TriStar Testing Document

Morningstar Corporation
Columbia, MD USA

This document outlines the steps necessary to verify the operation of the TriStar charge controller. This document is intended for qualified technicians. Exercise caution when working with live circuits in PV systems.

<u>Tools Required:</u>
Digital multimeter
Philips-head screwdriver (#1 size)
Small flat-head screwdriver (1/8" size)
~5A or larger DC power supply, current limited *
Small 12V battery (small 7Ah 12V brick batteries work well) *
~2A 12V DC load (bulb, fan, etc) *
In-line or clamp-on DC current meter (optional)

***suggested sizes and ratings.**

General Checklist

Before you remove the TriStar from the system for testing:

- ✓ **Check all system wiring, breakers, fuses, and disconnects. Check for shorts, damaged cable insulation, open-circuit conditions, blown fuses, and/or tripped breakers.**
- ✓ **Verify that the system battery voltage is above the minimum operating voltage of the TriStar (9.0 V)**
- ✓ **Ensure tight connections at the TriStar power terminals**
- ✓ **Check the temperature sensor and battery sense connections for tight connection**
- ✓ **If the LED indications are flashing a sequence, reference the Appendix B for more information.**
- ✓ **If the optional TriStar Meter is attached, check the Diagnostics menu for Alarm/Faults. Reference Appendix C & D for more information.**

Charging Mode

Power Supply as Battery

Wiring Instructions and Setup

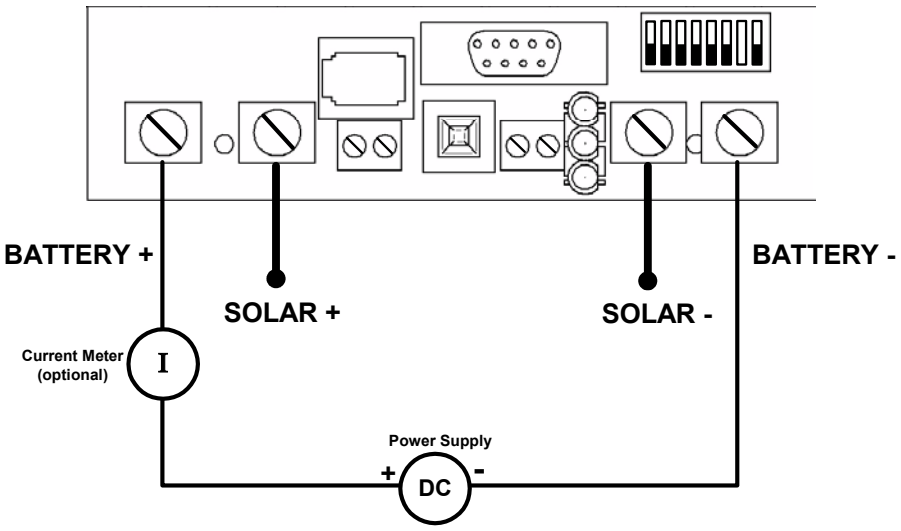

figure 1.

1. Set DIP switch position #1-6 & 8 to the "OFF" position as shown in figure 1.
2. Connect a TriStar meter if you have one.
3. Adjust a power supply output voltage to 12-13.0V. Current limit to approx. 1A
4. Wire the power supply to Battery +/-. Observe correct polarity.
5. Place an in-line or clamp on current meter in the positive lead. Set the scale to the mA range. (optional)

Taking Measurements

1. Measure the voltage at the Battery +/- terminals on the TriStar.
2. Measure the voltage at the Solar +/- terminals on the TriStar.
3. Note the current reading on the current meter(optional)

Checking Functionality

- If you have an in-line or clamp on current meter: The reading should be between 20 to 55mA(depending on whether a meter is attached). Large (70mA or more) or low readings indicate a problem with the circuitry. Disconnect power immediately.
- The measured Solar +/- voltage should be about half of Battery Voltage. At 13.0V, Vsolar ~= 6 to 7Vdc.
- If you have a TriStar Meter: Compare the measured battery voltage with the TriStar Meter battery voltage reading. Check for faults and alarms in the Diagnostics menu. If faults/alarms exist, reference Appendix C&D for detailed explanation.

Power Supply on Input

Wiring Instructions and Setup

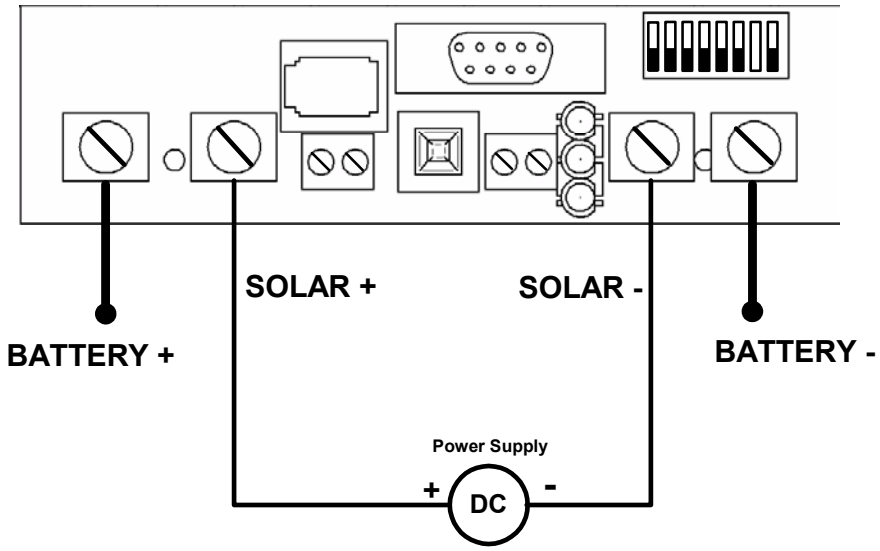

figure 2.

1. Adjust the DIP switches as shown in figure 2. DIP 1-6 & 8 should be in the "OFF" position as shown. It does not matter which position DIP 7 is placed.
2. Connect a TriStar meter if you have one.
3. Adjust a power supply output voltage to 18-20V. Current limit to approx. 1A
4. Wire the power supply to Solar +/-. Observe correct polarity.

Taking Measurements

1. Measure the voltage at the Battery +/- terminals on the TriStar.

Checking Functionality

- The TriStar should NOT power up. No LED indicators should be illuminated and the TS Meter should not turn on.
- Battery voltage should be approximately 0V.
- If $V_{battery} > 0V \rightarrow$ there is a problem with the input:
  - MOSFETs may be damaged. Refer to the TriStar MOSFET replacement instructions.
  - TriStar may require service or replacement

Power Supply and Battery

Wiring Instructions and Setup

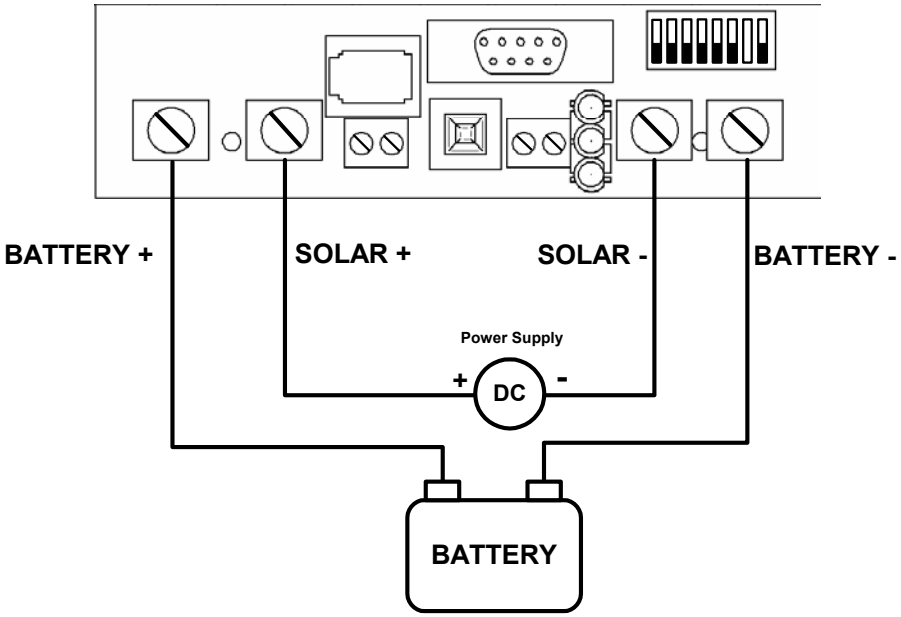

figure 3

1. Adjust the DIP switches as shown in the diagram. DIP 1-6 & 8 should be in the "OFF" position as shown in figure 3. It does not matter which position DIP 7 is placed.
2. Connect a TriStar meter if you have one.
3. Adjust a power supply output voltage to 18-20.0V. Current limit to approx. 3-5A
4. Wire a small 12V battery to Battery +/-. Observe correct polarity.
5. Wire the power supply to Solar +/-. Observe correct polarity.

Taking Measurements

1. Measure the voltage at the Battery +/- terminals on the TriStar.
2. Measure the voltage at the Solar +/- terminals.

Checking Functionality

- If $V_{battery} < 14.0V \rightarrow V_{solar} \sim= V_{battery}$ The TriStar is charging the battery and has not reached regulation.
- If Vbattery > 14.0V → The TriStar is overcharging the batteries and needs service or replacement
- If Vbattery = 14.0V → The TriStar is regulating the battery. Battery voltage should remain at 14.0V. Unit is charging correctly.
- If you have a TriStar Meter: Compare the measured battery voltage with the TriStar Meter battery voltage reading. Check the charging state. It should be "BULK" or "PWM". Check for faults and alarms in the Diagnostics menu. If faults/alarms exist, reference Appendix B&C for detailed explanation.

Load Mode (and Diversion)

Power Supply Only

Wiring Instructions and Setup

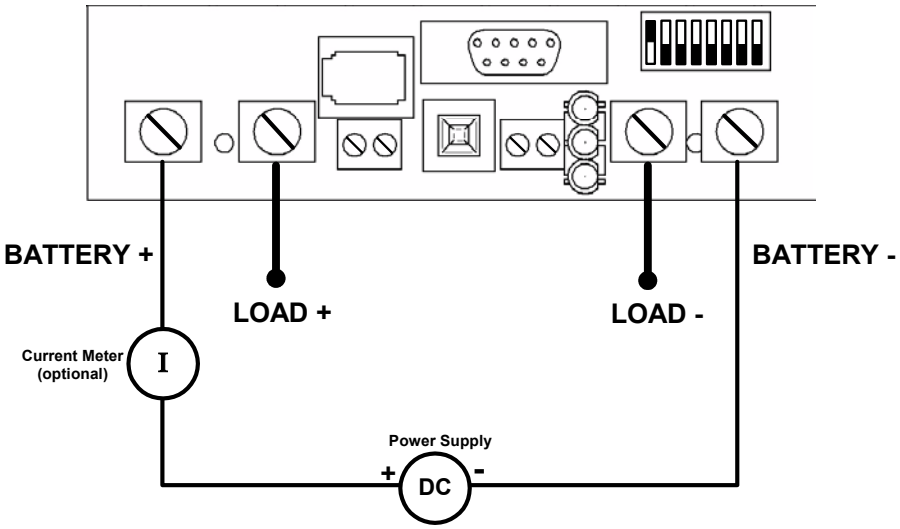

figure 4

1. Set DIP switch position #1 to the "ON" position, set all others to "OFF" as shown in figure 4.
2. Connect a TriStar meter if you have one.
3. Adjust a power supply output voltage to 12-13.0V. Current limit to approx. 1A
4. Wire a power supply to Battery +/-. Observe correct polarity.
5. Place an in-line or clamp on current meter in the positive lead. (optional)

Taking Measurements

1. Measure the voltage at the Battery +/- terminals on the TriStar.
2. Measure the voltage at the Load +/- terminals on the TriStar.
3. Note the current reading on the current meter(optional)

Checking Functionality

If you have an in-line or clamp on current meter: The reading should be between 20-55mA. Large (70mA or more) or low readings indicate a problem with the circuitry. Disconnect power immediately.
Vload ~= Vbattery. Load and Battery Voltage should be about the same.
If Vload < Vbattery, the MOSFETs or other circuitry may be damaged. Refer to TriStar MOSFET Replacement instructions.
If you have a TriStar Meter: Compare the measured battery voltage with the TriStar Meter battery voltage reading. Check for faults and alarms in the Diagnostics menu. If faults/alarms exist, reference Appendix C&D for detailed explanation.

Power Supply and Load

Wiring Instructions and Setup

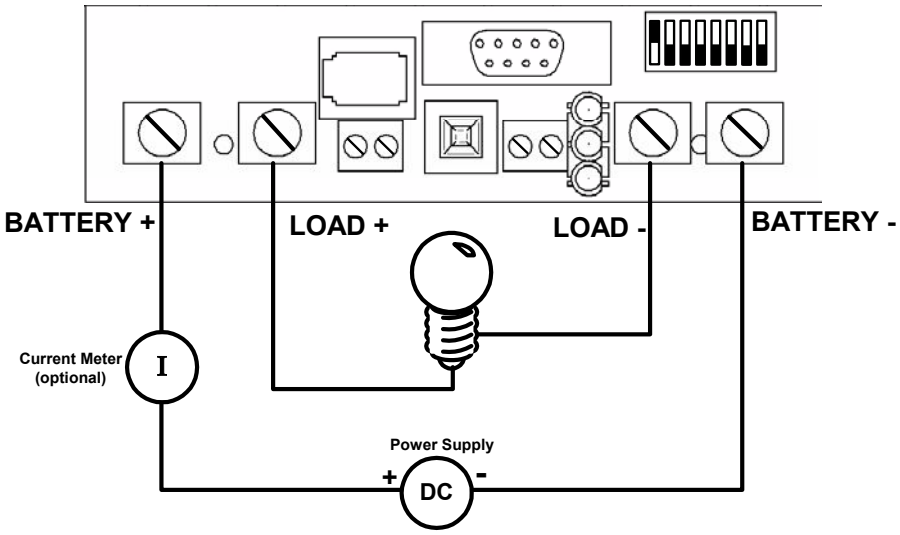

figure 5

1. Set DIP switch position #1 to the "ON" position, set all others to "OFF" as shown in figure 5.
2. Connect a TriStar Meter if you have one.
3. Adjust a power supply output voltage to 12-13.0V. Current limit to approx. 5A
4. Wire a power supply to Battery +/-. Observe correct polarity.
5. Place an in-line or clamp on current meter in the positive lead. (optional)
6. Wire a small (approx. 2A) bulb to the load terminals. Other small DC loads may be substituted.

Taking Measurements

1. Measure the voltage at the Battery +/- terminals on the TriStar.
2. Measure the voltage at the Load +/- terminals on the TriStar.
3. Note the current reading on the current meter(optional)
4. Adjust the powersupply voltage down to 10.8 V.

Checking Functionality

- The Battery and Load Voltages should be about the same.
- The bulb (or other DC device) should be lit or running.
- The LED indicators may take a few minutes to descend from Green to Yellow to Flashing Red.
- It takes approximately 10min in LVDWARN before the load is disconnected.
- At the LVD state change, the LED indicators should be Solid Red and the Load should be turned off. You should measure 0V at the load terminals(with load still attached)
- <u>If you have an in-line or clamp on current meter:</u> The reading should confirm the current draw of the DC load.
- <u>If you have a TriStar Meter:</u> Compare the measured battery and load voltages with the TriStar Meter battery and load voltage readings in the diagnostics menu. The TriStar state should change from NORMAL to LVDWARN, then finally to LVD after 10min. Check for faults and alarms in the Diagnostics menu. If faults/alarms exist, reference Appendix C&D for detailed explanation.

Appendix

A. Standard Battery Charging and LVD Setpoints

Charging

DIP(4,5,6)	Battery Type	Vreg (V)	Float (V)	Equalize (V)	EQ Time (hours)	EQ Interval	Max EQ Cycle
000	Sealed	14.00	13.40	None	None	None	None
001	Sealed	14.15	13.40	14.20	1	28	1
010	Sealed	14.35	13.40	14.40	2	28	2
011	Flooded	14.40	13.40	15.10	3	28	4
100	Flooded	14.60	13.40	15.30	3	28	5
101	Flooded	14.80	13.40	15.30	3	28	5
110	L-16	15.00	13.40	15.30	3	14	5
111	Custom	Custom	Custom	Custom	Custom	Custom	Custom

voltage setpoints double for 24V, 4x for 48V

Load

DIP(4,5,6)	LVD(V)	LVDR(V)	Battery SOC%
000	11.1	12.6	8
001	11.3	12.8	12
010	11.5	13.0	18
011	11.7	13.2	23
100	11.9	13.4	35
101	12.1	13.6	55
110	12.3	13.8	75
111	Custom	Custom	Custom

voltage setpoints double for 24V, 4x for 48V

Diversion

DIP(4,5,6)	Vreg (V)	Float (V)	Time Until Float (hours)	Equalize (V)	EQ Time (hours)	EQ Interval	Max EQ Cycle
000	13.7	13.5	3	14.0	3	28	3
001	13.9	13.7	3	14.20	3	28	3
010	14.1	13.9	4	14.40	3	28	4
011	14.3	14.1	4	14.6	4	28	4
100	14.5	14.3	4	14.8	4	28	5
101	14.7	14.5	4	15.0	4	28	5
110	14.9	14.7	4	15.2	4	28	5
111	Custom	Custom	Custom	Custom	Custom	Custom	Custom

voltage setpoints double for 24V, 4x for 48V

B. LED Indications

LED Indication Code:

G – Y = Green LED lit, then Yellow LED lit (Green off)
G/Y = Both Green and Yellow LEDs lit simultaneously

Condition or Fault/Alarm	Indication	Charge	Load	Diversion	Button Reset	Notes
Startup	G - Y - R	✓	✓	✓		Cycles Once on power-up.
PWM	Gblink 1Hz	✓		✓		In regulation
Float	Gblink 0.5Hz	✓		✓		In float charge
Equalize	Gblink 2.5Hz	✓		✓		Equalizing the battery
Short Circuit	R/G - Y	✓	✓	✓	No	External Short (see "External Short" under Appendix C)
Overload	R/Y - G	✓	✓	✓	No	Over-current (See "Overcurrent" under Appendix C)
Over Temp	R - Y	✓	✓	✓	No	TriStar is too hot (see "TriStar Hot" under Appendix C&D)
HVD	R - G	✓	✓		No	High voltage condition on battery (see "HVD" under Appendix C&D)
Reverse Pol.	NONE	✓	✓	✓	No	Reverse Battery - No power, Reverse PV, no charge
DIP SW error	R - Y - G	✓	✓	✓	No	A DIP switch was changed while running (see "DIP sw Changed" under Appendix C)
Self-Test Fault	R - Y - G	✓	✓	✓	No	Indicates a TriStar fault has been detected (see Appendix C)
RTS	R/Y - G/Y	✓		✓	No	Temp sense fault (see Appendix C)
Batt. Sense	R/Y - G/Y	✓		✓	No	Battery Sense fault (see Appendix C)
Battery Service	G/Y/R	✓		✓	Yes	Battery Service Reminder - set to user specified interval

C. Fault Table

Fault	Description	Charge	Load	Diversion	Causes	Solutions
External Short	Hardware detected an external short circuit	✓	✓	✓	A short occurred on a power cable	Inspect the system wiring for shorts, damaged insulation, etc.
					A system miswire	Be sure the positive power terminals are not wired together
					Dirt/Debris/Condensation on the PCB	Inspect the circuits for moisture, corrosion, debris
Overcurrent	The charge or load current exceeds the TriStar rating	✓	✓	✓	PV Array is too large, or Load is too large	Consult the TriStar documentation for maximum current ratings
					Dirt/Debris/Condensation on the PCB	Inspect the circuits for moisture, corrosion, debris
					The current sense circuitry is malfunctioning	TriStar Requires Service or replacement
FET Short	MOSFETs shorted	✓	✓	✓	A power MOSFET is damaged and shorted	Refer to the TriStar MOSFET Replacement instructions
					An external short has occurred	Be sure the positive power terminals are not wired together
					Voltage on the Load terminals	Verify there are no other power sources on the load circuit
					Dirt/Debris/Condensation on the PCB	Inspect the circuits for moisture, corrosion, debris
software	A software error has occurred in the processor	✓	✓	✓	This is an internal software problem	The TriStar software must be updated
HVD	The battery voltage is above acceptable levels	✓	✓		Another charging source in the system is over-charging the battery	Remove the other charging source, check its operation and setpoints.
					Power MOSFETs may be shorted	Refer to the TriStar MOSFET Replacement instructions
TriStar Hot	The TriStar Heatsink has exceeded exceptable operating temperature	✓	✓	✓	Controller is too hot	Verify the TriStar has ample ventilation and spacing. Be sure ambient temps do not exceed the TriStars operating temperature range.
					Over-current condition	Consult the TriStar documentation for maximum current ratings
					Miswire on Battery Sense or Temp Sense	Inspect the RTS and Battery Sense connections
DIP sw Changed	DIP switch changed while running	✓	✓	✓	User changed a DIP switch during operation	Return the DIP switches to original position or reset the TriStar so that the new changes take effect.
					Dirt/Debris/Condensation	Inspect the circuits for moisture, corrosion, debris
Settings Edit	EEPROM setting edited while running	✓	✓	✓	A setpoint was changed via RS-232 during operation	Restart TriStar or power cycle to reset
reset?	A fault was interrupted (usually power-cycle)	✓	✓	✓	The power was cycled on the TriStar during a fault (any fault)	Clears 10sec after startup. Ensures that a power cycle will not clear a fault in less than 10 seconds.
miswire	System miswiring detected		✓		There is voltage on the load terminals when the MOSFETS are turned off	Verify there are no other power sources on the load circuit
					There is charge current when the MOSFETs are turned off	Check the system wiring
RTS Shorted	A short has been detected in the Temp Sense cable	✓			The RTS cable has been pinched or otherwise shorted	Inspect RTS cable and connection
					There is a miswire on Battery Sense or Temp Sense connections.	Inspect the RTS and Battery Sense connections
RTS Disconnected	The RTS was properly connected.Now its not connected.	✓			The RTS cable has been severed or otherwise disconnected.	Inspect the RTS connection and cable
RTS Miswire	There is a miswire on the RTS connection	✓			Battery Sense wired to Temp Sense terminals	Inspect the RTS and Battery Sense connections

D. Alarm Table

Alarm	Description	Charge	Load	Diversion	Causes	Solutions
RTS Shorted	battery temp sensor shorted	✓		✓	The RTS cable has been pinched or otherwise shorted	Inspect RTS cable and connection
					There is a miswire on Battery Sense or Temp Sense connections.	Inspect the RTS and Battery Sense connections
RTS Disconnected	battery temp sensor was working, but got disconnected	✓		✓	The RTS cable has been severed or otherwise disconnected.	Inspect the RTS connection and cable
Ths Disconnected	heatsink temp sensor open	✓	✓	✓	RT1 on the PCB is damaged or open	Replace the Heatsink thermistor
Ths Shorted	heatsink temp sensor closed	✓	✓	✓	RT1 on the PCB is damaged or shorted	Check for debris, replace Heatsink thermistor
TriStar Hot	The TriStar heatsink temperature is approaching temperature limits	✓	✓	✓	Controller is too hot	Verify the TriStar has ample ventilation and spacing. Be sure ambient temps do not exceed the TriStars operating temperature range.
					Over-current condition	Consult the TriStar documentation for maximum current ratings
					Miswire on Battery Sense or Temp Sense	Inspect the RTS and Battery Sense connections
Current Limit	An overcurrent condition has put the TriStar into current limit	✓		✓	Charging current is too high.	Reduce the amount of PV
					Diversion load is too large	Refer to the TriStar documention for correct diversion load sizing
Current offset	There is a current reading even though the MOSFETs should be off.	✓		✓	Power MOSFETs Shorted	Refer to the TriStar MOSFET Replacement instructions
					Battery Sense/RTS Miswire	Inspect the RTS and Battery Sense connections
					System miswire	
					Dirt/Debris/Condensation on the PCB	Inspect the circuits for moisture, corrosion,
Battery Sense	battery sense out of range	✓		✓	Disconnected wire on the Battery Sense	Inspect Battery Sense connection
					Greater than 5V difference between Sense and Battery Voltage	Inspect Battery sense wires and connection. Inspect Battery power cables and connection.
Batt Sense Disc	battery sense was working, now out of range	✓		✓	Disconnected wire on the Battery Sense	Inspect Battery Sense connection
					Greater than 5V difference between Sense and Battery Voltage	Inspect Battery sense wires and connection. Inspect Battery power cables and connection.
Uncalibrated	Factory calibration was not performed	✓	✓	✓	Factory calibration was not performed to trim voltage and current readings.	TriStar Requires Service or replacement
RTS Miswire	battery temp sensor near 5V, miswire	✓		✓	Battery Sense wired to Temp Sense	Inspect Temp Sense connection
HVD	indicates high battery voltage in diversion			✓	Undersized diversion load/too much charge current	Refer to the TriStar operators manual for diversion mode system sizing.
					Load is disconnected or damaged	Check load wiring and diversion loads
					Power MOSFETs damaged	Refer to the TriStar MOSFET Replacement instructions
high d	The TriStar is nearing 100% diversion, beyond which the TriStar can no longer regulate the battery.			✓	Undersized diversion load/too much charge current	Refer to the TriStar operators manual for diversion mode system sizing.
					Load is disconnected or damaged	Check load wiring and diversion loads
					Power MOSFETs damaged	Refer to the TriStar MOSFET Replacement instructions
miswire	There is voltage on the load terminals when the MOSFETs are turned Off			✓	A system wiring problem	Check the system wiring for mistakes
					Another power source is wired to the load circuit	Verify that the TriStar is the only device wired to the load bank.
FET open	MOSFET open check	✓	✓	✓	Power MOSFETs damaged	Refer to the TriStar MOSFET Replacement instructions
P12	Internal power supply problem	✓	✓	✓	Dirt/Debris/Condensation on the PCB	Inspect the circuits for moisture, corrosion, debris
					Other internal problem	TriStar Requires Service or replacement