Coleman Air

C155-SMAD (C155D)

- Massive 155 amps solar array capability.
- Fully digital with intuitive user interface.
- PWM charging algorithm with 3-stage charge control.
- Menu selectable High speed PWM (1kHZ or Pulse Mode)
- No jumpers or potentiometers need to be set.
- LCD 2 x 16-character backlit display.
- USB Serial output for streaming data logging.
- Optional Remote Menu Module can be used up to 50' away.
- Both manual and automatic equalize modes are available.
- 200A shunt for monitoring/reporting solar amperage and wattage.
- Automatic nominal battery voltage detection.
- Nearly all charge parameters can be managed through the user interface.
- Fine tuning of voltage and amperage via the calibration menu.
- Bulk, float and re-bulk set points and/or timers can all be set.
- Automatic LCD back light dimming to save energy.
- Dual Truck Star breakers, one each for solar and battery inputs.
- Supports 12, 24 or 48-volt battery systems.
- Vented cover and hinged lid.
- Large heat sink capable of dissipating excess heat in normal environments.
- Modular PCB layout allows for quick and inexpensive repairs if ever needed.
- Large Enclosure for easy terminations. 12" (H), 10" (W) x 6" (D)

The newly upgraded C155D microprocessor offers substantially faster charging and more accurate set point tracking, along with the added bonus of data logging via the included USB serial cable.

Quick Start:

All user settable parameters as well as additional information are accessible via the user interface which consists of the LCD screen and the three buttons located on the front cover.

Pressing any key during the normal operation of the unit will cause the main menu to be displayed. Using the right/left buttons will scroll through the menu options. Pressing the "Enter" button will cause that menu option or value to be selected. Use of the up/down menu increases and decreases the current menu value. Pressing the up button exits the menu (unless you are currently modifying a value, in which case it will increase the value. First press "Enter" to select the current value, and then press the up button to exit the menu).

The Red LED on the front of the unit indicates an error of some nature. The exact cause of the error will be shown on the LCD screen (unless you have activated one of the menu options).

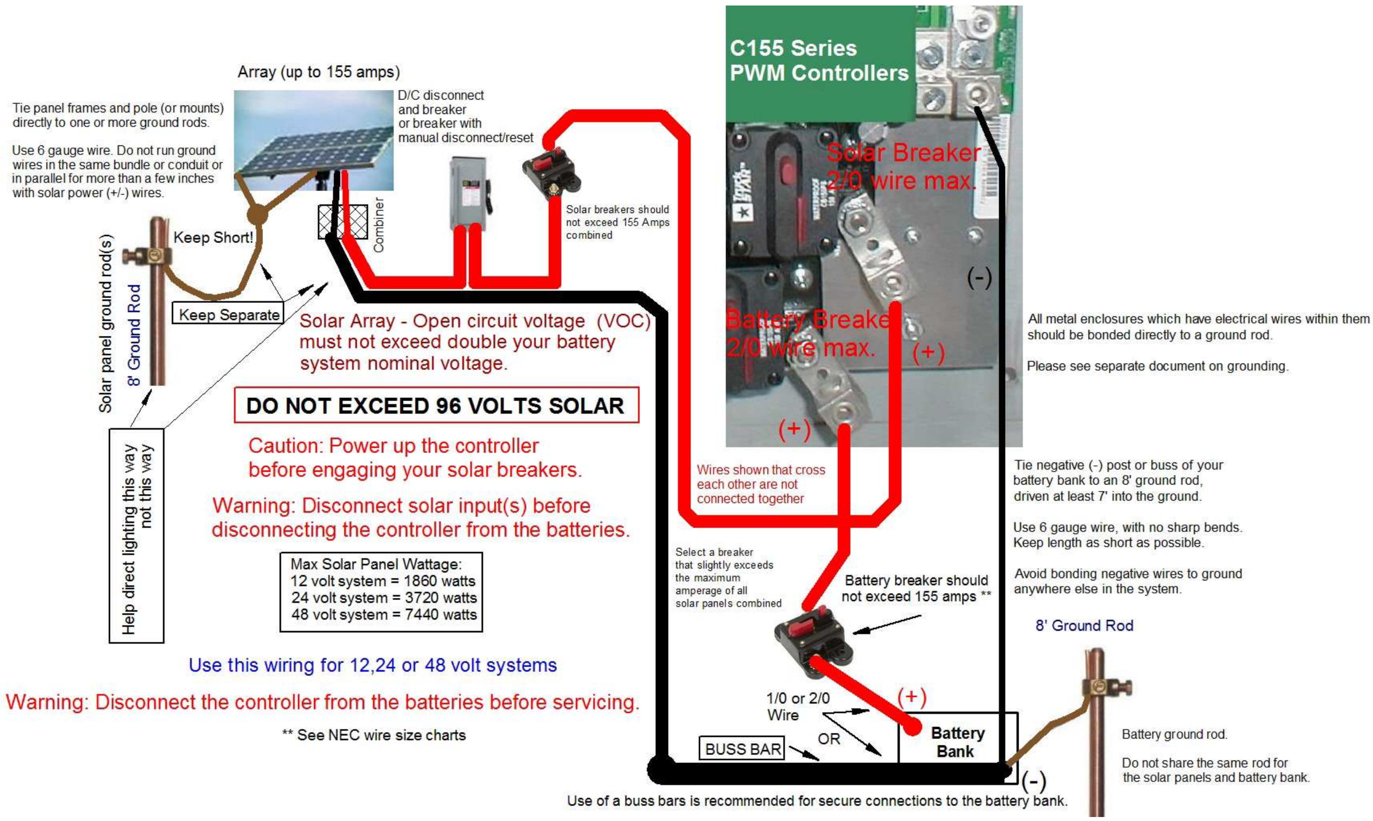
The Green LED on the front cover is illuminated when the unit is first turned on and also any time the charge performance is considered high enough to complete the current charge cycle. If the solar power is not adequate to complete the charge cycle, the cycle will be extended and the mode timer will not count down. When this green LED is lighted, the charger is able to pass enough current to the batteries to potentially complete a full charge of the batteries.

The internal green LED on the middle right of the large PCB board (motherboard) is lighted when the IGBT's are engaged, which internally connects the solar panels to the batteries.

The red LED on the small daughter board is lighted when there has been an over-voltage detected. **To clear an over-voltage condition, all power to the unit must be disconnected for at least 30 seconds**. Once power is re-applied, the unit should clear the fault. **Over-voltage conditions should be addressed by ensuring your solar inputs never exceed 100 volts** solar panels should never be enabled without first ensuring the controller is powered up and running from the batteries.

This unit is designed for mounting in a dry indoor environment. **The enclosure will not protect the contents from moisture, dust or insects**. Do not mount outdoors where rain, snow or high moisture and/or condensation is a possibility.

Solar systems should be designed for no more than 155 amps maximum current based on the manufactures data plate. To determine the total amperage of your solar system, divide the total wattage by your battery voltage. For example: On a 24 volt system, 3600 watts of solar / 24 volts = 150 amps. Wire your panels so the input voltage is between 1.6 and 1.8 times your battery voltage. On a 12 volt system, a VOC between 19 and 22 volts is optimum. Do not exceed twice your battery voltage.



This unit may be used with solar (photovoltaic) inputs only. **Multiple solar panels (arrays) may be hooked up as long as you do not exceed the total capacity of the unit.** More information on these subjects is provided at http://ColemanAir.us (See: Articles and Information.) The optimum solar panel VOC is generally around 1.6 to 1.8 times the battery voltage.

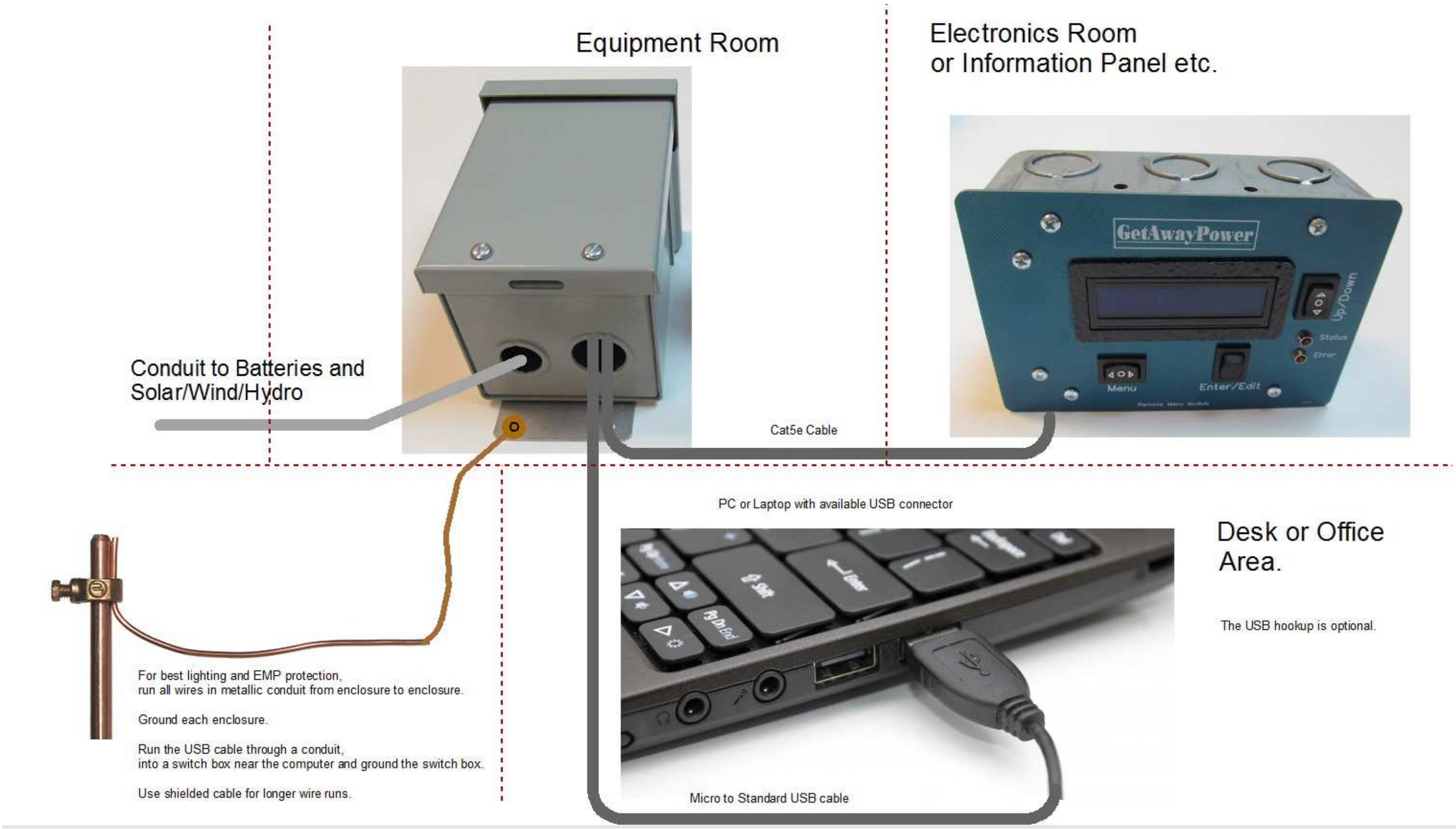
Ungrounded solar panel frames are an invitation for system wide damage due to lighting strikes and/or electrically charged air. Ground rods at the solar panels and battery negative are required for safety and reliability.

Ensure you have selected adequate sized wire for the amperage you will be controlling. Undersized wire can result in very high heat within the wire and connections possibly leading to a fire. Always use a fuse or DC disconnect! Hooking up an energy source or load without a fuse or disconnect can result in serious injury or death!

The breakers inside the unit do not disconnect the incoming battery cable from the battery bank power. The external breaker shown above is required by code!

Use extreme caution when installing or servicing this controller. High amperages and voltages can KILL you. – Always disconnect the controller before servicing.

The USB port is used to send log and status data to any computer that supports USB serial communications. The RJ45 connector is used to hookup the C155D to the local or remote menu module (one menu module only). A USB cable is provided. Longer cable runs are possible, however, you may need to use shielded cabling with a ferrite band for runs over 10 feet. Please note, the RJ45 connection is not the Ethernet protocol.



Picture above shows a MP-20 controller with the remote menu module.
The C155D can be setup to use this same menu module; however the LCD/menu on the front cover will then be disabled.

Connecting the Laptop or PC:

The C155D outputs steaming log data via USB Serial. The supplied cable is a standard male USB to mini USB. The data can be retrieved via any computer that has a standard USB connection available. Nearly all recent laptops and computers have some type of USB connection. Smaller laptops use micro or mini USB cables. If this is the case, you will need to obtain a USB micro-to-mini or mini to mini cable to complete the hookup to your computer.

The serial data from the C155D steams at all times, regardless if there is a connection to a computer or not. This log data is in CSV format and therefore can be easily imported into a spreadsheet program.

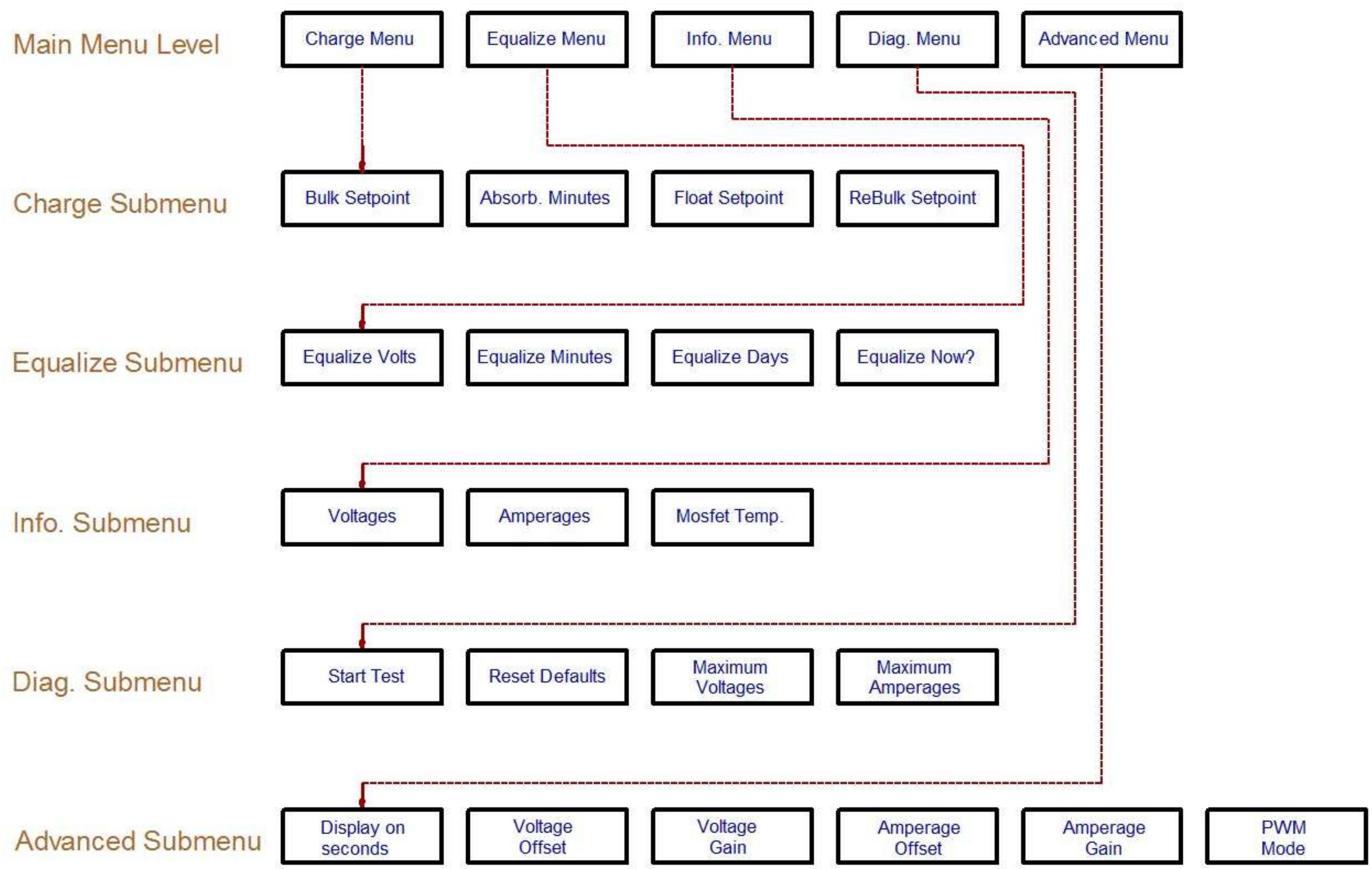
When you plug the C155D USB cable into your computer, the new serial port will be automatically installed and configured. You will however need to obtain an interactive serial communications program to communicate with the newly configured serial port. There are many such programs available for free download via the Internet. A very useful and easy to use one can be downloaded at:

https://freeserialanalyzer.com/

Once you install your software, then follow the instructions provided by the software manufacturer to complete the setup. When fully installed and configured, you should begin to receive steaming data from the C155D.

Important note: If you hookup your USB cable before hooking your C155D to a battery bank, then the C155D will power up via the USB supplied power. **This will cause it to configure itself as a 12-volt battery bank (which is dead).** It is therefore best to ensure the C155D is properly connected to the battery bank, before connecting the USB cable to the computer. If this is not possible, you will need to use the “Reset Defaults” option via the diagnostics menu once the C155D is powered up to the system battery bank.

The C155D Menu System Layout



The C155D Menu is selected by pressing any button on the front panel. Pressing the right/left buttons will scroll through the menu options at the current level. Pressing the "Enter" button will cause that menu option or value to be selected and/or displayed. Use of the up/down menu increases and decreases the current menu value. Pressing the up button exits the menu (unless you are currently modifying a value, in which case it will increase the value. First press "Enter" to select the current value, and then press the up button to exit the menu).

For example: To change the float set point of the controller. Press the "Enter", "Up/Down" or "Scroll" button on the front panel. The Charge submenu will then be displayed. Press the "Enter" or "Down" button to enter the submenu.

Press the "Scroll" button towards the right two times. This will display the float set point menu along with the current value of the set point. Press the "Up/Down" button to alter this value to the desired voltage. Press the "Enter" button to save this value. Press the "Up/Down" button upwards to exit the menu system. You could also of course continue to alter more values and/or view other settings.

The C155D is a Pulse Width Modulated (PWM) controller that incorporates both high-speed PWM and short pulse algorithms to best match the charging source to the battery. The default charge logic incorporates a standard three-stage charge cycle. Additional charging logic has also been added including such features as re-bulking, an absorb mode that allows for automatic adjustments due to changes in solar illumination (low current) as well as offering both a manual and automatic equalize modes.

PWM Controllers: Pulse Width Modulated controllers.

PWM controllers are advanced controllers that are well suited to solar systems when there is a good match between the solar VOC and the battery voltage. These controllers are most efficient when the VOC (Voltage Open Circuit) of the solar array is between 1.6 and 1.8 times the nominal battery voltage. For example, on a 12-volt system, a VOC between 19 and 22 volts will yield the best overall charging efficiency.

So how do PWM controllers work? PWM controllers are solid-state controllers that offer more advanced charging algorithms than single stage controllers are capable of. First lets talk about the PWM aspect. As the battery voltage increases, the charge controller's primary responsibility is to restrict the incoming voltage (and current) to insure the battery does not over charge. The simplest way to do this would be to open the circuit (turn off the internal switch), when the battery gets "full", but of course as soon as you do this, the battery voltage will start to drop and the controller will need to turn the switch on again. This on and off switching then would attempt to keep the batteries at a full charge state and everything would be fine. Turning on and off repeatedly is no problem for a solid-state device, but it really is not that simple. It is better if the charge voltage/current to the battery varies based on its state of charge and where the battery is in its overall charge cycle (Was it nearly depleted, or has it been mostly charged now for awhile and just needs to be maintained?)

There are many different philosophies used, including 3 stage charging, constant voltage and tapered charging, but for the most part, to promote better battery health, batteries are not just brought up to full charge then shut off by a multistage solid state controller. The controller examines the batteries state of charge (SOC) and as it progresses through the charge cycle, reduces or increases the current as required. Once the battery charge cycle is complete, the charge controller will reduce the current even more to hold the battery at the "Full State".

So this is what the controller does, but it does it via pulses of energy that may last from less than a 1000^{th} of a second to several minutes. The term pulse width modulation is really pretty simple to understand. If you had a garden hose with a hand held nozzle that you can turn on and off by squeezing the trigger, you could easily control the water volume to say 50% by simply squeezing the trigger half way, or conversely, you could, by repeatedly squeezing the trigger once every two seconds for a full second on, and a full second off accomplish the same thing. Each time you squeeze the trigger it's a pulse, the length of time you hold the trigger is the width of the pulse. Basically, if you turn on the water every second, and off the next second, then you are letting 50% of the water that is available to pass though the nozzle. If you where to hold the trigger for 1.5 seconds on and .5 seconds off, then you would be allowing 3/4ths of the volume to pass. This is what PWM controllers do. This pulsing action is much easier on the charger (most current carrying electronic switches heat up if they are half way on, but they don't mind at all if they are full on and full off many times a second). But there's another reason why this is done -- The batteries love it. These pulses of energy are very good for the general health of the battery plates.

PWM controllers allow an electrical pulse from the charge source to pass to the batteries that can be better for battery life then steady state charge currents. Some PWM controllers (like the C155D) can also incorporate pulsed (bursts). The same basic on/off cycles are used, but more pronounced bursts with longer on times. These short bursts of higher currents can be very effective on keeping the plates of the batteries in good health. Not all PWM controllers are the same, some use high frequency pulses, others use pulses only as the batteries reach a higher state of charge, but all PWM controllers incorporate pulses of energy of varying frequency to control the actual current to the battery.

The C155D uses a 1kHZ frequency (1000 pulses / second) by default and automatically switches to pulse mode if the internal components begin to heat up beyond desired operating regions.

The C155D is capable of providing 3-stage charging for Lead acid, AGM and Lithium based battery systems.

A three stage charge cycle consist of:

- 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 current is sent to the batteries to raise the battery voltage up to the bulk set point. This mode brings the battery to about 80% of its capacity. Generally the bulk charge voltage is set to between 14 and 15 volts, with 14.4 volts often used as a standard (12V system). There is really no perfect voltage setting as there are many factors involved. The ambient temperature, the size of the energy sources vs. the battery bank size, the desired length of time in this mode, the cost of the energy (if it is supplemented by the grid or generator, etc.). Simply stated, the bulk charge gets the battery up to a mostly full state at a quick but healthy rate. During this stage, the internal switches are fully closed (full conduction).

The 2nd stage of the 3-stage charging mode is the Absorption Charge: Once the bulk mode set point is reached, the charger attempts to hold and track this value, by varying the PWM duty cycle between 0 and 100%. The absorption mode uses the same set point as the bulk mode with the difference being that the battery voltage is no longer rising up to the set point; but instead, it is being maintained at that set point. Due to the chemical nature of the battery (and ohms law), this constant voltage causes the charge current to drop as the battery reaches a "full" state of charge. The factory default for the absorption mode is set to 120 minutes, which under sufficient energy input is ample to charge most battery banks.

The 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 around 13.2 to 13.7 volts (for a flooded, 12 volt lead acid battery). 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. Please note: Lithium based batteries should generally not be float charged and thus, a very low set-point should be utilized for the float setting.

Another charge mode incorporated by many chargers (and the C155D) is the equalize charge. This mode is not a part of the normal charge cycle, but is instead initiated (either manually or automatically based on a timer) to help mix the electrolytes of the battery. During normal use, the battery's chemical mix becomes stratified. (Separated from top to bottom). An equalize charge uses approximately 10 percent higher voltage to help mix these elements in the 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 for lead acid batteries. During this charge cycle quite a lot of gassing will occur, which causes the fluids to be mixed and the plates to be "cleaned". An equalize charge is not recommended for sealed batteries or lithium batteries. Be sure your battery room has good ventilation before running an equalize charge.

The C155D also incorporates a "ReBulk" set point. Should the battery voltage drop to the "Re-bulk" set point for more than a few seconds, the controller will exit the current charge mode and start a new bulk mode. If the Bulk mode is already active, then the controller will restart the countdown timer to force a new full-length bulk mode charge.

Fine tuning your system:

As introduced above, the C155D is fully configurable through the front panel buttons and display. There are no jumpers that need to be set or potentiometers that need to be adjusted. All configurable options are reachable via the menu system. This menu system is comprised of a main menu and several submenus as depicted above in the menu layout graphic (page 5). Each submenu allows you to either set a particular value, view information, or perform specific actions like running a test or starting the equalize mode. Most of these menu items are self-explanatory and will not be discussed in detail; however, there are some features and settings that deserve greater explanation.

First and foremost, **you generally do not need to change anything.** When the controller is first powered up, it analyzes the current battery voltage to determine whether the battery bank is a 12, 24 or 48-volt bank. If your battery bank nominal voltage has changed since the last time the unit was powered up, then the microprocessor will reset all values to the factory defaults and store the new information. These factory defaults are normally perfectly adequate for a lead acid battery bank used with most solar installations. Changes to the settings are therefore only required when your requirements are different in one manner or another from what has been set by the factory. The controller is basically plug-and-play! Factory defaults can be viewed in the technical specifications page at the end this manual.

- ❖ **Setting up the charge parameters**. See the technical specifications pages for the factory defaults. If you need to alter any charge settings, simply select the charge menu choice from the main menu and scroll though the submenu to select and alter the values. There are very few limits placed on the values you set, other than you cannot set a float set point higher than the bulk, or the bulk higher than double the battery system voltage etc. Once you set or reset these settings, you should monitor the controller and see that these settings are working to achieve the results you require.

  The factory time setting for the absorption is 120 minutes. This value can be changed as required. This timer is performance based. The microprocessor uses multiple algorithms to determine if during the last minute the batteries actually realized a certain level of charging. The main consideration is whether the controller was able to reach and hold the upper set point. If the performance during the last minute for the absorb mode is considered adequate, the timer will be decremented by one minute. If on the other hand, the performance is below the standard, the timer will not be decremented, which can result in a charge cycle that lasts much longer to ensure the batteries actually receive the best charge possible even with less than optimal charging conditions.

  The green LED on the remote panel will be illuminated when the processor determines the performance is high enough and off when the performance is not high enough to properly charge the batteries. This allows you to quickly visualize the real time charging performance that the controller is detecting. Often the green LED will blink on and off randomly and rapidly as the solar energy fluctuates.

- ❖ **Turning on or off the Equalize mode**. By default, the equalize mode is not enabled. To start a manual equalize, select the Equalize submenu, scroll right or left to the “Equalize Now?”. When this submenu is displayed, press the “Up/Down” button to select “YES” and then press the “Enter” button to request this mode. The equalize mode will then be queued. The controller will not actually start the equalize mode until the bulk set point has been reached. Once the mode is started, the countdown timer will start and the mode will stay in affect until the timer expires. The length of time in this mode is controlled by the “Equalize Minutes” submenu option. The equalize mode is not performance based and will not be restarted automatically due to low current conditions.

  The automatic equalize: Changing the Equalize days from “0” to any number up to 90 will enable this feature. The equalize function will then run once the day timer has been triggered and the bulk set point has been achieved. The equalize will not actually start if the bulk set point is not achievable via the solar charge inputs.

- **The Advanced Menu:** The advanced menu allows you to change the LCD backlight options, voltage and amperage calibration adjustments as well as allow you to change the type of pulse mode that is used.

  By default, the LCD backlight will be turned off after 120 seconds of no activity. If you would like to extend this, to say 5 minutes, then simply raise the seconds on time to 300. If you do not want the backlight to be turned off, set this value to zero.

  There are 4 submenu locations that allow you to fine tune both the voltage and amperage calibration. This should only be necessary if you notice that the unit is displaying a voltage or amperage, which you believe to be incorrect and wish to calibrate in order to correct the measurement error.

  > The voltage and amperage "offsets" allow you to raise or lower the displayed values by a set amount across the entire measurement range equally. Setting the offset to .2, causes the voltage displayed (and used internally) to be raised by .2 volts at both the low end as well as the upper end of the input range. 10V becomes 10.2V and 49.5V becomes 49.7V.

  > The voltage and amperage "gain" allows you to raise or lower the upper end of the range by more than the lower end. This is used when you notice that the lower end measurements seem to be pretty close, but the upper end is off by a tenth or more. Setting the gain does alter both the upper and lower end, but the upper end is affected more than the lower. A gain of .1 = .1% gain, which is not a lot of change on the lower end, but about a tenth of a volt at the maximum input of 100 volts. This same logic applies to the amperage offsets and gains.

  PWM Mode: By default, the C155D uses a 1kHZ frequency (1000 pulses / second) and automatically switches to pulse mode (short, higher energy pulses) if the internal components begin to heat up beyond the desired operating regions. Generally this setting need not be changed unless you find the 1kHZ signal is emitting a sound within your system that you find bothersome.

  The default frequency is very much within the range of human hearing and can be heard during normal operation when the PWM mode is actively holding the target set point. The amplitude of this audio signal will increase as the VOC of the solar panels is increased (bright sun). When your VOC is considerably higher than your battery voltage, then this signal will be much more noticeable. In addition, if your input wires are lying on a metal roof and not enclosed in conduit, then you may get additional "amplification" from the antenna created by the wires and the speaker created by the roof.

  If you find this frequency to be obtrusive or simply not desirable for your installation, then simply choose the "Pulse" mode and the system will use only short and seemingly random pulses of energy, generally lasting from less than a second to several seconds as required to keep the battery near the desired set-point. This mode works very well and is also very healthy for your batteries; however, there will be considerably more "bouncing" of voltages and amperages each time the controller sends a pulse of energy to the battery. This bouncing is even more noticeable when there is a great deal of solar energy and a relatively small battery bank.

- **The View Submenu:** The view menu allows you to view the real time voltage and amperage of the connected battery and solar array.

  The current reading (amperage) of the solar will be zero (or very close to zero), if there is no active input from the energy source.

  The voltage shown for the Solar input is affected by the PWM processing. For example, if the PWM is currently running at a 50% duty cycle (½ on and ½ off each full cycle), then the solar panel will read about ½ way between its full VOC and the battery. If the duty cycle is at 100%, then the solar panel will read the same voltage as the battery (since their positive wires are in essence fully connected together, their voltages must be the same also). When the duty cycle is 0% (fully off, then the solar voltage will read the full VOC of the solar panel (as it currently illuminated).

Other Menus and Submenus:

In addition to changing the charging parameters, the diagnostics menu system can be used to view the maximum voltages and amperages reached during the active charge cycle. These values are reset each time the charge mode is changed (a change from the bulk mode to the absorb mode for example). They are also reset when the controller is powered up. These values can be helpful in determining the performance of the charging sources.

Another diagnostics submenu option is the **"Start Test?"**. To select this feature, press any button on the front panel, scroll right or left to the Diagnostics menu, press the down button to select the "Start Test?" feature. Press the "Up/Down" button UP until "YES" is displayed, then press "Enter". The controller will now enable and disable the PWM processing at full output, 5 times, using two-second intervals. During this time, the battery voltage, solar voltage and solar amperage will be displayed in an alternating and repeating pattern that allows you to see each of these values during both the fully enabled and fully disabled state.

During the test, all LEDs on the remote menu will be illuminated when the solid-state switch is enabled and off when it is disabled. Generally, this test will only be run when you suspect problems and are working with a factory technician to diagnose the issue.

Resetting to factory defaults:

If for any reason you wish to start over with all configuration settings and parameters, then simply select the "Reset Defaults?" submenu, choose "YES", then press "Enter". All configuration settings will be reset to the factory defaults. This reset is also performed anytime the batteries nominal voltage (12, 24 or 48-volt) changes from the last time the unit was powered up. This means if you change your battery bank from a 12-volt system to a 48-volt system, then the microprocessor will automatically initiate a reset to factory defaults for the currently detected battery bank.

Installing and hooking up your C155D Controller:

To help prevent over-voltage, always hookup the controller to the batteries (and power it up) before enabling your solar energy sources. The controller cannot engage its protective circuits if there is no connection to the battery bank.

Inspect the unit when it first arrives. Please contact your dealer immediately if any problems are found.

The controller should be connected as close to the battery bank as possible, using finely stranded, insulated copper wire.

A common installation method is to mount the controller on the wall, often reinforced with plywood or similar material, in a room specifically built for your alternate energy equipment. A garage or similar room is also fine. **Installation of the main controller in your living area is not recommended!** Large currents and voltages are passed through the unit and there can be a noise emitted during the normal cycling of the controller. The optional remote menu module can be mounted in a living area, such as the electronics area in your house, RV, Motor home etc. The remote menu module will not emit any noise, nor does it contain any high voltages. Of note, the LED's can be disruptive to sleeping if the remote module is located in a sleeping area.

Do not install the controller in a small area that does not allow for proper ventilation. **Absolutely do not install the controller in a small "battery box" without substantial ventilation.** Lead acid batteries expel hydrogen into the air as they charge, which can be ignited by the controller during normal operation.

The controller has four holes within the enclosure of the unit that accommodate up to ¼" screws or similar to be used to securely fasten the unit to the wall or panel. The unit must be installed vertically to ensure proper heat dissipation. When mounting, ensure there is adequate space above the unit for any heat to be expelled.

Use heavy gauge stranded wire. Solid wire is not recommended, as it is very difficult to terminate inside the controller.

Again, do not install under sized wire, it is utterly dangerous! See the NEC wire charts to determine your minimum safe wire gauge for the amperage of your system and energy sources.

Remember, any wire that leaves an energy source MUST have a breaker or fuse. Do not run a wire from your battery bank that is not protected against over current. This means you need a breaker or fuse between the battery bank and controller.

Inspectors generally insist that a breaker or disconnect be located as close to the energy source as possible and may also insist on a 2nd breaker or disconnect near its final termination point. Please consult NEC regulations and your local inspector to determine the requirements in your area. These subjects are outside of the scope of this manual; however, it is your responsibility to ensure your unit is installed safely!

Solar panels are energy sources. A breaker or fuse is required between the panels and any other components (including the C155D). **Do not hook up a wire from any energy source into the C155D without the ability to quickly and safely disconnect the input. All inputs need fuses or breakers!**

Grounding your C155D and alternate energy system.

A properly grounded system is extremely important for both safety and reliability. An ungrounded system is significantly more likely to be damaged during an electrical storm than a properly grounded system.

Solar panels and wind turbines act as lighting antennas or "magnets" as they are always mounted in manner that opens then up and elevates them in some manner or another which often makes them the most likely target for a lightning strike.

It is important to note, that due to the relationship between the earth's ground and the electrically charged sky during an electrical storm, the lighting bolt does not actually seek the highest object, but the highest object actually attracts the lighting bolt to it, with an initial burst of conductivity that starts from the ground up, not the sky down. So, putting it simply, if you put a wind turbine up in the air and that tower is not grounded, then you can fully expect it to be hit by a lighting strike, which will result in equipment failure. This is a "not if, but when" scenario and then "how often".

When a lighting bolt hits an ungrounded tower, the entire voltage/current spike will travel down the wires that lead directly to your controllers and inverters, looking for a ground. On the way through, untold damage can be done. The C155D incorporates multiple over-voltage surge protection devices and circuits, but they may be no competition to a direct lighting hit. Many of our controllers have survived direct lighting hits due to the internal protective circuits yet the connected equipment like meters, inverters, etc. are damaged beyond repair. Proper grounding is paramount!

To make matters worse, the lighting strike does NOT have to be direct. Highly charged atmosphere may be present for many miles around an active lighting area. This super charged air is more than sufficient to damage the sensitive equipment used in an alternate energy systems where the solar panels and towers act as antennas for this energy.

Additionally, indirect electrical charges can be present at other times, including a stand-storm, high wind event, very low humidity conditions etc., that are more than sufficient to generate static electricity that exceeds hundreds or even thousands of volts. Without grounding, this static electricity alone can damage any piece of equipment used in your system.

A properly grounded system is comprised of (at the very minimum) 6' ground rounds and large (6 to 8 gauge) bare copper wire that ties the enclosures and battery bank negative post directly to the ground rod. Ground rods (plural) should be placed as close to turbine towers and solar panel installation as possible. The towers and panel frames should be tied directly to the ground rods with few or no splices. The battery bank's negative (or buss bar) should also be tied to a grounding rod.

Damage due to lightning strikes and high voltage surges are not protected under the warranty.

Grounding details:

Solar Panels:

All authorities agree that grounding is paramount! Proper grounding requires carefully thinking about how a burst of energy from an externally (i.e., grid) connected wire and/or the atmosphere to the earth are likely to travel. Ground wires need to be as short as possible and as numerous as required to ensure each and every panel is grounded.

Each vertical row of solar panels requires a separate ground wire running vertically down to the ground. Multiple ground wires may be combined into a single ground rod. Generally a new ground rod should be driven for every 8 to 12 feet of lateral ground distance, driven (6' or 8' deep) the more the better, the deeper the better.

Use an aluminum grounding strap between each solar panel frame (even if you have mounted the panels to an aluminum rack). Alternatively, you may tie each and every solar panel frame directly to the grounding wire via a ground lug or bolt. This is often the best and easiest method.

Grounding enclosures.

Each and every enclosure must be grounded directly via a copper ground wire. Each of these wires must make a separate run to the nearest ground rod or a grounded buss bar. Do not daisy chain copper ground wires, this does not work but instead can bring an otherwise unaffected enclosures into the direct path of the high-energy burst.

Grounding the battery bank.

The negative ground post or ground buss of the battery bank must be grounded. This is one of the most important grounding places, yet often overlooked. If your battery bank is not grounded it can easily pass the high energy burst back into EVERY piece of equipment that is connected to it! Important: The bond between the negative post of your battery bank and the ground rod (or ground rod array) should be the only point in your system where a negative wire is tied to earth ground.

It is difficult to over ground, but it is actually possible. Please do an Internet search for solar system "ground loops" to ensure you are setting up a grounding system that is not subject to ground loops, which can introduce a new set of problems.

There is a great deal of information on these complex subjects including, grounding, EMP protection and lighting strikes. There is also a great deal of misinformation which can cost you a lot of money and hardship unless you take the time to research and then take the time to properly install and protect your system. This is knowledge you will be forced to garner, it's really just a matter of being proactive or reactive and then how costly will such an education be.

An ungrounded system is also a safety hazard for a multitude of reasons that are outside of the scope of this manual. No safety conscience installer will ever design and/or install a system that fails to include grounding.

Please research "solar or wind systems grounding" on your favorite search engine for more information.

General Operating specifications	System Voltage		
C155D PWM Controller	12V	24V	48V
Minimum operating voltage	10.5V	10.5V	10.5V
Maximum allowable intermittent/surge voltage (*1)	102V	102V	102V
Maximum input from energy source (VOC)	24V	48V	96V
Most efficient VOC	20.5V	41V	82V
Maximum continuous solar charge amperage (*2)	150A	150A	150A
Maximum surge charge amperage	155A	155A	155A
Energy consumed by the electronics (meters off, standby current)	< .1W	< .15W	< .3W
Energy consumed by the electronics (meters on, PWM active. (*3)	< .75A	< .5A	< .25A
Minimum float setting (volts)	12.0	24	48
Maximum float setting (volts)	24	48	96
Factory default float setting (volts)	13.5	27	54
Minimum bulk setting (volts)	12	24	48
Maximum bulk setting (volts)	24	48	96
Factory default bulk setting (volts)	14.4	28.8	57.6
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 102v at the battery+ input terminal will trigger the over-voltage protection circuitry causing the isolation circuit to be engaged. The red over voltage LED will be illuminated (on the small PCB board upper right, inside of the unit). The controller must be un-powered for at least 30 seconds to clear this condition.

*2: The internal mosfet temperatures determine continuous power capabilities. If the controller is not mounted where it can expel heat and/or does not have adequate ventilation and cooling then these values will be reduced. Steady state amperage is limited to 150 amps via the internal breaker. Do not use a fan to blow air inside the controller. This will result in environmental damage to the PCB. Forced air may however be used across the upper heat sinks to help with cooling when ambient temperatures are high and there is no air conditioning available.

*3: Additional power is consumed/expelled when the C155D is controlling large currents with large differences between input to output voltage. The highest PWM operating efficiency is 98% to 99.5%, when the solar array VOC is slightly higher then battery set-point target and the controller is able to use a steady state 100% duty cycle. A 48-volt system is more efficient than a 24V system, which in turn is more efficient than a 12-volt system.

Install in a non-corrosive dust free environment only.
External dimensions of the enclosure (Inches) 12” (H) x 10” (W) x 6” (W)

Minimum ambient air temperature	-20F
*2) Maximum ambient air temperature (150 Amps)	72F
*2) Maximum ambient air temperature (100 Amps)	95F

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.

Automatic Nominal Battery Bank detection:

When power is first applied to the C155D controller, the voltage of the connected battery bank is measured to determine if the controller should operate in the 12, 24 or 48-volt mode. This process is automatic and eliminates the need for manual jumper settings or other user intervention. This process; can however, report the wrong value to the controller if the connected battery bank has been depleted beyond normal limits (a very dead battery). For example, if a 24-volt battery has been allowed to deplete to perhaps 15 volts and the controller is restarted during this period, then the controller will assume it is connected to a 12-volt bank, not a 24-volt. If this occurs, then simply increase the bulk charge point and let the battery bank recharge. Once the battery is recharged to a normal region; then via the menu system, select the “reset defaults” to set controller back to the factory defaults or simply restart your controller by removing power from it for 30 seconds or more.

Over-Voltage:

To help prevent over-voltages, always power up the controller (ensure it is running on the batteries) before enabling your solar panels. All solar inputs must have a manual disconnect that allow you to safely power up the controller and then and only then, enable the energy sources.

The C155D use a specialized over-voltage sensing circuit that is MUCH faster than a fuse for detecting and protecting against over-voltage conditions such as a lighting strike or an over-voltage wind turbine connected to the system, but damage can still ensue if the controller is not grounded and properly wired to your battery bank. This protection circuit will be engaged should the input voltage rise above 102-104 volts. If this occurs, the Red O.V. LED will illuminate (inside the controller) indicating the O.V. condition. **You must remove all power from the controller for at least 30 seconds to reset the O.V. circuit.**

General Information:

The enclosure will not protect the contents from high moisture areas such as beach houses, sail boats etc. Salt air will quickly oxidize the electronic components and connections, eventually resulting in failure of the unit. This type of failure is not covered under warranty and may also preclude repair.

Note: Some of the photos of circuit boards may be from earlier versions of this controller.

Modified 7/28/20.