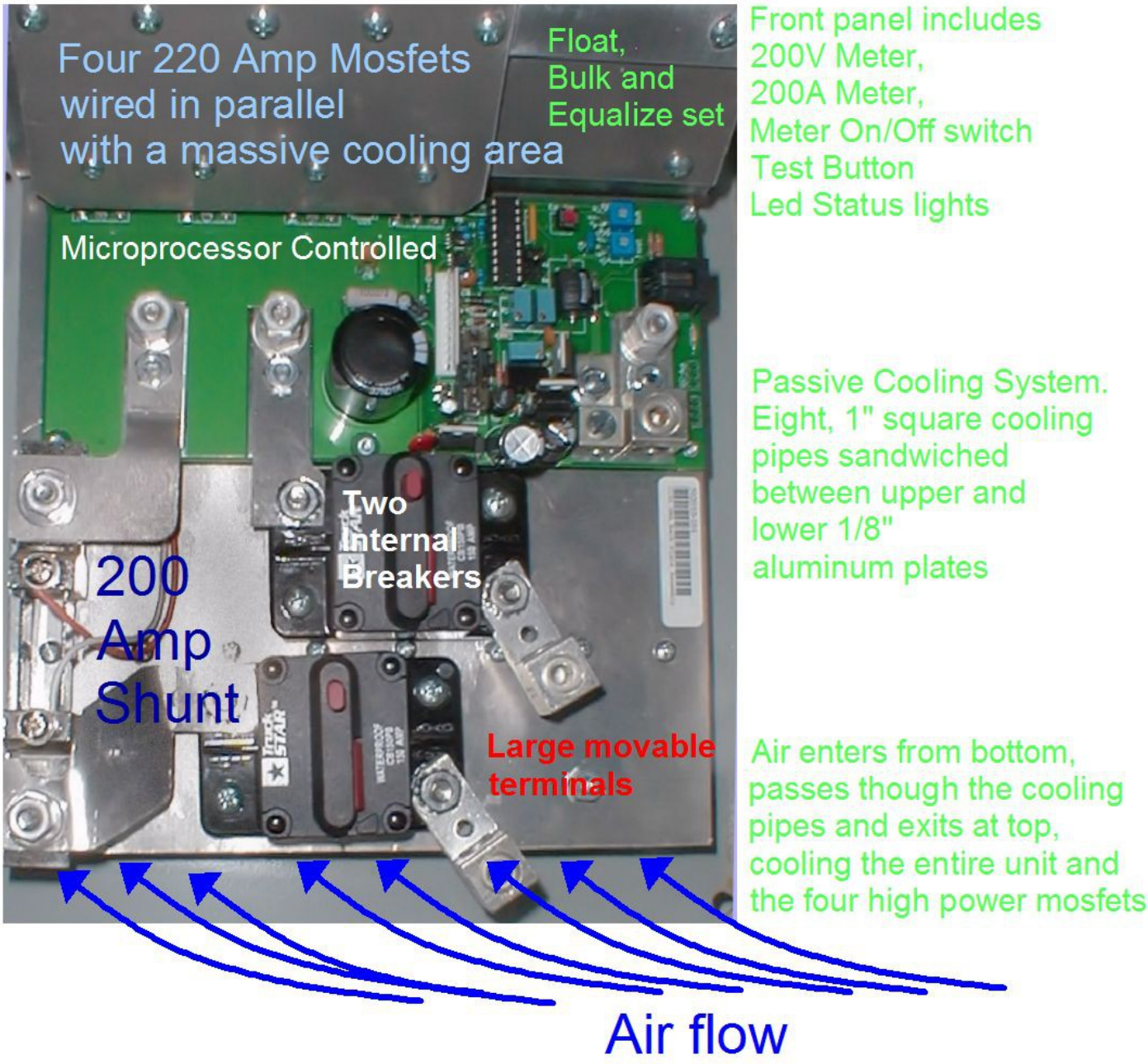
Coleman Air

C155-SMA

155 Amp Solid State PWM Charge Controller
12, 24 or 48 volt battery based systems
Version 1.01

With Auto Equalize

The Coleman Air C155-SMA Charge Controller



This controller is suitable for operation in a 48-volt system, which may have charge and overcharge voltages exceeding 75 volts, (VOC of solar panels in a 48 volt system may exceed 90 volts!)

60+ volts at these amperages can be LETHAL! – It only takes a micro-amp and the right (or wrong conditions) at higher voltages to kill you! Don't take chances!

Use extreme caution when installing or servicing this controller. Always disconnect the energy source before servicing this unit.

Introduction

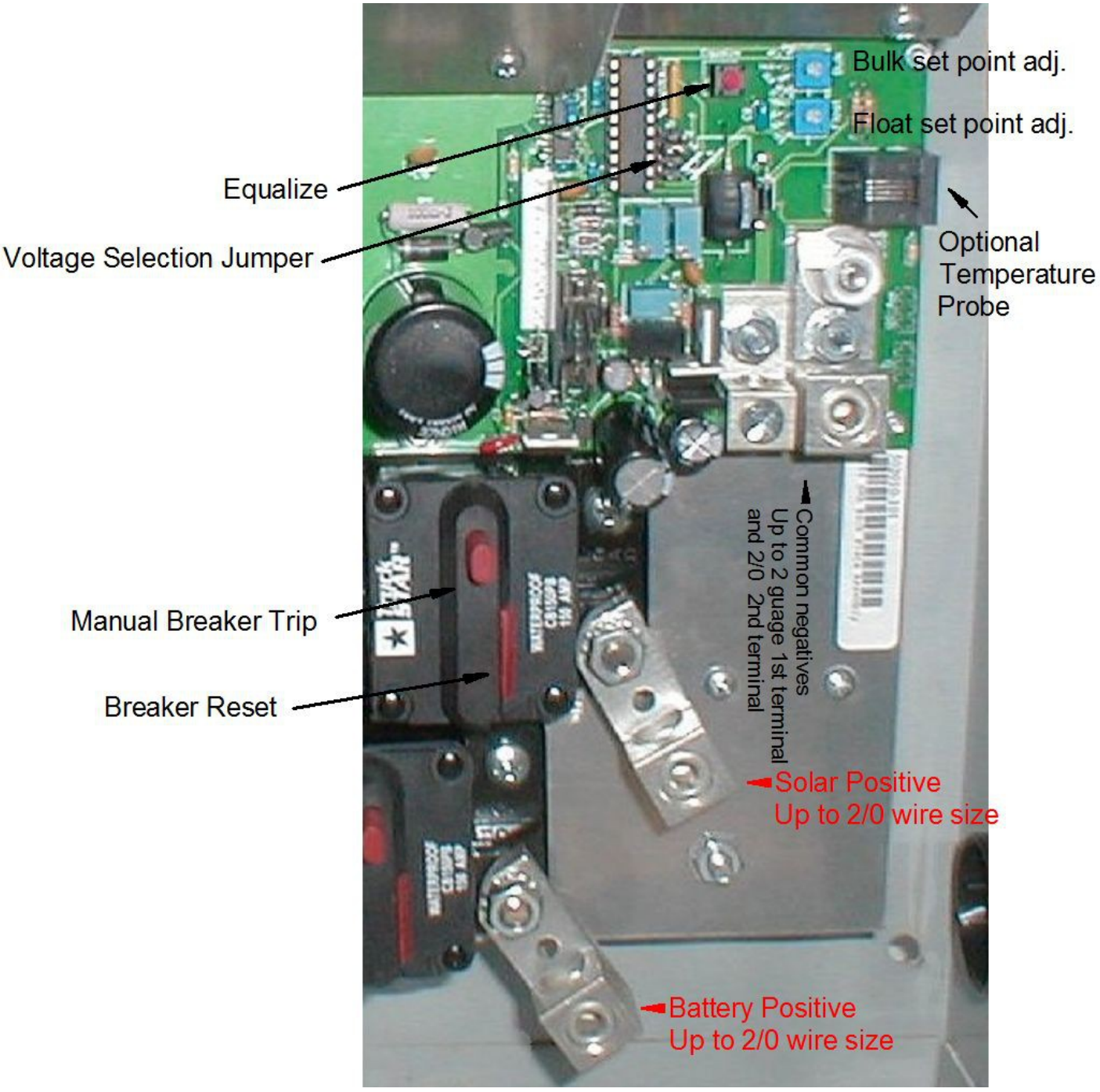
This solid-state (no relays or solenoids) charge controller has been specifically designed for large to medium sized solar, battery based alternate energy systems of up to 155 amps. With thousands of hours of R&D, this controller solves many of the issues currently unaddressed in most if not all other charge controllers. One of the most prevalent problems has been, how to handle more than 60 amps of solar power without using multiple controllers. Most charge controllers on the market use one or two power mosfets, generally limiting their current capabilities to a range of 40-60 amps. The Coleman Air C155-SMA uses four high-power (220 amps each), in a parallel configuration, allowing a significant increase in total current handling capability. Our in house testing has shown that this controller can handle surges of 12,500 watts! We are unaware of any other solid-state charge controller that can come close to this level of power handling.

Some of the key features of this controller are:

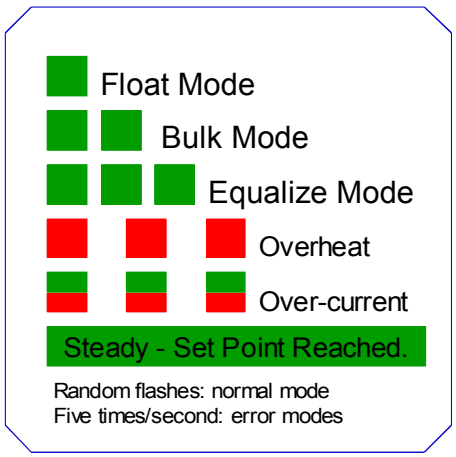
- **Microprocessor controlled** -- This is very important for both stability and functionality.
- **Solid-State. No relays or solenoids to wear out.**
- **PWM (pulse width modulation) charging. (Charges using pulses of varying lengths)**
- **Three stage charging for better battery life.**
- **Both manual and automatic (30 day) equalize function.**
- **User changeable settings** -- Several controllers on the market set the voltage levels, and that's that!
- **High amp rating** – 155 amps solar mode**.**
- **Over-current, over-voltage and overheat protection**.
- **Multiple system voltage settings** – Easy to set jumper allows use on 12, 24 or 48 volt systems.
- **High Contrast LED battery voltage and amperage meters**.
- **On/Off switch for the meters to allow extremely low idle current.**
- **Battery and charge status LEDs** - Several controllers do not tell you what's going on - This one does!
- **Push to test**. - Ever wonder if your controller is working OK?
- **Reverse polarity protected** – This unit will not be damaged if you inadvertently reverse the inputs.
- **Steel enclosure** – 12 x 10 x 6 enclosure with multiple conduit openings and cooling vents**.**
- **Large terminals** - that can actually terminate large wire, with lugs that accept up to 2/0 wire.
- **Passive cooling systems uses aluminum cooling pipes that run the length of the unit for continuous cooling of the entire unit allowing for proper operation at high power levels.**
- **Two internal 150-amp breakers with manual reset/disconnect.**
- **No blocking diodes are required, the mosfets prevent reverse leakage.**
- **Optional accessories include a battery temperature probe. Remote monitoring accessories will be available in the future.**

Note: Continuous power handling may be reduced in hot climates or installations.

Hookup and Adjustment Image Detail



The front panel decal



The front panel decal describes the functionality of the two LED's (Green and Red)

Float Mode Active: Indicated by a single repeating flash of the green LED (on/off- pause on/off etc.)
Bulk Mode Active: Indicated by a two quick ON flashes of the green LED followed by an OFF pause.
Equalize Mode Active: Indicated by a three quick ON flashes of the green LED followed by an OFF pause.

The red light will be on steady when the battery voltage is below the set point voltage. The red light indicates the mosfets are active (conducting current), which allows the solar current to charge the batteries. When the set point is reached, the red LED will begin to flash, often very rapidly and randomly. This on/off time period will be constantly changing as required to maintain the set point voltage. **The random flashing red LED is very normal.** If the battery voltage is above the set point, the red LED will remain off until the battery voltage drops back to the set point.

Overheat (Cool down period active) – The Red LED will be flashing **exactly 5 times per second, there will be no amperage shown on the amp meter (SMA), the green LED will remain off, this period will last for exactly 10 seconds or 30 seconds. This overheat mode looks very different from the randomness of the normal mosfet activation.**

Over-current (Cool down period active) – Both Red and Green will be flashing together exactly 5 timers per second.)

To start the equalize mode, press and hold the equalize button at any time. The equalize function will run for two hours beginning when the voltage of the battery rises to the equalize trip point.

Hold down the equalize button during power up (trip and reset the battery breaker – turn the solar breaker off 1st), to enable the automatic thirty-day equalize function. Note: the 30 day function may not be exact and is likely to wander somewhat as it will not begin unless the charge source is capable of bringing the battery to the equalize voltage. A cloudy day may not allow enough solar energy to bring the batteries to the equalize voltage; therefore, the equalize charge will be delayed.

When no error is active**, the red LED will be on when the mosfets are enabled** (passing current), allowing solar energy to flow to the batteries. **When you click the "TEST" push-button** - the mosfets are cycled. (One time unless the batteries are within the active trip point region.)

Some specifics

The microprocessor is the heart of the controller. The battery level is constantly checked by the microprocessor and compared to the active mode's (Float, Bulk or Equalize) set point to determine how much (if any) current should flow into or out of the batteries. As the battery's level of charge increases, so does the voltage of the battery (the battery's level of charge can be determined by the voltage of the battery.) As the charge level increases the controller may use very short pulses of energy to "top off" or maintain the charge at the optimum level. These pulses of energy will be of varying lengths as required. This charging algorithm is referred to as pulse width modulation (or PWM), and when properly controlled, offers a very suitable method of charging deep cycle batteries to ensure good battery health and longevity.

Settings are of course user changeable! By simply turning the set point potentiometers with a small screwdriver, you can quickly adjust the trip point for the float or bulk mode. (Equalize mode is about 7% higher then the bulk mode).

Four very powerful 220A mosfets are wired in parallel to insure plenty of reserve capacity above the rated 155 amps this controller.

The controller can handle surges in excess of 155 amps; however, sustained high amperage currents will cause the internally mounted breakers to trip and/or the unit to heat up rapidly causing a cool down period. It is recommended that you use the controller to control currents that will not exceed the 155 amps of solar energy under the best of charging conditions.

1st a note about amperage and voltage – This controller has a very high amp rating: 155 Amps is a lot of current; please take all applicable safety precautions to insure your safety and to prevent injury or death from electrocution or fire.

This controller is suitable for operation in a 48-volt system, which may have charge and overcharge voltages exceeding 75 volts, (VOC of solar panels in a 48 volt system may exceed 90 volts!)

60+ volts at these amperages can be LETHAL! – It only takes a micro-amp and the right (or wrong conditions) at higher voltages to kill you! Don't take chances!

Do not rely on the internal breakers as the only disconnect. Disconnects should always be available that do not require you to open a box or enclosure to activate or disengage.

About wire size -- 155 amps is a lot of current! – Insure you have selected an adequate size wire for the amperage you will be controlling. Undersized wire can result in high heat build up in the wire and connections possibly leading to a fire. Use extreme caution when installing or servicing this controller. Always disconnect the energy source before servicing this unit.

The Three Stage Charging processes in detail:

The main advantage to solid-state controllers is that they offer more advanced charging modes than single stage controllers. We will briefly discuss the three stage-charging modes used by the Coleman Air C155-SMA

- Bulk Charge
- Absorption Charge
- Float Charge

The 1st stage in a 3 stage-charging mode is the bulk charge: In this mode, most if not all of the available charge current is sent to the batteries until they reach the bulk charge voltage set point, which will generally equate to about 80% of the capacity of the battery. The bulk charge rate should be set to between 13.5 and 14.5 volts for a normal flooded lead acid battery. There is really is no perfect voltage setting here as there are many factors involved. The ambient temperature, the size of the energy sources verses battery size, the desired length of time in this mode, the cost of the energy etc. The factory setting for the Bulk Charge set point is 14 volts.

The 2nd stage of the 3 stage-charging mode is the Absorption Charge: As the batteries gets full; due to internal resistance, they accept less charge current. During the Absorption charge, the charger will hold voltage at the bulk charge voltage for specific amount of time. During this stage, the current flowing into the batteries will begin to decline, but the voltage will be held steady. Via this stage, the battery will be brought up to its maximum capacity (fully charged). During this stage, battery gassing is normal and required in order to complete the chemical reactions to obtain a fully charged battery. On the Coleman Air solid-state controllers, the Absorption Charge is held for two hours once the batteries reach the bulk voltage setting.

The 3rd and final stage is the Float Charge: This mode is the charge mode that the battery is under most of the time for a properly designed system. Once the batteries are brought to a full state of charge, the float charge mode maintains the batteries at a voltage level of about 13 to 13.5 volts (for a flooded, 12 volt lead acid battery), by applying pulses of current as required. These pulses may last less than a second or be several seconds long. (This action can be seen as the red LED will flash for each pulse.) By applying the required amount of charge current to offset any load the battery might be powering, as well as overcoming the batteries natural self-discharge, the batteries longevity is greatly increased. Allowing a battery to sit in a depleted state of charge for long periods of time significantly reduces battery life. A decent battery, kept at its proper float setting, will last many years. The factory setting for the Float Charge of the Coleman Air solid-state controllers is 13.5 volts. When the battery drops down below the float charge for an extended period of time, a new bulk charge cycle will automatically be started.

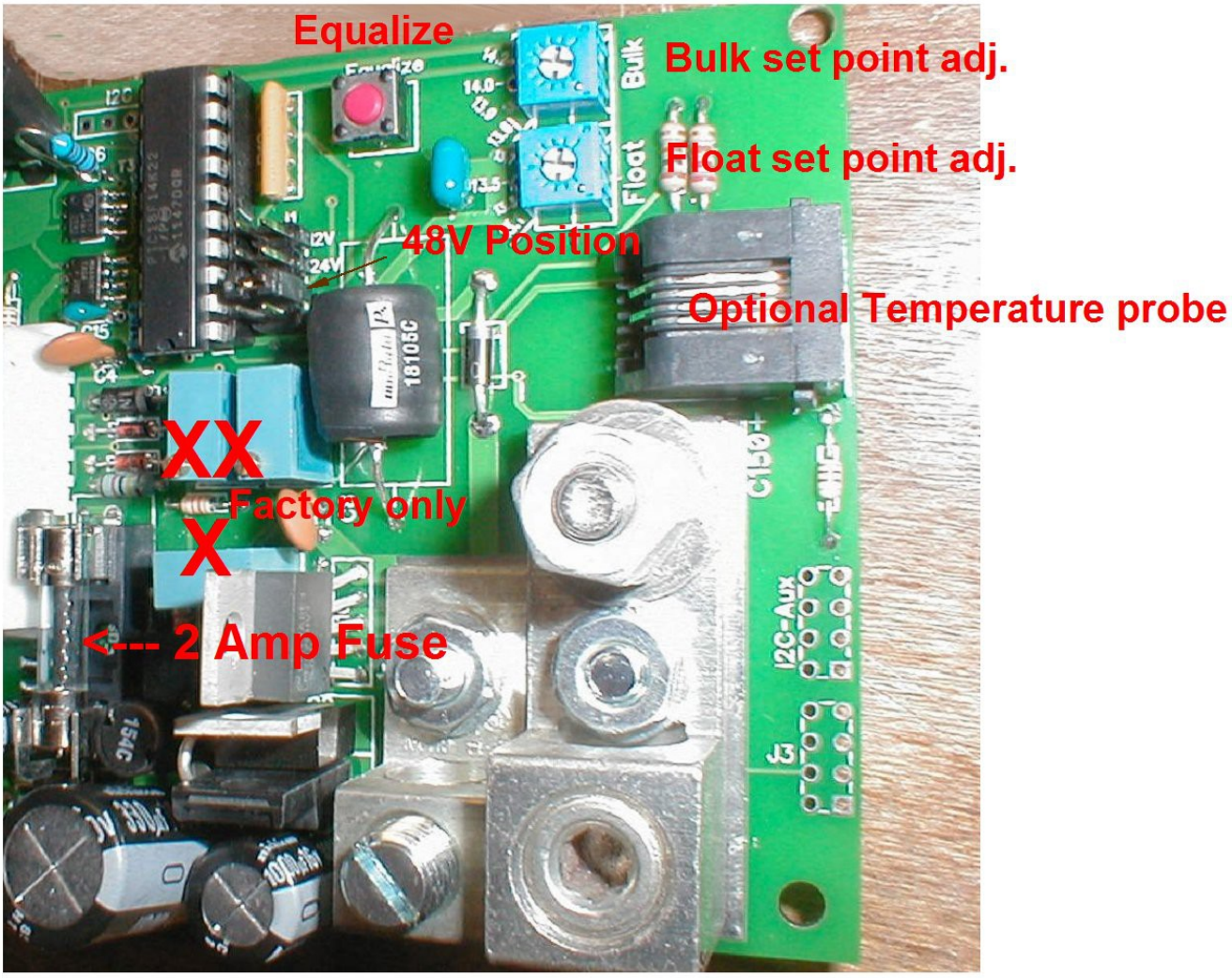
The Equalize Charge: This mode is not a part of the normal charge cycle, but is instead initiated to help mix the electrolytes of the battery. During normal use a battery's chemical mix becomes stratified. (Separated from top to bottom). An equalize charge uses an approximately seven percent higher voltage to help mix these elements in your battery. Equalize charging also helps bring all of the batteries in a multi-battery bank to an equal state. Most people agree that an equalize charge should be run once every 10 to 40 days, for 2 to 16 hours. During this charge cycle quite a lot of gassing will occur, which causes the fluids to be mixed and the plates to be "Cleaned".

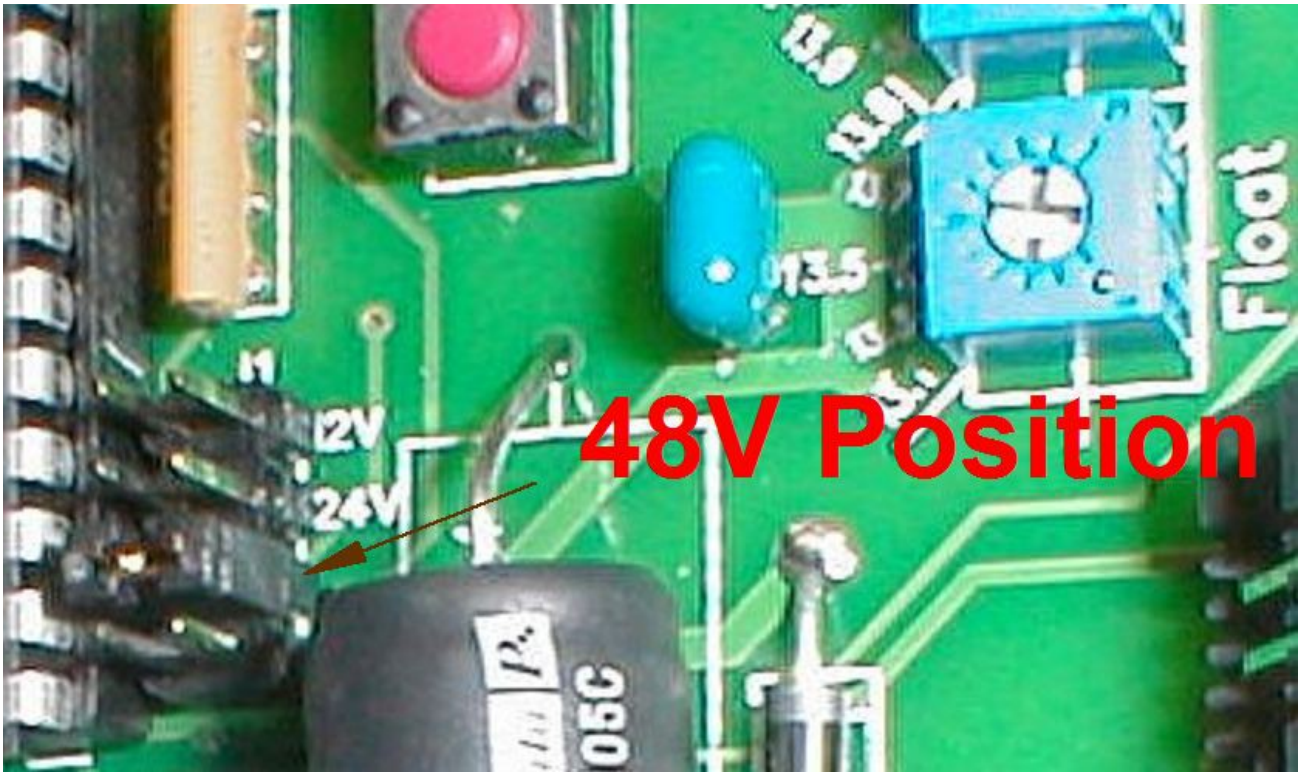
To start the equalize mode, press and hold the equalize button at any time. The equalize function will run for two hours once the voltage of the battery rises to the equalize trip point.

Hold down the Equalize button during power up (trip and reset the battery breaker), to enable the automatic thirty-day equalize function. Note, the 30 day function may not be exact and is likely to wander somewhat as it will not begin unless the charge source is capable of bringing the battery to the equalize voltage. A cloudy day may not allow enough solar energy to bring the batteries to the equalize voltage; therefore, the equalize charge will be delayed.

Selecting your battery system voltage (Jumper settings)

The Coleman Air C155-SMA can handle 12, 24 or 48-volt battery based systems. To set the controller for use with a 12-volt system, place the jumper in the 1st position closest to the top; use the 2nd position for 24-volt systems; and the 3rd position for 48-volt systems.





Blow up of jumper

To change the voltage selection, Remove this jumper with your fingernails or carefully using a small pair of pliers, and place it across the desired two pins of the voltage selection. (Horizontally across the two protruding pins for that selection.)

← This jumper position would select a 48 volt system.

The controller is shipped with the voltage selection jumper set to the 24-volt position.

The C155 operates as a series disconnect controller. Series disconnect charge controllers are used with solar systems and other energy sources where the charge source does not require a constant load. In this mode the charge source is simply disconnected from the batteries once the active trip point is reached. It is then reconnected as soon as the battery voltage drops a little (< $1/10^{th}$ of a volt). This on/off cycle may happen many times per second, or may last for several hours depending on the current available from the charge source, the current charge state and size of the battery bank. This controller excels in the solar mode and can handle up to 155 amps of solar charge current on a continuous basis providing there is adequate cool air entering the bottom and sides of the enclosure. In warmer installations, the mosfets may be disconnected by the microprocessor as required (if handling high currents) to allow for a 10-30 second cool down period.

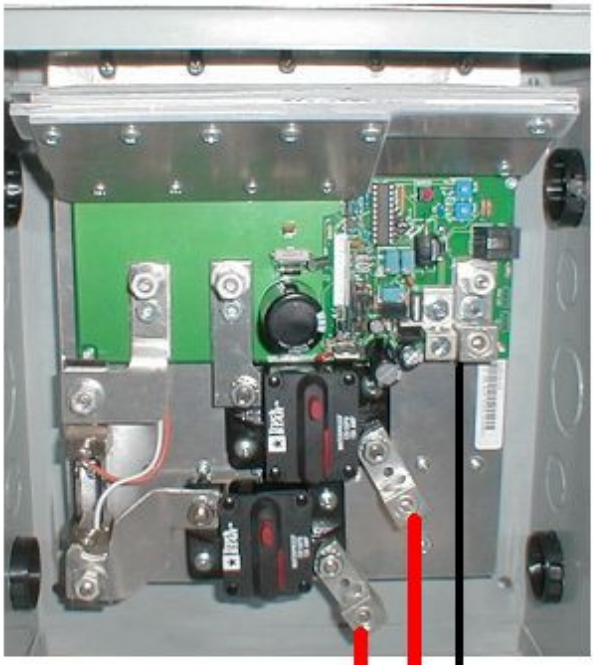
Wiring the C155 Charge Controller

When the batteries reach the trip point, the mosfets are deactivated which opens the circuit from the solar panels to the batteries. This may happen several times per second.

Caution:
Disconnect solar Input, before disconnecting the controller from the batteries.

Disconnect the controller from the batteries before servicing.

12, 24 or 48 Volt Solar Wiring Diagram

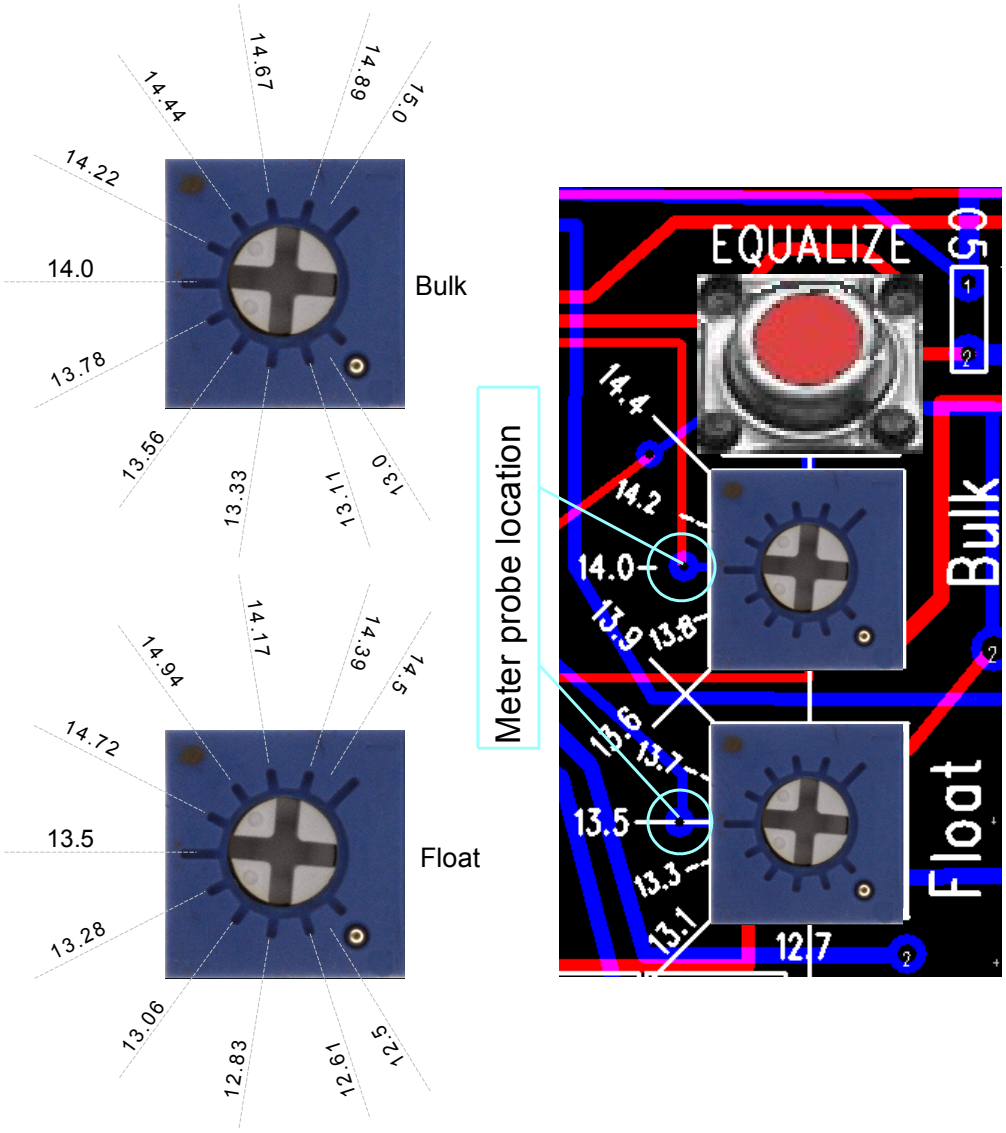


Solar Array - Open collector voltage should not exceed double your battery system nominal voltage.

Wires shown that cross each other are not connected together.

The negative wire from the solar panel can also be terminated inside the C155 controller if that is more convenient than terminating at the battery; however, if the negative wire from the solar panel is terminated directly to the battery negative (recommended), then a smaller negative wire (12 gauge wire) is all that is required to run the controller's internal electronics.

Calibrating the Controller



PCB set point adjustments

The controller has already been calibrated by the factory using the following settings, and does not require calibration unless the factory set points are not satisfactory for your installation.

Factory Defaults: Float Set Point: 13.50 volts
Bulk Set Point: 14.00 volts
Equalize Set Point 15.00 volts

Note: Double the above numbers for a 24-volt system, quadruple them for a 48-volt system. Be sure to set the proper voltage for your system using the voltage selection jumper (page 8-9).

The float and bulk settings are independent of each other. Adjusting the float potentiometer does not alter the bulk setting and visa-versus. The equalize setting is always about 7 to 8 percent higher than the bulk setting. Using the factory settings, the equalize set point will be approximately 30 volts on a 24 volt system.

If you would like to change either set point, please use one of the following procedures.

Use a small screwdriver; an oversized tool may damage the potentiometers!

Method 1: If you own a variable voltage power supply and would like to calibrate the unit on the bench or while it is disconnected from the main system**,** then the following procedure is recommended.

Connect the positive lead from your power supply to both the Battery + and Solar terminals of the charge controller (You will need a small jumper to go from the battery+ to the Solar+ terminals).

Connect the ground lead from your power supply to one of the ground terminals of the controller.

1) Turn the float or bulk level potentiometer fully counter clockwise. (calibrate one at time.)
2) Set the voltage of the power supply to the desired trip point (for instance 14.2 volts)
3) Slowly turn the potentiometer clockwise until the red LED is illuminated and/or blinking rapidly.
4) Increase the voltage of the power supply slightly and the red LED should go off.
5) Slowly turn the voltage of the power supply up and down near your set point, checking to see if you achieved your desired setting.

If you do not own a variable voltage power supply, or would rather set the controller while it is installed, then there are three additional calibration options:

Method 2: If you have an inverter that is able to set the exact float or bulk charge voltage of the battery bank to a particular level, use the inverter as your variable voltage supply and follow the instructions in method 1 to calibrate your set points.

Method 3: Using a volt/ohm meter to measure the exact position of the float or bulk potentiometers.

Please take a look at the figure on the preceding page, PCB set point adjustments. If you look just to the left of either of the two blue potentiometers (pots), you will see there is a small blue circle and hole on the PCB itself. These are meter test probe points (The drawing above has indicated them using a light blue circles drawn around the test probe test points). If you measure the voltage at either of these trip points, you will see a reading between 0 and 5 volts, with 2.5 volts being exactly midway. These voltages are what the microprocessor itself uses to determine the set points you have chosen. The math used is quite simple.

The float setting of the controller can range from 12.5 to 14.5 volts (a 2 volt span). The float potentiometer output can range from 0-5 volts (a 5 volt span).

0 volts on the float pot (0%), equals 12.5 volts float setting (0%), and 5V (100%) on the pot, equals 14.5 volts (100%). 2.5 volts on the pot (50%) equals 13.5v (50%).

The exact formula is:
(Desired set point – Lowest set point) / 2 * 5

To set your float to say 14 volts:

(14 – 12.5) / 2 * 5 = 3.75 volts – You would set the float potentiometer to 3.75 volts (as read with the volt/ohm meter at the test probe location) – This will result in the float setting for the controller to be at exactly 14 volts.

The bulk setting voltage range is 13 to 15 volts, also a 2-volt span.

To set the bulk setting to say 14.4 volts:

(14.4 – 13) / 2 * 5 = 3.5 volts – You would set the bulk potentiometer to 3.5 volts (as read with the volt/ohm meter at the test probe location) – This will result in the bulk setting for the controller to be at exactly 14.4 volts.

Method 4:

If you are unable to use any of the above methods, then you will need to cause your batteries to be brought to desired trip point via your wind/solar/hydro energy source(s). Then once they have achieved this set point, turn the desired set point potentiometer fully counter clockwise. Wait a few seconds, and then slowly turn the same potentiometer clockwise until the red LED changes state. You will want to check this setting as the battery voltage is brought up and down around your set point.

You may choose to simply use the markings on the potentiometers themselves to determine the approximate set point within +/- .075 volts. Please refer to the image on page 11 in this manual for more precise voltage reference locations over that which may be printed on the circuit board.

Remember, the red LED is illuminated when the mosfets are conducting current, regardless of whether it is in the solar or diversion mode. If the red LED is illuminated in the solar mode, then solar energy is being allowed to charge the batteries. If the red LED is illuminated in the diversion mode, then battery and excess energy is being diverted to the diversion load.

General Operating specifications	System Voltage		
C155-SMA/SVM (Solar only PWM Controller)	12V	24V	48V
Minimum operating voltage	8.5v	8.5v	8.5v
Maximum allowable intermittent/surge voltage (1)	120v	120v	120v
Maximum input from solar panels (VOC)	24v	48v	96v
Preferred maximum input from solar panels	18v	36v	72v
Maximum continuous solar charge amperage (2)	155A	155A	155A
Maximum continuous diversion amperage	N/A	N/A	N/A
Maximum surge solar charge amperage	200A	175A	175A
Maximum surge diversion amperage (resistive)	N/A	N/A	N/A
Energy consumed by the electronics (meters off)	< .1W	< .15W	< .3W
Energy consumed by the electronics (meters on)	1.2W	1.0W	.9W
On state resistance of the mosfets at 77F -- (Ohms)	0.00125	0.00125	0.00125
Voltage drop across mosfets during charge at 155 Amps	.2V	.2V	.2V
Voltage drop across mosfets during charge/diversion at 100 Amps	.13V	.13V	.13V
Voltage drop across mosfets during charge/diversion at 60 Amps	.08V	.08V	.08V

Minimum float setting (volts)	12.5	25	50
Maximum float setting (volts)	14.5	29	58
Factory default float setting (volts)	13.5	27	54
Minimum bulk setting (volts)	13	26	52
Maximum bulk setting (volts)	15	30	60
Factory default bulk setting (volts)	14	28	56
Time in absorption charge once bulk set point has been reached.	2 hours	2 hours	2 hours
Time in equalize charge once equalize set point has been reached.	2 hours	2 hours	2 hours

(1) -- Voltages spikes above 120v at the Battery+ terminal will trigger the over-voltage protection circuitry causing the 2 amp fuse to be blown. Replace this fuse with a 2 to 2 1/2 amp, regular speed fuse (not slow blow)
(2) -- May require automatic 30 second cool down periods if installation environment ambient air temperature is higher than shown below.

For indoor use only. Install in a non-corrosive, dry environment only.

External dimensions of the enclosure (Inches)	10.5 x 12.5 x 6.5

Minimum ambient air temperature	-20F
Maximum ambient air temperature (155 Amps)	85F
Maximum ambient air temperature (100 Amps)	110F
Maximum ambient air temperature (60Amps)	140F

Operations above or below the maximum temperature range may result in loss of accuracy and/or a reduction in current handling capability

Designed for battery based systems only.

These specifications and measurements are subject to periodic change without notice.