L-24V** 10A / 24V
 - **SS-20L** 20A / 12V
 - **SS-20L-24V** 20A / 24V
-

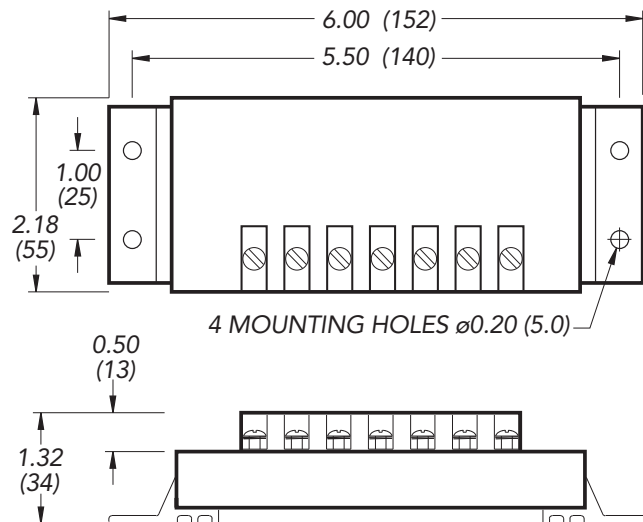


**1098 Washington Crossing Road
Washington Crossing, PA 18977 USA
Website: www.morningstarcorp.com**

SPECIFICATION SUMMARY

		SS-6	SS-10	SS-20	24 Volt
System Volts	(V)	12	12	12	24
Maximum PV Volts	(V)	25	25	25	44
Rated PV Input	(A)	6.5	10	20	n/a
Rated Load	(A)	6	10	20	n/a
Maximum array short circuit current	(A)	8.1	12.5	25	n/a
Setpoints:					
Sealed PWM	(V)	14.1	14.1	14.1	28.2
Flooded PWM	(V)	14.4	14.4	14.4	28.8
LVD	(V)	11.5	11.5	11.5	23.0
LVD Reconnect	(V)	12.6	12.6	12.6	25.2
Ambient Temp Range	(°C)	-40 to 60	-40 to 60	-40 to 60	-40 to 60
Temp Compensation	(mV/°C)	-28	-28	-28	-56

DIMENSIONS INCHES (MM)



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1.0 GENERAL INFORMATION

Thank you for selecting the SunSaver™ PV controller. The SunSaver is a sophisticated controller using advanced technology and series switching PWM charging. The battery charging process has been optimized for longer battery life and improved system performance.

Many specifications of the SunSaver are unique. Although the SunSaver is very simple to use, please take the time to read this operator's manual and become familiar with the controller. This will help you to make full use of the many advantages the SunSaver can provide to your PV system.

2.0 IMPORTANT SAFETY INSTRUCTIONS

- **SAVE THESE INSTRUCTIONS**—This manual contains important instructions that should be followed during installation and maintenance of the SunSaver controller.
- **WARNING**—Be very careful when working with batteries. Lead acid batteries can generate explosive gases, and short circuits can draw thousands of amps from the battery. Read all instructions provided with the battery.
- Do not exceed the voltage or current ratings of the controller. Use only with a 12 volt or 24 volt battery.
- **DO NOT** short circuit the PV array or load while connected to the controller. This will **DAMAGE** the controller.
- The controller should be protected from direct sunlight. Ensure adequate space for air flow around the controller.
- Pressure terminal connectors are not required. Use only copper wire with minimum 75°C insulation rating and between 10 AWG (5.2 mm²) and 14 AWG (2.1 mm²) gage.
- The negative system conductor should be properly grounded. Grounding should comply with local codes.

2.1 INSTALLATIONS IN HAZARDOUS (CLASSIFIED) LOCATIONS

The SunSaver family of charge controllers have been listed to UL1604 and CSA 22.2 No. 213-M1987 for use in Class I, Division 2, Groups A, B, C and D hazardous locations. In order to comply with the UL and CSA standards, the installation should follow the

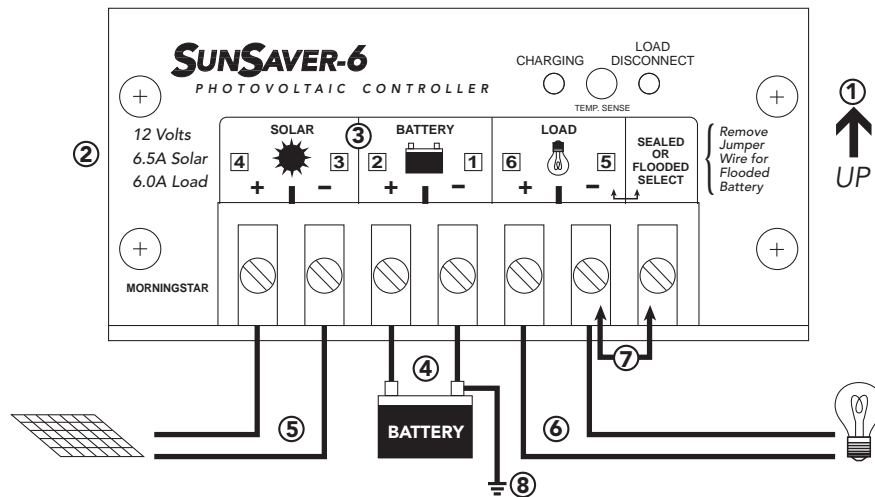
requirements of the National Electrical Code Article 501-4(b) and/or Canadian Electrical Code Article 18-156 when installing a SunSaver in a Hazardous (Classified) Location.

WARNING: Do not disconnect while the circuit is alive unless the area is known to be nonhazardous.

AVERTISSEMENT: Risque D'explosion—Avant De Deconnecter L equipment; Couper Le Courant Ou S'assurer Que L'emplacement Est Designe Non Gereux.

3.0 QUICK START INSTRUCTIONS

This section provides a brief overview of how to get started using the SunSaver controller. However, please review the entire manual to ensure best performance and years of trouble-free service.



1. Mount the SunSaver to a vertical surface. Allow space above and below the controller for air flow.
2. Make sure the PV and load currents will not exceed the ratings of the SunSaver model being installed.
3. The 6 system connections to the SunSaver terminals are numbered on the label. It is recommended that the connections be made in order from 1 to 6.
4. Connect the **BATTERY** first. Use care that bare wires do not touch the metal case of the controller.

5. Connect the **SOLAR** (PV array) next. The green LED indicator will light if sunlight is present.
6. Connect the **LOAD** last. If this model includes an LVD and the red LED indicator lights, the battery capacity is low and should be charged before completing the system installation. (Refer to Section 5.3)
7. The controller is shipped with a jumper installed. This sets the controller for charging **SEALED** batteries.
If a **FLOODED** battery is being used, simply remove the jumper to optimize the battery charging for a flooded battery. If the jumper is connected again, the charging will return to the setpoints for a sealed battery. (Refer to Section 5.3)
8. For most effective surge protection, it is recommended that the battery negative conductor be properly grounded.

4.0 LED INDICATORS

GREEN LED:

The green LED indicator will light whenever sunlight is available for battery charging. The green LED will turn off at night.

Because the SunSaver uses a PWM constant voltage charging process, there is usually some amount of energy going into the battery at all times. Although the charging current falls to very low levels when the battery reaches full charge, the green LED will continue to stay ON (during the daytime). This is to indicate that the controller is working and that energy is available from the PV array for charging.

RED LED:

If your SunSaver model includes an automatic load disconnect (LVD) feature, a red LED indicator is also provided. Whenever the battery charge state falls below the LVD setpoint, the load will be disconnected and the red LED will light. This indicates that the controller has disconnected the load to protect the battery from further discharge and possible damage.

After some period of recharging the battery such that it recovers to approximately 40 to 50 percent of its rated capacity, the load will automatically be reconnected and the red LED will turn off.

5.0 INSTALLATION INSTRUCTIONS

5.1 RATINGS AND LIMITS

- The SunSaver is rated for 12 volt (or 24 volt) PV systems. Do not connect to a PV array with open circuit voltage (Voc) greater than 25 (or 44) volts.
- Maximum array short circuit current rating:

SUNSAVER-6	8.1 amps
SUNSAVER-10	12.5 amps
SUNSAVER-20	25.0 amps
- Because the SunSaver is a series controller, the PV current rating is specified at the PV array's peak power (I_{pp}). The SunSaver does NOT short the PV array for regulation, and it is not necessary to derate the controller for short-circuit current (I_{sc}) as is commonly done with shunt controllers.
- SunSaver models with an automatic low voltage load disconnect function (LVD) are rated for either 6, 10 or 20 amp loads depending on the model.
- SunSaver models without an LVD capability are rated for a maximum load of 10 amps. All loads connected to the SunSaver **LOAD** terminals should not exceed 10 amps of current.

NOTE: *It is not necessary to use the SunSaver load terminals. Loads that exceed the load rating of the SunSaver can be connected directly to the battery.*

- The rated PV input current and the rated load current can both be exceeded by 25% for up to 5 minutes. This 25% overload will reduce the safety margins for surges and will cause heating that can shorten the life of the controller.
For the reasons noted above, these higher overload ratings should **NOT** be used for routine operation. They are only to note overload capability for system design purposes.
- The SunSaver is designed to operate continuously in 60°C ambient temperatures. However, do not install the controller near heat generating sources or in direct sun. This could cause the temperature rating to be exceeded and damage the controller.
- The date of manufacture can be found on the serial number (bottom of case). The first 4 digits are the year and week.

5.2 POLARITY PROTECTION

The SunSaver is generally protected from reversed connections, but the system operator and other equipment will be at risk when polarities (+ and –) are reversed. Carefully check before making each connection to be certain the polarity is correct.

5.3 INSTALLATION PROCEDURE

NOTES:

- The SunSaver prevents reverse current leakage at night, so a blocking diode is not required in the system.
- The connector terminals will accept a maximum wire size of AWG #10 (up to 5.2 mm²). A flathead screwdriver is required. (Some #10 spade connectors may not fit in this terminal.)
- Tighten each terminal clamping screw to 20 inch-pounds of torque.
- The SunSaver is designed to regulate power from a PV array. Other generators can be connected directly to the battery, however, with no effect on the SunSaver.
- Do not connect any system wires (Solar, Battery, Load) to the **SEALED OR FLOODED SELECT** terminal.
- The installation should follow the requirements of the U.S. National Electric Code, Section 690.
- The installation should follow the requirements of the National Electrical Code Article 501-4(b) and/or Canadian Electrical Code Article 18-156 when installing a SunSaver in a Hazardous (Classified) Location.

Refer to the connection diagram on page 5 to illustrate each of the following installation steps.

1. Inspect the controller for shipping damage. If possible, mount the SunSaver to a vertical surface.

Allow a minimum of 5 cm (2 inches) space above and below the controller for air flow. Protect the controller from direct sunlight or other heat sources.

The SunSaver can be mounted outdoors. Avoid mounting in direct rain such that water could collect under the cover. If installed in an enclosure, some ventilation is recommended to minimize operating temperatures.

NOTE: *The SunSaver is very corrosion resistant. The case is hard coat anodized, cover screws are stainless steel, the circuit is encapsulated, and the terminals are copper and nickel plated brass.*

2. Confirm that the PV array and loads will not exceed the current ratings of the SunSaver model being installed (see specifications on page 2).

NOTE: *Multiple SunSavers can be connected in parallel to charge a single battery. Make sure each PV sub-array does not exceed the solar rating of the SunSaver, and be careful not to connect a load that exceeds a single SunSaver's load rating. Separate loads can be connected to different SunSavers.*

3. **CONNECTION ORDER** The label has each system connection numbered from 1 to 6. This is the recommended order of system connections. However, a different order will not damage the controller.
4. **BATTERY** Connect the 12-volt (or 24-volt) system battery. The green LED will not light. If a red LED (LOAD DISCONNECT) is provided with this model and it lights, the battery charge state is low and should be recharged before completing the installation.

NOTE: *If the battery voltage is below 11.5 volts (or 23.0 volts), the load has been automatically disconnected due to a very low battery charge condition, and the battery must be recharged.*

NOTE: *If the battery voltage is between 11.5 and 12.0 (or 23 and 24) volts, the SunSaver will sometimes power-up during initial installation in the LVD (load disconnected) state. This will automatically clear when the battery voltage rises above 12.6 (or 25.2) volts. The LVD can also be reset manually (only if the battery voltage is above 11.5 (or 23) volts). First connect the **SOLAR** array (see step 5 below). Next disconnect and then reconnect the **BATTERY** positive wire. The red LED will turn off to indicate that the LVD has been reset.*

5. **SOLAR** First, be certain the battery (+ and –) is connected correctly. Then connect the PV array to the **SOLAR** terminals. Be **CERTAIN** that the PV + and – wires are connected correctly. The green LED will light if the array is connected during the daytime.

CAUTION: Remember that the PV array will generate power whenever in sunlight. Also, be careful not to **SHORT-CIRCUIT** the PV array while connected to the controller, since this will **DAMAGE** the controller.

6. **LOAD** Turn the load off. Connect the load to the **LOAD** terminals, and then turn the load on.

If the load causes the red LED to turn on (for models with LVD) soon after the load was activated, the battery must be recharged. (see Section 6.2)

7. **SEALED OR FLOODED SELECT** The SunSaver is shipped with a jumper installed between the **LOAD**-negative terminal (connection 5) and the **SEALED OR FLOODED SELECT** terminal. With this jumper installed, the SunSaver is configured for charging **SEALED** batteries.

If your PV system has a **FLOODED** battery, simply remove the jumper to change the SunSaver to a flooded battery charger. (see Section 6.2)

The SunSaver can be changed between SEALED and FLOODED as many times as you wish by using the jumper. Save the jumper for future use in case your battery type is changed. If the jumper is lost, a wire can also be used.

8. For safety and the most effective lightning protection, the negative conductor of the PV system should be properly grounded. The SunSaver connects the PV-negative, Battery-negative and Load- negative internally per UL recommendations. No switching is done in the negative current path.

6.0 OPERATION

6.1 OPERATOR TASKS

The SunSaver is a fully automatic PV system controller that includes electronic functions to protect both the controller and

the PV system. Battery charging is managed by a constant voltage PWM algorithm that has been optimized for PV systems.

The only manual tasks performed by the operator are:

- a. Installation (see Section 5.3)
- b. Battery type selection (see Section 5.3-7)
- c. Maintenance (see Section 6.3)

6.2 OPERATION AND FUNCTIONS

The PV system operator should become familiar with the following operating functions and design of the SunSaver controller. Refer to the Technical Specifications (Section 8.0) for actual setpoints and other parameter values.

- **100% Solid State**
All power switching is done with FETs. No mechanical relays are used in the controller.
- **Battery Charge Regulation**
SunSaver uses an advanced series PWM charge control for constant voltage battery charging. A true 0 to 100% PWM duty cycle is very fast and stable for positive charge control under all system conditions.
- **Temperature Compensation**
A sensor next to the green LED measures ambient temperature conditions. The SunSaver corrects the constant voltage setpoint -28 (-56 for 24V) mV per $^{\circ}\text{C}$ with a 25°C reference. This correction matches the battery charging to the changing electrochemical properties of the battery, and works best if the battery and controller are in a similar thermal environment.
- **Sealed / Flooded Select**
Flooded batteries require more vigorous charging to avoid stratification, and sealed batteries require precise control to avoid outgassing. The SunSaver constant voltage setpoints are 14.4 (or 28.8) volts for flooded batteries, and 14.1 (or 28.2) volts for sealed batteries. See Section 5.3-7 for more information.
- **LED Indicators**
See Section 4.0

- **Low Voltage Disconnect (LVD)**
The automatic load disconnect is an option. If the battery falls below 11.5 (or 23.0) volts, the load is disconnected from the battery to protect against harmful deep discharges. A 2-second delay prevents load disconnects from transients. The load is automatically reconnected when the battery voltage recovers to 12.6 (or 25.2) volts.
- **Battery Disconnect**
If the battery is disconnected during the daytime, the PV array will continue to provide power to the controller. The SunSaver will immediately go into PWM and provide power at a constant voltage to the load. This may continue as long as power is available from the PV array.
- **Parallel Controllers**
The SunSaver controllers work very well in parallel configurations. No blocking diodes are required. The only constraint is that each controller must have an independent and separate PV subarray and load. Make sure that each SunSaver's rating for PV and load current is not exceeded. (see Section 5.3-2)
- **Auxiliary Generators**
Engine generators and other sources of power may be connected directly to the battery for charging. It is not necessary to disconnect the SunSaver from the battery. However, do not use the SunSaver to regulate these other generators.
- **Reverse Current**
The SunSaver prevents the battery from discharging through the PV array at night. There is no need to install a blocking diode for this purpose.
- **Noise**
The SunSaver circuit minimizes switching noise and filters all noise output to extremely low levels when the system is properly grounded. If noise is present in a telecom load, it is most likely a grounding problem in the system.

6.3 INSPECTION AND MAINTENANCE

The following inspections and maintenance tasks are recommended at least once per year for best controller performance.

1. Confirm that the correct battery type has been selected (sealed or flooded with the jumper).

2. Confirm that the current levels of the PV array and load do not exceed the SunSaver ratings.
3. Tighten all the terminals. Inspect for loose, broken, or burnt wire connections. Be certain no loose strands of wire are touching other terminals.
4. Check that the controller is securely mounted in a clean environment. Inspect for dirt, insects, and corrosion.
5. Check that air flow around the controller is not blocked.
6. Protect from direct sun and rain. Confirm that water is not collecting under the cover.
7. Check that the controller functions and LED indicators are correct for the system conditions at that time.

7.0 TESTING AND TROUBLESHOOTING

7.1 TESTING WITH A POWER SUPPLY

Normal SunSaver operation can be tested with a power supply used in place of either the PV array input or the battery. To be certain the SunSaver will not be damaged, observe the following cautions:

- Current limit the power supply to no more than one half the SunSaver rating.
- Set the power supply to 15 volts DC or less for 12V systems and 30 volts DC or less for 24V systems.
- Connect only one power supply to the controller.

NOTE: *For more information on testing SunSaver controllers with a power supply contact the Morningstar Web Site for test procedures*

7.2 TROUBLESHOOTING

The SunSaver is very rugged and designed for the most extreme operating conditions. Most PV system problems will be caused by connections, voltage drops, and loads.

Troubleshooting the SunSaver controller is simple. Some basic troubleshooting procedures are listed on the next page.

- CAUTIONS:**
1. Troubleshooting should be done by qualified personnel only.
 2. Remember that a battery can cause serious damage if shorted.
 3. There are no user serviceable parts, fuses or circuit breakers inside the SunSaver.
 4. Observe all normal precautions when working with energized circuitry.

1. BATTERY IS NOT CHARGING

- a. Check the green LED indicator. The green **CHARGING** LED should be on if it is daytime.
- b. Check that the proper battery type (sealed or flooded) has been selected.
- c. Check that all wire connections in the system are correct and tight. Check the polarity (+ and –) of the connections.
- d. Measure the PV array open-circuit voltage and confirm it is within normal limits. If the voltage is low or zero, check the connections at the PV array itself. Disconnect the PV from the controller when working on the PV array.
- e. Check that the load is not drawing more energy than the PV array can provide.
- f. Check if there are excessive voltage drops between the controller and the battery. This will cause undercharging of the battery.
- g. Check the condition of the battery. Determine if the battery voltage declines at night with no load. If unable to maintain its voltage, the battery may be failing.
- h. Measure the PV voltage and the battery voltage at the SunSaver terminals. If the voltage at the terminals is the same (within a few tenths of volts) the PV array is charging the battery. If PV voltage is close to the open circuit voltage of the panels and the battery voltage is low, the controller is not charging the batteries and may be damaged.

2. BATTERY VOLTAGE IS TOO HIGH

- a. First check the operating conditions to confirm that the voltage is higher than specifications. Consider the temperature compensation of the controller's PWM setpoint. For example,

at 0°C the controller will regulate at about 15.1 volts (for 12 volt flooded batteries).

- b. Check that the proper battery type (sealed or flooded) has been selected.
- c. Check that all wire connections in the system are correct and tight.
- d. Disconnect the PV array and momentarily disconnect the lead from the **BATTERY** positive terminal. Reconnect the battery terminal and leave the PV array disconnected. The Green charging light should not be lit. Measure the voltage at the **SOLAR** terminals (with the array still disconnected). If the green charging light is on or battery voltage is measured at the **SOLAR** terminals, the controller may be damaged.

3. LOAD NOT OPERATING PROPERLY

- a. Check that the load is turned on. Check that no system fuses are defective. Check that no system circuit breakers are tripped. Remember that there are no fuses or circuit breakers inside the SunSaver.
- b. Check connections to the load, and other controller and battery connections. Make sure voltage drops in the system wires are not too high.
- c. Check for proper LED indications on the SunSaver. If the red **LOAD DISCONNECT** LED is on, the load has been disconnected due to low battery voltage. This is generally a normal state when the load exceeds the PV array output due to weather and other sunlight conditions.
- d. Measure the voltage at the controller **BATTERY** terminals. If this voltage is above the LVD, the load should have power. Then measure the voltage at the controller **LOAD** terminals, and if there is no voltage present, the controller may be defective.

NOTE: For more detailed testing instructions contact the Morningstar web site.

8.0 TECHNICAL SPECIFICATIONS

RELIABILITY

- 5-year failure rates at a 95% confidence level
- SunSaver-6 < 0.1%
 - SunSaver-10 0.2%

PERFORMANCE / ELECTRICAL

- Accuracy:
 - Sealed +/-35 mV
 - Flooded +/-60 mV
 - LVD +/-100/160 mV
- Maximum array voltage 25 V/44 V
- Minimum voltage to operate 6 V
- Ground negative
- Parallel capability yes
- Self-consumption: 8 to 10 mA
- Voltage drops (typical):
 - PV/Battery 0.4 volts
 - Battery/Load 0.3 volts
- Operating life 15 years
- Transient surge suppressors:
 - Pulse power rating 1500 watts
 - Response < 5 nanosec
- 25% current overload capability 5 minutes
- Reverse current leakage < 10 µA

ENVIRONMENTAL

- Operating temperature -40 to +85°C
- Max ambient temperature +60°C
- Storage temperature -55 to +100°C
- Humidity 100%

MECHANICAL

- Dimensions: (inches) 6.0 x 2.2 x 1.3 (W•H•D)
(mm) 152 x 56 x 33 (W•H•D)
- Weight (oz) 8
(kg) 0.23
- Wire terminals:
 - Wires per terminal 1 or 2 wires
 - Max size per wire #10 AWG
5.2 mm2
 - Screw material Nickel plated brass
 - Terminal material Tin/Copper plated brass
- Encapsulation Epoxy
- Case 6063-T5 Aluminum
- Finish Electrolytic anodize
- Mounting orientation Any

CONTROL SETPOINTS

- | | <u>Sealed</u> | <u>Flooded</u> |
|------------------------------------|---------------|----------------|
| • Low volt load disconnect | 11.5 | 11.5 |
| • LVD reconnect | 12.6 | 12.6 |
| • Constant-voltage regulation | 14.1 | 14.4 |
- (24 V setpoints are twice 12 V values)

CONTROL PARAMETERS

- Charge algorithm constant-voltage series configuration
- PWM duty cycle 0% to 100%
- Temp comp coefficient... -28 mV/°C (25°C ref) 12V
-56 mV/°C (25°C ref) 24V
- LVD delay 2 seconds

Specifications subject to change without notice.

