aerl

USER'S MANUAL

COOLMAX SR
Australian Energy Research Laboratories
AER07.004 – Version 3
15th October 2012

COOLMAX SR MAXIMIZER

WALLMOUNT

USER’S MANUAL

TABLE OF CONTENTS

1 OVERVIEW

The AERL Coolmax SR is a high efficiency, buck only, common positive Maximum Power Point Tracker (MPPT). It is the latest development in the Maximizer™ range, which was pioneered by AERL in 1985. The Coolmax SR blends the famously reliable AERL power stage with easy to use digital features such as system performance logging, fully configurable alarms and remote system monitoring and control.

The Coolmax SR employs a maximum power point tracking strategy which has been proven to be highly robust, immune to local extrema, and results in power losses of less than 0.5% over the whole operating temperature range of a PV Array.

Some of the device's main features include:

- Increase PV output by approximately 35%
- Super high conversion efficiency > 98%
- Built-in logging — 1 million sample points
- 12 months of daily statistics logged internally
- Common positive wiring configuration
- CAN bus interface
- High power density — 1kW/l & 1.5kW/kg
- Modular subrack mounting design is also available

2 WHY USE AN MPPT?

In simple terms, a Maximum Power Point Tracker sets the voltage of the solar panels to the ideal operating point of the panels. This is the maximum power voltage, or the voltage at which the solar cells can deliver maximum power to the load. This means that by using MPPT technology, the Coolmax can harvest up to 35% more energy from a solar array compared to a non-MPPT charge controller.

The bottom line for solar system installers is that a cheaper, less powerful solar array can always be installed when using an MPPT – this saves cost, wiring and solar area. Because the MPPT can boost the panel's output by up to 35%, the required array size and cost is reduced.

The other benefit of MPPT converters is that a high voltage solar array can be converted down to a low voltage battery pack. This is advantageous because solar arrays are designed to be wired in series, and require much lighter wire when doing so. Additionally, a low voltage battery pack is intrinsically safer than a lethal, high voltage pack.

3 INSTALLATION

The Maximizer is designed to be installed in a clean dry location away from direct sunlight.

Best cooling is achieved when the Maximizer is mounted vertically against a wall with a clear open area at the top of the unit. At least 20cm should be kept clear above the Maximizer to allow free air flow.

3.1 MOUNTING

The maximizer should be fixed to a vertical surface using M5 screws through the 8 mounting holes in the chassis, shown as red holes in Figure 1.

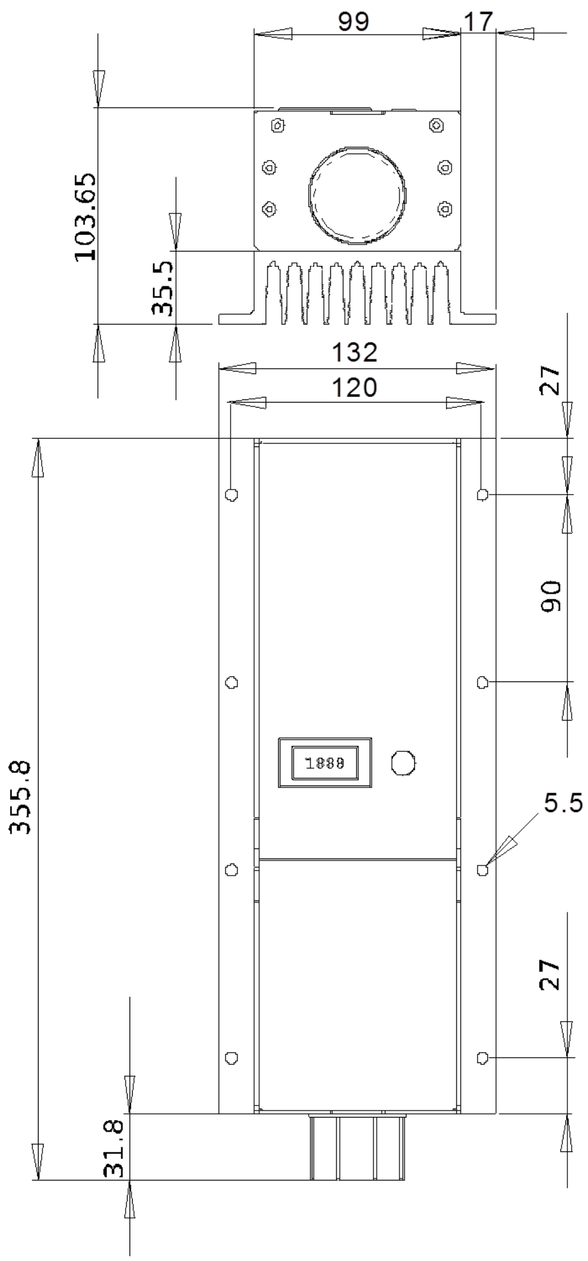


Figure 1 - Mounting Holes

4 WIRING

All Maximizer wiring must enter the unit via a 40mm conduit fitting at the bottom. Remove the access cover at the bottom of the Maximizer to install the cabling. This is done by removing the two M3 countersunk hex screws on the bottom of the enclosure at the front, as shown in Figure 2.

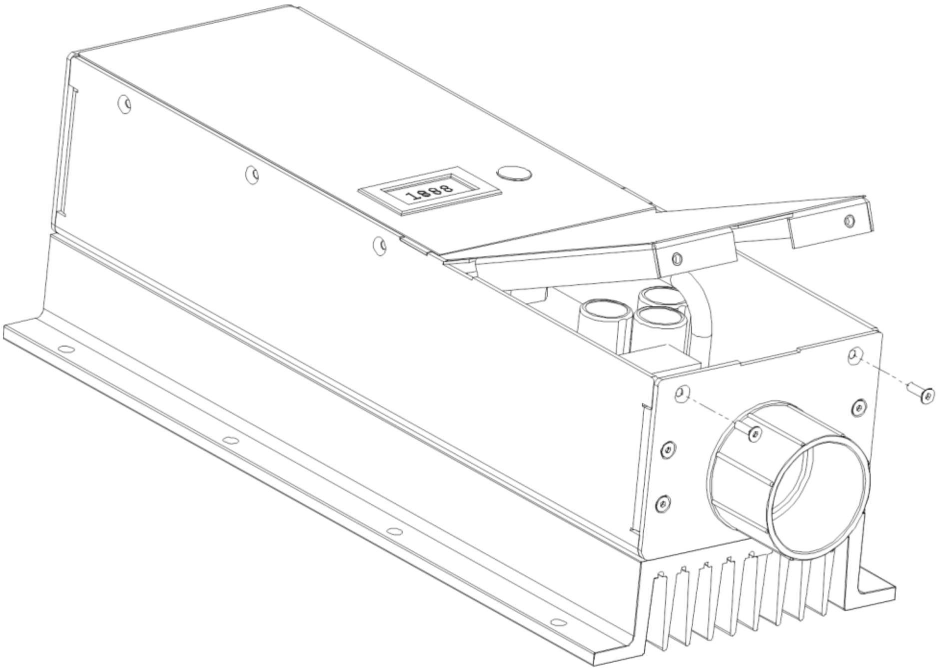


Figure 2 - Removal of the Access Panel

With the access cover removed, three terminal blocks should be visible. The left most terminal block is for the alarm output, remote shutdown input, and temperature compensation. The terminal block on the right is for the Controller Area Network (CAN). The central terminal block is for power in and power out. Figure 3 shows the pin-outs for these terminals.

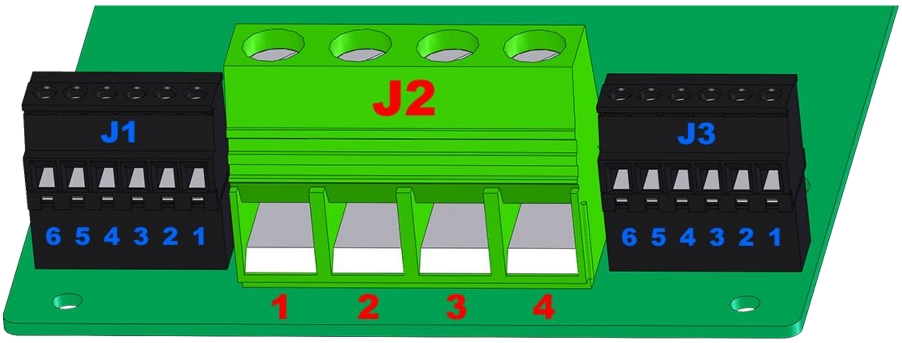


Figure 3 - Terminal Board Pinout (Looking into Access Port)

4.1 SIGNAL PIN ASSIGNMENT

Pin	Assignment	Type	Functional Description	Isolated
J1-1	GND	Analogue input	Temperature compensation thermistor	NO
J1-2	TMPCMP			
J1-3	GND	Digital input	Pull these lines together to disable output of the Maximizer	NO
J1-4	ON/OFF			
J1-5	Alarm NO	Clean contact output	Will close when an alarm is active	YES - 1000V
J1-6	Alarm COM			
J2-1	PV IN-	PV PWR IN	Refer to datasheet for the current and voltage limitations	NO
J2-2	PV IN+			
J2-3	BATT OUT +	BATT PWR OUT	Refer to datasheet for the current and voltage limitations	NO
J2-4	BATT OUT -			
J3-1	CAN +12V	Output power	Power for the CAN bus	YES
J3-2	CAN GND			
J3-3	SHIELD			YES
J3-4	CAN H	Digital IO	CAN signals	
J3-5	CAN L			
J3-6	NC			

Table 1 - Signal Pin Assignment

5 CIRCUIT BREAKERS

AERL recommends the use of 6kA, 8kA or 10kA DC rated circuit breakers with an appropriate voltage rating on both input and output. Double or triple ganged circuit-breakers can be connected in series to give the desired voltage rating as shown the example configurations of Figure 4.

It is important that the peak voltages are taken into account when selecting breakers. For example a 120V nominal battery pack will be close to 150V at top of charge, so the breaking capability of the circuit breakers will need to be selected accordingly.

It is important to note that the Maximizer attempts to process all available power from the PV array and therefore the output current from the Maximizer increases with decreasing output voltage. At a low enough output voltage the current will exceed the Maximizer's over current trip point and will shutdown in order to protect itself. In the COOLMAX SR MV this trip point is 72A and in the COOLMAX SR HV it is 55A. This implies that a PV panel rated to produce the Maximizer's maximum battery charge current at nominal battery voltage will shutdown due to over current if the battery voltage falls below 1.7V per cell.

The implication of the Maximizer behaviour described above is that an 80A rated circuit breaker should be used for the COOLMAX SR MV and a 63A rated breaker should be used for the COOLMAX SR HV.

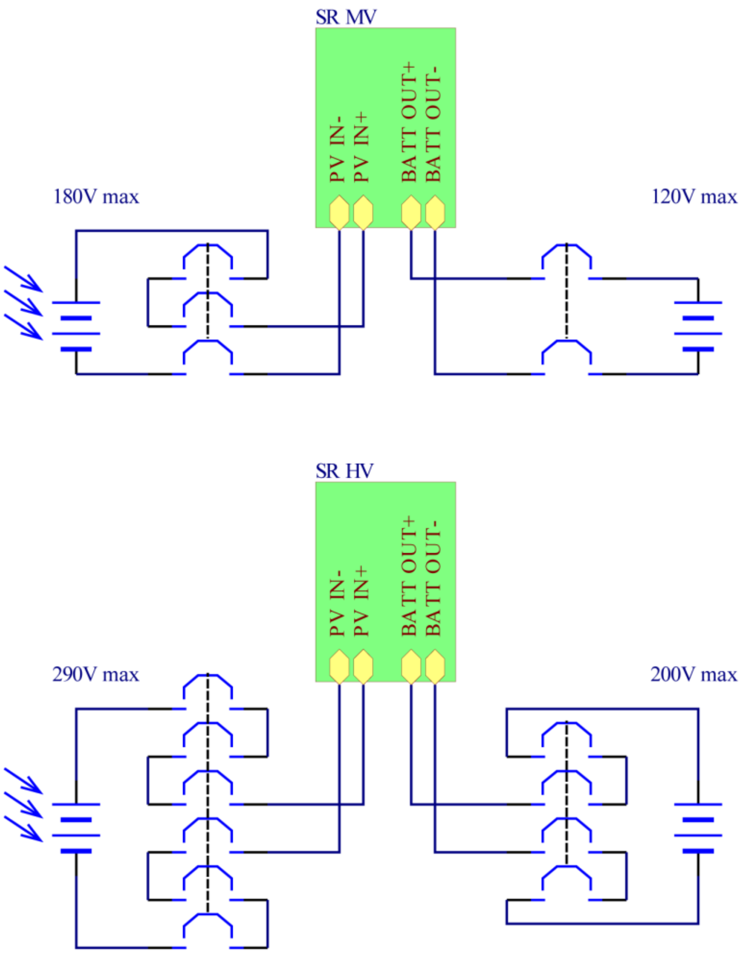


Figure 4 - Example breaker configuration for both the MV and HV COOLMAX SR assuming 60V rated DC breakers

6 EARTHING

<u>NOTE:</u> The chassis of the Maximizer should be earthed by installing an earthed ring terminal under the bottom left mounting bolt of the chassis.

AERL recommends that the Maximizer be utilized in a floating system (no earthing to the power terminals) whenever possible. For very exposed systems, it is recommended that a lightning conductor be provided nearby to prevent damage to PV equipment, batteries and the Maximizer.

For systems using Sunpower PV arrays, it is necessary to provide a positive earth for the array.

DO NOT EARTH THE ARRAY in any way if a negative earth is used for the batteries or DC system.

6.1 CONNECTIONS

Use appropriately rated wire to connect PV input and battery bank output. Check the polarity in the diagram provided in this user's manual.

<u>NOTE:</u> Reversing polarity of either the input or the output will cause damage to the Maximizer.

Install circuit breakers as described in Section 5 - Circuit Breakers.

Check the polarity of the input and output with a multimeter before closing the breakers.

7 LCD DISPLAY

The LCD display cycles through four measurements, battery current, battery voltage, PV current, and PV voltage. Press the button to change which measurement is being displayed.

7.1 LCD SYMBOLS

The display uses symbols to represent which measurement is being shown. The following table shows how to interpret the symbols.

Measurement	LCD symbols
Battery current	A, BAT
Battery voltage	V, BAT
PV current	A
PV voltage	V

Table 2 - LCD Symbols

7.2 LCD FAULT CODES

If the Coolmax detects a fault, it will display a code on the LCD display, as well as illuminating the 'HOLD' symbol. The fault codes are described in the following table. Faults can be reset by disconnecting the input and output of the Coolmax until the LCD display switches off.

Fault Code	Fault	Description
1	Negative PV Current	Current was detected flowing into the PV array.
2	High PV Current	PV current high enough to damage Coolmax.
4	High PV Voltage	PV voltage high enough to damage Coolmax.
8	High Battery Current	Battery current high enough to damage Coolmax.
16	High Battery Voltage	Battery voltage high enough to damage Coolmax.
32	High Temperature	Heat-sink temperature high enough to damage Coolmax.
64	Fan Failure	Fan has failed to start.

Table 3 - LCD Fault Codes

If multiple faults were detected by the Coolmax, the fault code displayed will be the sum of the fault codes of the individual faults.

For example if high PV current and high battery voltage were detected together, the LCD display would show 18 (i.e. 2 + 16 = 18).

8 CAN COMMUNICATIONS

8.1 CAN NETWORK TOPOLOGY

Multiple Coolmax units can exist on the same CAN bus and this can be connected to other networks using a CAN-Ethernet Bridge adaptor.

The CAN bus is structured as a linear network, with short stubs branching from 'T' connectors on the main bus backbone to each device. The CAN bus data lines must be terminated at each end of the main bus with 120 Ω resistors between the CAN-H and CAN-L signals.

A simple method of implementing the 'T' junction is shown in Figure 5. The in and out wire of each CAN line are twisted together and screwed into the appropriate terminal on the CAN connector, as shown in Figure 6. This connector plugs into J3 of Figure 3.

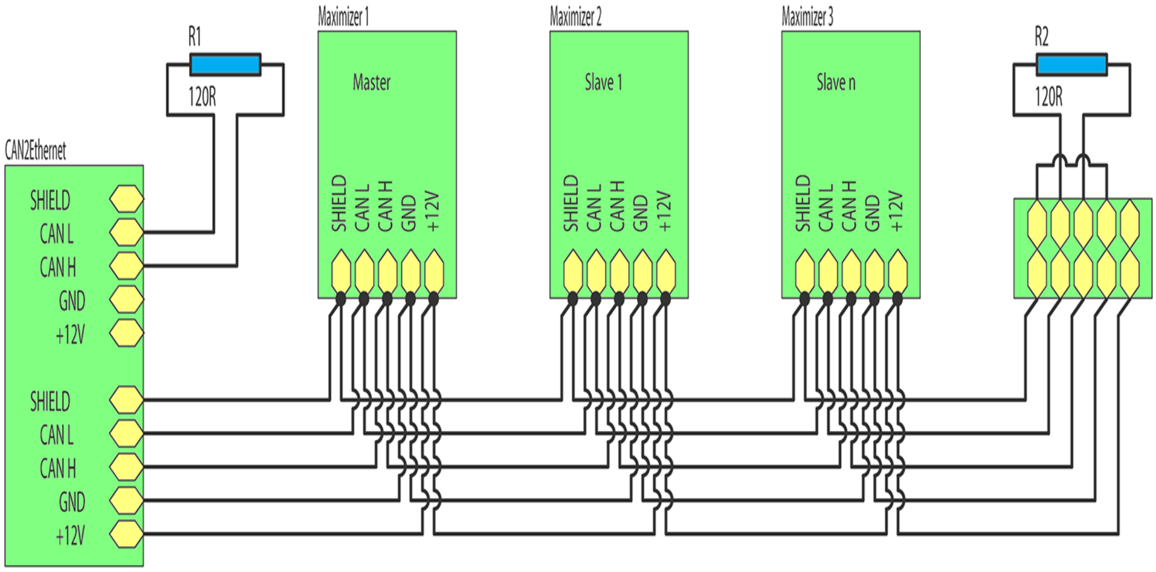


Figure 5 - CAN Network Wiring Diagram

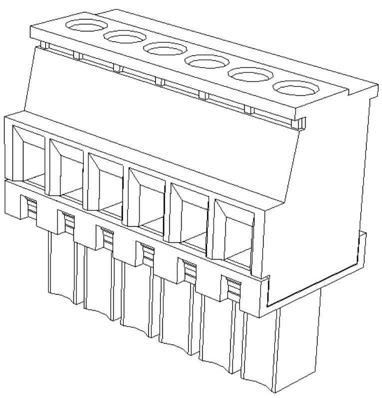


Figure 6 - CAN Connector (6-Way Screw Terminal)

8.2 CAN WIRING

The CAN data lines (CAN-H and CAN-L) must be implemented with twisted-pair wire for proper data integrity. The wire should have a characteristic impedance of 120 Ω.

Power should also be provided along the CAN cable, ideally with another twisted pair to minimise noise pickup. An overall shield can also be advantageous.

The recommended choice of cable is 7mm DeviceNet CAN-Bus 'thin' cable, with 24 AWG (data) + 22 AWG (power) twisted pairs and a braided shield. Using this cable will result in a robust installation.

Standard CAT5 network cabling (which has an impedance of 100 Ω) can be used, but may become unreliable in longer networks or in the presence of electrical noise from DC/DC converters and other electrical devices in the system.

8.3 SHIELDING

Correct shielding practice is important for error free communications. Incorrect shielding can cause more interference than unshielded cables would experience. Shields should be linked between each wire segment along the network but only grounded in one place. The following paragraphs explain how to achieve this.

The shield should be wired through the entire network independently of the ground and connected to ground at the end of the network and nowhere else in the network. This is shown at the right hand end of the example network in Figure 5.

8.4 CAN TERMINATION

A 120 Ω resistor needs to be wired between the CAN-H and CAN-L lines at either end of the linear network in order to terminate both ends of the network. At the far end of the network the resistor can be simply installed into the last terminal block.

If no CAN-Ethernet Bridge adapter is present on the network the same terminal block style termination can be made on the other end of the network. However, if a CAN-Ethernet Bridge adapter is present on the network, it can be used to terminate the network by wiring a termination resistor across CAN-H and CAN-L on the unused header.

9 OPERATING GUIDELINES

9.1 BATTERY CHARGING SETUP

The batteries are charged using an automatic equalise / anti-sulphation charging profile. This profile is designed for lead-acid batteries, which can be equalised automatically by allowing each battery to vent for a short time.

The charge profile can be edited for other battery chemistries by manipulating the following parameters

- Bulk voltage
- Float voltage
- Bulk reset voltage
- Bulk time

Battery chemistries other than lead acid should be used with extreme caution as it is not safe to overcharge individual cells. It is always recommended to employ a battery monitoring system as an unbalanced battery pack can result in damage to batteries due to overcharging.

An example charge profile for the Coolmax SR is shown below to illustrate the charge profile parameters above. To edit the charge profile parameters, please refer to the documentation for the Coolmax SR communications software.

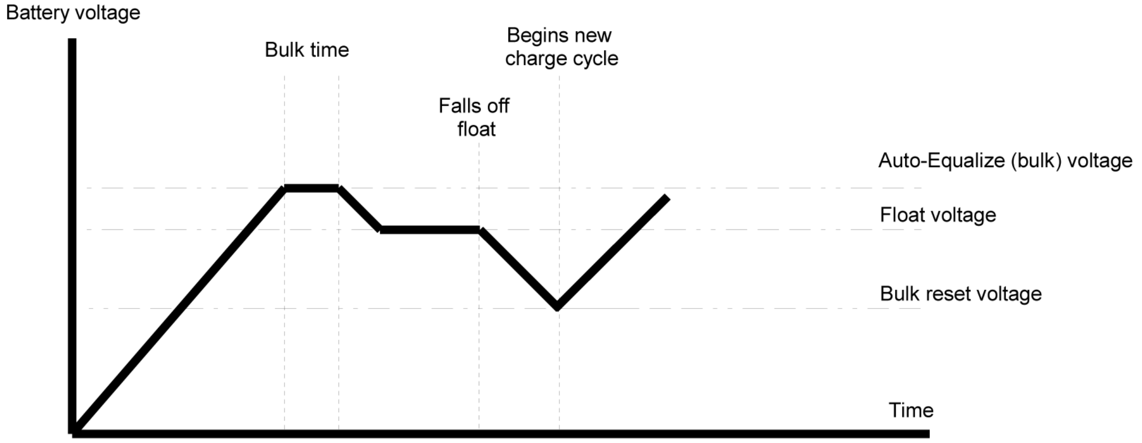


Figure 7 - Battery Charge Control Profile

9.2 TEMPERATURE COMPENSATION

Temperature compensation measures the temperature of the batteries and adjusts the float voltage set point to the ideal voltage for batteries at that temperature.

The thermistor is connected between J1-1 and J1-2 as shown in Figure 3. The Coolmax SR measures the voltage between TMPCMP+ and GND to determine the temperature of the batteries.

Using the temperature of the batteries, the Coolmax SR adjusts the float voltage by a user specified factor in millivolts per °C.

NOTE: The temperature compensation factor is adjusted using the Coolmax SR software. Please refer to its documentation for more information.

9.3 RELAY ALARM / GENSET CONTROL

The ALARM pins are the contacts of an isolated 12V, 1A relay. When an alarm state is in effect, ALARM will be connected inside the Maximizer. When the alarm state is removed, ALARM will be completely disconnected from each other.

An external alarm or Genset control circuit can be used to sense whether ALARM is open or closed.

Many different events can be attached to the relay. These are:

- System init (system starts up after a reset or off period)
- Low output voltage warning
- Low output voltage fault
- Low output voltage Genset start
- High output voltage fault
- High output current fault
- High discharge current fault
- Input breaker open
- Output breaker open
- Temperature sensor fault
- Regulation fault
- Log file full
- Panel missing

These are configurable so that multiple faults could trigger the relay. There is also a time hysteresis which prevents the relay from triggering on spurious readings.

To configure the events, consult the documentation for the Coolmax SR software.

9.4 REMOTE ON/OFF CONTROL

The remote ON/OFF control can be implemented with a single switch connected between the ONOFF pin and GND pin.

The Coolmax SR will sense if the ONOFF pin has been connected to GND when the switch closes and this will disable the Maximizer.

9.5 MAXIMIZER STARTUP

The Maximizer electronics will begin to run when either the input or output is connected with a voltage above the start-up voltage listed in the datasheet. CAN communications can be used whenever the Maximizer is powered up.

10 ADJUSTING THE CHARGE PROFILE

10.1 CHARGE CYCLE SETPOINTS

The CoolMax SR uses a 2 stage bulk / float charge cycle. Only the float point can be set using the LCD display, but the bulk voltage set−point is automatically set to 108% of the float set−point. Any other parameters of the charge cycle, such as the bulk reset voltage, are automatically calculated.

<u>**Note:**</u> If the bulk set−point needs to be chosen independently of the float set−point, PC software will need to be used with a CAN-Ethernet Bridge adaptor to communicate with the CoolMax.

10.2 CHANGING THE FLOAT SETPOINT

1. Press and hold the button for 5 seconds until the screen changes. This is the float set mode. It will display the currently set float voltage in the Maximizer.

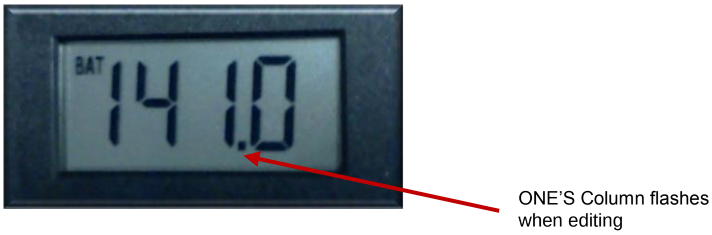
   <u>**NOTE:**</u> If you have just changed the float voltage in the CoolMax SR software using a CAN-Ethernet bridge, you may see a different float voltage than you expect. You will need to reset the device before your original change will take effect.

   The HUNDREDS column can now be edited. Press the button to toggle between a 1 and a 0 in the hundreds column.

2. Press and hold the button for about 2 seconds until the TENS column starts to flash.

   The TENS column can now be edited. Repeatedly push the button to change the value of the digit. The value rolls over from 9 back to 0 if you accidentally overshoot.

3. Once you have the correct digit, press and hold the button for about 2 seconds until the ONES column starts to flash.



   The ONES column can be edited when that digit is flashing. Repeatedly push the button to change the value of the digit. The value rolls over from 9 back to 0 if you accidentally overshoot.

4. Once you have the correct digit, press and hold the button for about 2 seconds until the TENTHS column starts to flash.

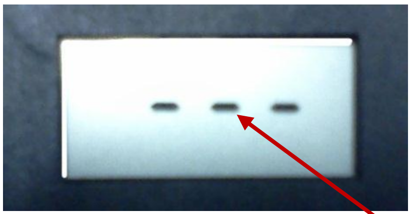
TENTH'S Column flashes when editing

The TENTHS column can be edited when that digit is flashing. Repeatedly push the button to change the value of the digit. The value rolls over from 9 back to 0 if you accidentally overshoot.

5. If you need to change any digit, press and hold the button for 2 seconds, the TENTHS column will stop flashing, and you will be editing the HUNDREDS column again.

   Otherwise, if you are happy with the float voltage that you have input, press and hold the button for 5 seconds.

6. The display will change to all dashes and will flash. This means that the changes are taking effect. Wait 30 seconds to a minute.



All flashing dashes – "Please Wait" while the new float voltage is committed to memory.

After about 30-60 seconds, the display will reappear with the new float voltage that you have set. This will be flashing so that you can confirm that it is correct.

7. Press the button again to take the CoolMax SR back to normal operation.

11 PV ARRAY CONFIGURATION NOTES

11.1 OPTIMAL PV ARRAY CONFIGURATION

- The minimum Vmp of the array must be greater than the battery bulk charge point.
- The closer the nominal Vmp of the array is the nominal battery voltage the more efficient the maximizer.
- The input open circuit voltage (Voc) must be above the minimum voltage listed in the datasheet for the Maximizer to run.

11.2 PV INPUT BLOCKING DIODE

A PV Input blocking diode should not be used as long as the open circuit voltage of the PV array is within the range specified by the datasheet for the appropriate Maximizer model and battery voltage.

The idea of the blocking diode is to prevent night time reverse leakage from the battery into the PV array. However the diode introduces power wastage during operation which outweighs the leakage, resulting in a net power loss.

11.3 PV MODULE POWER RATING AND MOUNTING CONSIDERATIONS

The nominal power output rating of a particular PV Module is specified by the PV Module Manufacturer, at One Sun (1000W/sq.m of sunlight radiation) and 25°C.

PV Module Maximum Power Voltage (and consequently maximum power) falls off by 4% per every 10°C that the PV panel rises above this 25°C specification, so typical panel temperatures on a hot summers day of 65°C will result in a panel power derating of 16% of the manufacturers rating.

It is best to mount the PV Array in a way that the hot air behind the panels can easily escape via the natural breezes or convection. So don't mount the PV Array flat against the roof surface, but ensure there is at least 40mm spacing below the panels. Small gaps (20-30mm) left between adjacent panels are also a good idea to let out the hot air from the sides.

NOTE: Around 80% of the sun-light energy falling on the solar cells is converted directly into heat, not electricity, and heat is the power output enemy of PV modules.

12 TROUBLESHOOTING

12.1 LOW BATTERY ALARM TRIGGERS OFTEN

This could indicate that the PV system is underpowered, never reaching a full 108% equalise value. The battery life will be severely compromised in this situation. The more often the alarm comes on, the more power should be added to the PV array.

Solution: Add more PV modules to the array to increase the power output.

If the array is sufficiently powerful, but the alarm is still very often on, check that the Maximizer is set up for the correct voltage of the battery pack. See the Coolmax SR software user's manual for adjusting the battery float voltage. Also check that the Maximizer is charging the battery by checking the output current on the LCD meter, and if the Maximizer is not functioning contact technical support.

12.2 BATTERY BANK USING EXCESSIVE WATER (ELECTROLYTE)

The battery bank is lightly loaded compared to the input PV power and rarely comes off float voltage.

Adjust the float voltage down by a few volts using the Coolmax SR software.

13 APPENDIX A – CAN COMMUNICATIONS PROTOCOL

13.1 OVERVIEW

13.1.1 Hardware

The CAN hardware interface used is compatible with the CAN 2.0B standard. The supported bit rates (bits per second) are 1 Mbps, 500 kbps (default), 250 kbps, 125 kbps, 100 kbps and 50 kbps.

13.1.2 Software

The CAN protocol uses data frames for most communication. Remote frames are also enabled. All measurement data is transmitted using IEEE single-precision 32-bit format (IEEE 754) with most significant byte (MSB) sent first.

Bit Length	1	11	6	8 Bytes	16	2	7
	Start	Identifier	Control	Data Field	CRC	Ack	End

Figure 8 - CAN Data Frame

13.1.3 Identifier

The identifier field has been split into two sections for the Coolmax SR. Bits 10-5 contain the device identifier and bits 4-0 contains the message identifier associated with that device, as shown below.

10 5	4 0
DEVICE IDENTIFIER	MESSAGE IDENTIFIER

Figure 9 - CAN Device Identifier Address Format

13.1.4 Data Field

The data field in all frames is fixed at 8 bytes (64 bits) which allows space for two IEEE 754 32-bit floating point variables as shown in the figure below. The data field is sent and expected to be received least significant byte first. This allows a direct overlay of a float[2] array and char[8] array on a little endian processor.

High float	**Low float**
s eeeeeeee mmmmmmmmmmmmmmmmmmmmmmm ^ ^ ^ ^ ^ 63 62 55 54 32	s eeeeeeee mmmmmmmmmmmmmmmmmmmmmmm ^ ^ ^ ^ ^ 31 30 23 22 0

Figure 10 - Format of a Data Field in a Data Frame

13.2 COOLMAX BROADCAST MESSAGES

Data frames containing telemetry values are periodically broadcast onto the bus by the Coolmax.

13.2.1 Identification Information

ID: Coolmax Base Address + 0

Variable	Bits	Type	Description
Serial Number	63…32	Uint32	Device serial number, allocated at manufacture.
Product ID	31…0	Uint32	“A001” stored as a string.

13.2.2 PV Voltage/Current Measurement

ID: Coolmax Base Address + 1

Variable	Bits	Type	Description
PV Current	63…32	float	PV Current
PV Voltage	31…0	float	PV Voltage

13.2.3 Output Voltage/Current Measurement

ID: Coolmax Base Address + 2

Variable	Bits	Type	Description
Output Current	63…32	float	Output Current
Output Voltage	31…0	float	Output Voltage

13.2.4 PV Open Circuit Voltage/Output Charge Measurement

ID: Coolmax Base Address + 3

Variable	Bits	Type	Description
Output charge	63…32	float	Output charge
PV OC Voltage	31…0	float	PV OC Voltage

13.2.5 PV Power/Battery Temperature Measurement

ID: Coolmax Base Address + 4

Variable	Bits	Type	Description
Battery Temperature	63…32	float	Battery Temperature
PV Power	31…0	float	PV Power

13.2.6 Active Flags

ID: Coolmax Base Address + 5

Variable	Bits	Type	Description
Unused	63…13	-	-
Panel missing	12	Boolean	Input voltage indicates panel missing
Log file full	11	Boolean	Log file full
Maximizer fault	10	Boolean	Regulation or power stage fault
Bat temp sensor fault	9	Boolean	Battery temperature sensor fault
Not used	8	Boolean	-
Not used	7	Boolean	-
Hi bat temp	6	Boolean	High battery temp fault
Bat current	5	Boolean	High battery discharge current fault
Iout fault	4	Boolean	High output current fault
Vout high fault	3	Boolean	High output voltage fault
Not used	2	-	-
Vout low fault	1	Boolean	Low output voltage fault
Vout low warning	0	Boolean	Low output voltage warning

13.2.7 Time

ID: Coolmax Base Address + 7

Variable	Bits	Type	Description
Time	63…0	Uint64	System Unix time

13.3 COOLMAX COMMAND MESSAGES

13.3.1 Reset Command

ID: Driver Controls Base Address + 23

Variable	Bits	Units	Description
Unused	63…32	Unit32	-
Reset command string ALL – full reset RCO – remote config reset	31…0	Uint32	Send 'ALL' or 'RCO' as a string ("00000ALL") Coolmax replies with Y or N in byte 0

14 WARRANTY INFORMATION

1. AERL warrants that the Product will be free from manufacturing defects for a period of 24 months from the date of dispatch of the products by AERL to the customer.
2. The Products technical specifications are contained within the Product Datasheet. The Product will conform to the technical specifications contained in the Product Datasheet at the time of dispatch of the Products to the Customer. If the technical specifications as contained in the Product Datasheet are not met, AERL will repair, replace the Product, or refund the amount paid by the Customer in relation to the Product at the Customers option. AERL is under no obligation to provide assistance or advice to the Customer in relation to the technical specifications.
3. The Products must be installed in strict accordance with the Installation Recommendations listed in this Manual.
4. In no event will AERL be liable for:

a) any loss or damage which the Customer suffers arising from, or caused or contributed to by, the Customer's negligence or the negligence of the Customer's agents or servants; and

b) special, indirect or consequential loss or damage as a result of a breach by the Customer of these Standard Terms including, without limitation, loss of profits or revenue, personal injury, death, property damage and the costs of any substitute Products which the Customer obtains.

5. The Product is not covered for damage occurring due to water, including but not limited to condensation, moisture damage and other forms of precipitation.
6. The Product is not covered for damage occurring due to the Product being incorrectly installed or installed in a manner not in accordance with the Installation Recommendations listed in the Product Manual.
7. The Product is not covered for damage occurring due to failure on the part of the customer to operate the product in accordance with the technical specifications as listed in the Product Datasheet.
8. The Product is not covered for damage occurring due to lightning.
9. The Product is not covered for situations where it is used in a manner not specifically outlined in the Product Manual.
10. If any provision in this document is invalid or unenforceable this document will remain otherwise in full force apart from such provision, which will be deemed deleted.

15 REVISION RECORD

REV	DATE	CHANGE
1	05/07/2011	Document creation (DAF)
2	05/09/2012	Converted from Open Office document to Word 2007 document. Made formatting changes. Added the correct use of styles.
3	15/10/2012	Added section for Adjusting the Charge Profile. Added new image for Pin-outs.

Table 4 - Revision Record

16 NOTES