TRACE™ C-Series

Multifunction DC Controllers

Installation and Operation Guide

XANTREX
Smart Choice For Power

P/N 975-0004-01-01 Rev. B 11/00

C-Series
Multifunction DC Controllers

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IMPORTANT SAFETY INSTRUCTIONS

This manual contains important safety instructions that should be followed during the installation and maintenance of this product.

To reduce the risk of electrical shock, and to ensure the safe installation and operation of this product, the following safety symbols have been placed throughout this manual to indicate dangerous conditions and important safety instructions.

WARNING - A dangerous voltage or condition exists in this area. Use extreme caution when performing these tasks.

AVERTISSEMENT - Une tension ou condition dangereuse existe dans cette zone. Faire preuve d'extrême prudence lors de la réalisation de ces tâches.

CAUTION - This procedure is critical to the safe installation or operation of the unit. Follow these instructions closely.

ATTENTION - Cette procédure est essentielle à l'installation ou l'utilisation de l'unité en toute sécurité. Suivre ces instructions de près.

NOTE - This statement is important. Follow instructions closely.

NOTE - Cette déclaration est importante. Suivre les instructions de près.

- All electrical work must be done in accordance with local, national, and/or international electrical codes.
- Before installing or using this device, read all instructions and cautionary markings located in (or on) the manual, the inverter, the controller, the batteries, and the PV array.
- Do not expose this unit to rain, snow or liquids of any type. This product is designed only for indoor mounting.
- To reduce the chance of short-circuits when installing or working with the inverter, the controller, the batteries, or the PV array, use insulated tools.
- Remove all jewelry such as rings, bracelets, necklaces, etc., while installing this system. This will greatly reduce the chance of accidental exposure to live circuits.
- The controller contains more than one live circuit (batteries and PV array). Power may be present at more than one source.
- This product contains no user serviceable parts. Do not attempt to repair this unit unless fully qualified.

SAVE THESE INSTRUCTIONS !

BATTERY SAFETY INFORMATION

- Always wear eye protection, such as safety glasses, when working with batteries.
- Remove all loose jewelry before working with batteries.
- Never work alone. Have someone assist you with the installation or be close enough to come to your aid when working with batteries.
- Always use proper lifting techniques when handling batteries.
- Always use identical types of batteries.
- Never install old or untested batteries. Check each battery's date code or label to ensure age and type.
- Batteries are temperature sensitive. For optimum performance, they should be installed in a stable temperature environment.
- Batteries should be installed in a well vented area to prevent the possible buildup of explosive gasses. If the batteries are installed inside an enclosure, vent its highest point to the outdoors.
- When installing batteries, allow at least 1 inch of air space between batteries to promote cooling and ventilation.
- NEVER smoke in the vicinity of a battery or generator.
- Always connect the batteries first, then connect the cables to the inverter or controller. This will greatly reduce the chance of spark in the vicinity of the batteries.
- Use insulated tools when working with batteries.
- When connecting batteries, always verify proper voltage and polarity.
- Do not short-circuit battery cables. Fire or explosion can occur.
- In the event of exposure to battery electrolyte, wash the area with soap and water. If acid enters the eyes, flood them with running cold water for at least 15 minutes and get immediate medical attention.
- Always recycle old batteries. Contact your local recycling center for proper disposal information.

Introduction

The C35/C40/C60 (C-Series) controllers are among the finest controllers available and can be used with 12, 24, or 48 volt DC systems (depending upon model) as PV charge controllers, DC diversion controllers, or DC load controllers (low voltage disconnect). These capabilities make the C-Series the only DC controllers you'll need! Numerous standard features are provided to maximize the performance of the system:

- Solid-state Pulse Width Modulated (PWM) charging process with three-stage control, temperature compensation, and manual or automatic equalization to maximizes system performance and increase battery life.
- Meets National Electrical Code (NEC) and other international controller specifications.
- UL listed for the U.S. (UL Standard 1741 (draft) 1998), and Canada (CSA-C22.2 No. 107.1-95).
- Electronic overload and short circuit protection with automatic and manual reset capability increases the reliability of unattended systems by eliminating blown fuses and tripped circuit breakers.
- Field adjustment of charge setpoints is provided by rotary controls with removable knobs, reducing the potential for setpoint tampering. Calibrated scales and test points allow precise adjustments of settings.
- Optional external battery temperature compensation sensor (BTS) for automatic adjustment of charge setpoints (required by UL draft standard 1741 and strongly recommended for sealed batteries).
- Over-temperature protection for the electronic circuitry when used in hot environments (over 113 °F/45 °C).
- Indoor-type, powder-coated enclosure for wall mounting.
- Multicolor LED with easy to read mode/status label.
- Optional LCD meter for remote or direct mounting on the controller. May be mounted up to 1000 feet away.
- 2-year limited warranty.

Operating Modes

The C-Series controller can operate as either a photovoltaic charge controller, a diversion controller, or a DC load controller. The controller cannot operate in more than one mode at the same time. If several modes are required in a system, a dedicated controller must be used for each mode.

Photovoltaic Charge Control

When this mode is selected, the status LED will indicate either blinking green or solid green. It will alternate red/green when in equalization mode.

Diversion Control Mode

When this mode is selected, the status LED will indicate either blinking green or solid green.

DC Load Control Mode

When this mode is selected, the status LED will typically indicate blinking red or solid red as the controller turns the DC loads OFF when battery voltage is low.

Photovoltaic Charge Control Mode

Depending on the model, the controller can regulate up to 60 amps of continuous photovoltaic (PV) array current at 12 or 24 volts (C60), or 12, 24 or 48 volts DC (C40) for charging batteries. This rating includes the NEC required deratings. When used in this mode, ensure that the operating mode jumper is on the charge control pins. To enable the Photovoltaic Charge Control Mode, see *Configuring the C–Series* in the installation section of this manual.

If the PV array's output increases above the rated amp level due to reflection or "edge of cloud effect," the controller will continue to operate until the heatsink reaches a maximum safe operating temperature. This will take several minutes to occur depending upon the ambient temperature involved. When the heatsink reaches the maximum safe temperature, the controller will reduce the current, cooling the transistors and the heatsink.

If the current from the PV array reaches 85 amps, the controller will turn off to protect the circuitry. In the event of a shutdown, the controller automatically resets itself after 10 minutes (if overcurrent condition is no longer present).

The C-Series charge controller rapidly cycles the current source on-and-off to control the charging current and voltage of the battery. This occurs in both the charge control mode and the diversion control mode. The amount of time the current source is connected to the battery is varied to control the average current flow. This is often referred to as "pulse width modulation" (PWM) and allows the current to be tapered, rather than coarsely turning the current off and on as with relay type PV array charge controllers.

Automatic PV Array Night Disconnect

At night, the PV array is automatically disconnected from the battery to prevent reverse leakage of power. This eliminates the need for a blocking diode between the battery and the PV array. If thin-film or amorphous solar modules are being used, diodes may still be required to prevent damage from partial shading conditions. Check the documentation provided with the PV modules.

Diversion Control Mode

The C-Series can operate as a diversion control to manage battery charging from alternative-energy sources such as wind or hydroelectric generators. Systems utilizing solar arrays do not have a requirement for diversion loads since a solar module can be open-circuited without damage. However, even with a solar based system it may be desirable to use excess power to operate DC loads. When used in this way, the C-Series controls a diversion load to redirect the excess power generated instead of allowing it to flow into the battery. This prevents damage to the charging source from an over-speed condition which could occur if the charging source is suddenly disconnected from all loads – as series relay regulators do. Consult your dealer for load and regulator size recommendations.

When the controller operates as a diversion regulator, it provides three-stage regulation of battery voltage, with temperature compensation and automatic or manual equalization. See the *Three-Stage Battery Charging* section for more information on this process.

Diversion mode requires a separate "dump" load to regulate the battery. This load must be able to absorb more power than the charging source is able to produce at its peak output, or the DC voltage will become unregulated. The dump load must be available for the diversion of power at all times. Resistive-type heating elements are the best diversion loads. Special direct current water heating elements are available. Light bulbs and motors are not recommended as diversion loads because they are unreliable.

When used in diversion mode, ensure that the operating mode jumpers are on the charge control pins. See *Configuring the C–Series* in Section 3 of this manual.

Current draw of the diversion load is very important. Problems may arise from operating with a load that is too small or too large. A diversion load that is too small will not be able to absorb all the excess power from the current source once the batteries are full.

Diversion loads in excess of 85 amps are capable of absorbing more power than the C-Series is designed to handle, resulting in an over-current shut down. During this time, the unit will not regulate electrical flow in the system, and battery damage may result.

A diversion load that draws about 25% more current than the charging source's maximum output capability is usually suitable for use with the C-Series.

1.0 INTRODUCTION

DC Load Control Mode

The C-Series can also operate as a load control (also called a low voltage disconnect) to manage the discharging of the battery. A load controller prevents damage to the battery from over-discharge during periods of poor weather or excessive loads.

When used in load control mode, ensure that the operating mode jumpers are on the load control pins. See *Configuring the C-Series* section of this booklet.

The controller delays disconnecting the DC loads for 6 minutes after the voltage drops below the low voltage disconnect (LVD) setting. Loads are either automatically or manually reconnected when battery voltage exceeds the low-voltage reconnect (LVR) setting for 6 minutes. The EQUALIZE jumper determines manual or automatic reconnect when the C-Series is used as a load controller.

When used as a DC load controller, the settings of the LVR and LVD are controlled by two rotary potentiometers on the circuit board. The scale on the adjustment potentiometers differ from the scale used for other functions. A decal with the appropriate adjustment scale is included with the C-Series and shown below. Place this scale over the pots when using the C-Series as a load controller. Do not temperature-compensate these settings. Do not install the optional battery temperature compensation sensor.

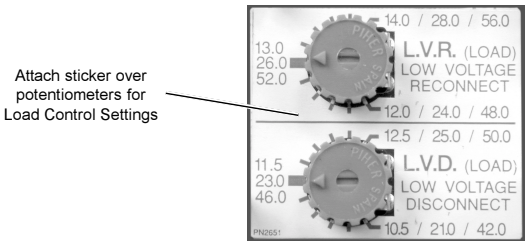


Figure 1
Sticker Displaying Load Control Voltage Settings

Features

The C-Series features include over-temperature protection, electronic over-current protection, and automatic battery temperature compensation.

Over-Temperature Protection

The temperature of the controller's transistors is continuously monitored. This protects the charge controller from damage in high temperature environments. If excessive temperatures are detected while operating in charge or diversion control mode, the controller's transistors are rapidly turned off and on to reduce the charge rate. This will reduce the transistor temperature.

As a load controller, the load is disconnected before the transistors reach an excessive temperature. Once the temperature has dropped, the loads are reconnected. When the over-temperature protection system has caused the controller to shutdown, the status LED will be orange and will blink fast (about once a second). This is the same indication shown during an over-current condition.

Electronic Over-Current Protection

During operation, the C-Series controllers continuously monitor the current flowing through it. If the current exceeds 85 amps, the transistor switches are opened, stopping the flow of electricity. The detection circuitry is faster than breakers or fuses, and they will not trip or blow when a fault occurs. When the over-current protection system is activated, the status LED will indicate orange and will blink fast (about once a second). This is the same indication as produced by an over temperature condition.

The C-Series controllers automatically resets the over-current protection system every 6 minutes. If an overload or short circuit is still present, the controller will shut off and wait another 6 minutes. This will occur continuously until the problem is corrected.

The reset switch on the right side of the controller allows the user to manually reconnect the PV array or DC loads after an over-current condition occurs. Hold the reset switch for 5 seconds to return to normal operation. If the controller is unable to restart, check the wiring and reduce the loads connected. There may be a delay after manually pressing the reset switch before reconnecting the PV array.

The shunt used to measure the current flow in the C-Series is located in the positive conductor of the circuit allowing greater flexibility in system grounding. The negative terminals are all common to one another.

2.0 FEATURES

Battery Temperature Compensation

The optional plug-in external Battery Temperature Sensor (BTS) automatically fine tunes the charging process of the C-Series. The BTS is required by UL Standard 1741 and UL approval is based on its installation. However, do not install the battery temperature sensor if you are using the C-Series as a DC load controller. The BTS may be extended by using a standard phone cable with RJ-11 plugs.

If the temperature sensor is installed, the regulation setpoints should be adjusted for a battery at room temperature (23–27 °C/74–80 °F). The C-Series adjusts the BULK and FLOAT setpoints –30 mV per degree Celsius for a 6-cell, lead-acid type battery and –20 mV per degree Celsius for a 10-cell, NiCad type battery, as required per UL Standard 1741. For 24 and 48 volt systems, the compensation is twice and four times the values listed respectively. See Table 1.

If the temperature sensor is NOT installed, the setpoints should be adjusted for the temperature of the battery during operation. Seasonal adjustment of the setpoints may be necessary to prevent battery damage and to ensure proper charging. If the battery temperature sensor is installed, no seasonal adjustments are required (see Temperature Compensation in this manual).

If the wiring to the sensor is damaged and the wires are shorted or cut, the system will return to the non-temperature compensated settings.

Install the BTS on the side of the battery below the electrolyte level. It is best to place the sensor between batteries and place the batteries in an insulated box to reduce the influence of the ambient temperature outside the battery enclosure. Ventilate the battery box at the highest point to prevent hydrogen accumulation.

CHARGER SETPOINT TEMPERATURE COMPENSATION CHART			
Battery Type	**System Voltage**		
	12 VDC	**24 VDC**	**48 VDC**
Lead Acid	0.030 volts/°C	0.060 volts/°C	0.120 volts/°C
NiCad	0.020 volts/°C	0.040 volts/°C	0.080 volts/°C

Table 1
Charger Setpoint Temperature Compensation

LED Status Indicator

A multi-color LED indicates the operating status of the controller. A color-coded label is included on the cover of the controller explaining the status LED's operation. When the controller is in Charge Control mode, the LED will be green. When in Load Control mode, the LED will be red. An orange LED indicates an error or a load disconnect condition. When battery equalization is in process, the LED alternates between red and green.

NOTE: The green and red color of the LED only indicates the particular operating mode and the battery voltage level. It does not indicate whether the charging source is functioning properly.

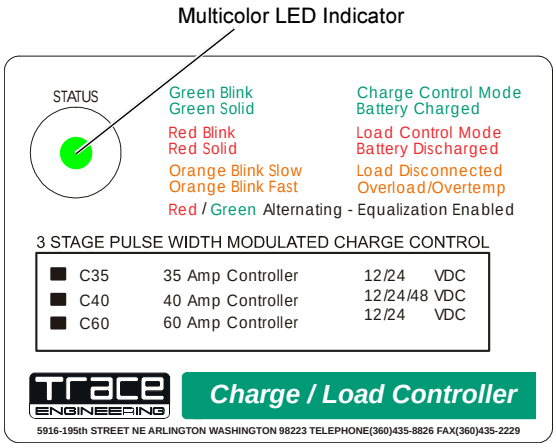


Figure 1
C–Series Front Panel Label

BATTERY VOLTAGE (Using LED Status Indicator)						
Green LED(Charge/Diversion Mode)			**LED STATUS**	**Red LED (Load Control Mode)**		
Battery at FLOAT Setting			**Always ON**	Battery at LVD Setting (for 6 minutes = LVD)		
Battery at BULK Setting			**5 Blinks**	> 0.15 above LVD	>0.30 above LVD	>0.45 above LVD
Bulk Setting Minus (-)				LVD Setting Plus (+)		
0.25 VDC	0.50 VDC	1.00 VDC	**4 Blinks**	0.15 VDC	0.30 VDC	0.45 VDC
0.50 VDC	1.00 VDC	2.00 VDC	**3 Blinks**	0.30 VDC	0.60 VDC	0.90 VDC
0.75 VDC	1.50 VDC	3.00 VDC	**2 Blinks**	0.45 VDC	0.90 VDC	1.35 VDC
> 0.75 below Bulk	> 1.50 below Bulk	> 3.00 below Bulk	**1 Blink**	> 0.45 above LVD	> 0.90 above LVD	> 1.35 above LVD
12 volts	**24 volts**	**48 volts**	**DC Voltage**	**12 volts**	**24 volts**	**48 volts**

Table 2
Battery Voltage LED Indications

2.0 FEATURES

Charge Control or Diversion Control Mode Indications

Solid Green

The battery is being charged in the FLOAT stage. The status LED remains ON solid unless the batteries drop below the float voltage setting for an accumulative period of one hour. This allows the user to confirm that the system reached the float stage during the charging process when checked at the end of the day. Reaching the float stage frequently is a good indication of proper system operation and will maximize battery life and performance.

Blinking Green

The controller is in the CHARGE CONTROL or DIVERSION CONTROL mode and the battery is not fully charged. As the battery voltage approaches the BULK setting, the status LED will blink green several times (up to five) and then pause, indicating the battery voltage is approaching the bulk setting and provides an indication of the battery condition. Refer to Table 2 on the previous page to determine the battery voltage.

NOTE: A single green flash indicates the battery is below the bulk voltage setting. It does NOT indicate the batteries are charging.

Load Control Indications

Solid Red

The controller is in the DC LOAD CONTROL mode and the battery voltage has reached the Low Voltage Disconnect (LVD) setting. After a 6-minute delay, DC loads will be disconnected unless the user reduces the loads to a point that the battery voltage exceeds the LVD setting.

Blinking Red

As battery voltage approaches the LVD setting, the LED will blink red several times (up to five) and then pause providing an indication of battery voltage. Refer to Table 2 on the previous page to determine the battery voltage.

Slow Blinking Orange

The controller is in the DC LOAD CONTROL mode and has disconnected the loads due to reaching the LVD setting. The user can press the reset switch for a maximum 10-minute “grace” period, or can wait until the voltage rises above the Low Voltage Reconnect (LVR) setting to allow an automatic reset to occur.

Equalization Mode Indication

Alternating Red and Green

The controller is in the EQUALIZE mode. It will automatically stop the equalization process after accumulating two hours of operation at a voltage above the BULK setting. The user can stop the equalization process at any time by pressing the reset switch until the status LED stops alternating red and green.

Error Mode Indication

Fast Blinking Orange

The controller detected an over-current or an over-temperature condition and the loads are disconnected. The controller will try to automatically restart the loads after a 6-minute delay. If the controller will not restart, turn off all loads and press the reset switch. If it then restarts, the loads may be too large. A delay up to five seconds may occur before the controller attempts to restart after pressing the reset switch.

Installation

The C-Series controllers are state-of-the-art precision electronic instruments. Installation, environment, mounting, and wiring must be accomplished in accordance with applicable local and national electrical codes. The instructions that follow are applicable to the typical installation. For special applications, consult a qualified electrician or your Trace™ dealer. Installation procedures will vary according to your specific application.

Mounting

The C-Series controllers are designed for indoor mounting. Care should be taken in selecting a location and when mounting the enclosure. Avoid mounting it in direct sunlight in order to reduce heating of the enclosure and subsequent high operating temperatures. The enclosure should be mounted vertically on a wall.

Mounting and enclosure dimensions are shown in Figure 2 (the C-35 controller does not feature an external heat sink). Remove the faceplate on the controller and locate the upper two screw locations on the wall. The back of the enclosure is provided with keyholes for mounting. Leave the screw heads backed out approximately 1/4 inch (6 mm) or less. Place the controller onto the screws and pull it down into the keyhole slots. Then insert the two lower screws to lock the enclosure onto the wall. Provide either strain-relief clamps or conduit to prevent damage to the circuit board and terminal block from pulling on the wires. The cover should be replaced and retained with the screws provided (#10-32 x 3/8" SMS).

In outdoor installations, the C-Series units must be installed in a rainproof enclosure to eliminate exposure to rain or water-spray. The use of conformal-coated circuit boards, plated terminals, powder-coated metal components, and stainless steel fasteners improves tolerance to hostile environments.

CAUTION: INSTALL THE C-SERIES CONTROLLER IN A DRY, PROTECTED LOCATION AWAY FROM SOURCES OF HIGH TEMPERATURE, MOISTURE, AND VIBRATION. EXPOSURE TO SALTWATER IS PARTICULARLY DESTRUCTIVE. CORROSION OF THE CIRCUIT BOARD IS NOT COVERED BY THE WARRANTY.

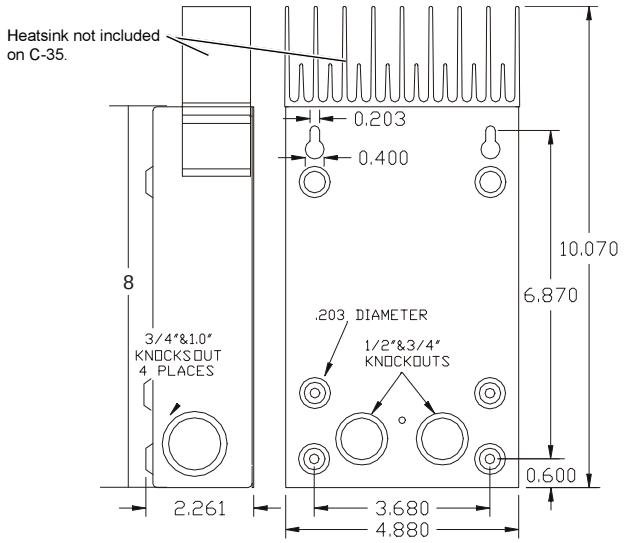


Figure 2
C–Series Dimensions

Do not locate the C-Series controller in a sealed compartment with the batteries. Batteries can vent hydrogen sulfide gas, which is corrosive to electronic equipment. Batteries also generate hydrogen and oxygen gas that can explode when exposed to a spark.

If using “sealed” batteries, the controller can be mounted in the same enclosure as long as it is adequately ventilated.

3.0 INSTALLATION

Wiring

Disconnect battery and PV sources before wiring. Set the voltage selection jumper to the appropriate setting before energizing the system (see *User Configuration Options* for instructions). Incorrect settings may result in damage to the system as charging regulation will not occur. Torque the terminals to 20 inch-pounds for 14-10 AWG (25 for 8 AWG, 35 for 6 AWG) once the wires have been installed. Replace the cover.

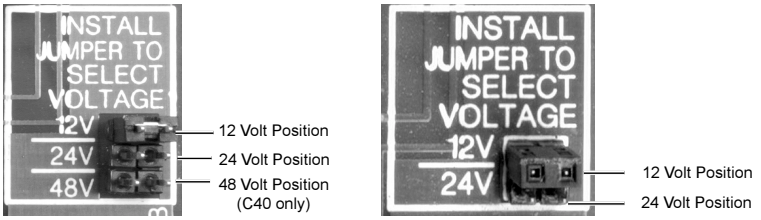


Figure 3
Voltage Selection Jumper

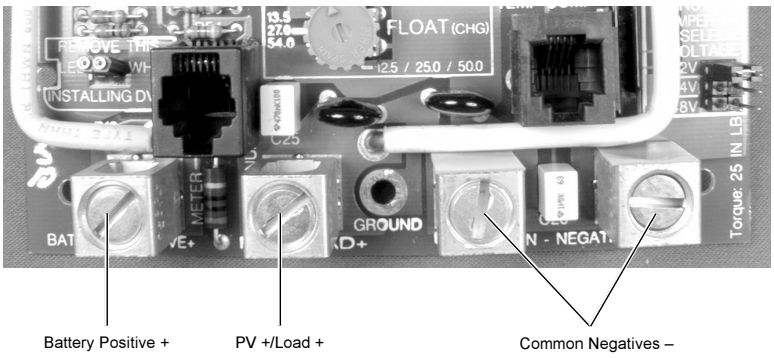


Figure 4
Battery Connection Terminals

NOTE: Regardless of configuration, only the positive conductor from a PV array OR a DC load may be connected to the terminal marked “PV POS/LOAD.”

Minimum Recommended Wire Size

The minimum recommended wire gauge is #8 AWG (for C35 and C40) with a 75 °C insulation rating and #6 AWG, 90 °C wire for the C60. The terminals on the C-Series will accept up to #2 AWG (33.6 mm^2) copper or aluminum wire, however, UL specifications only allow the use of up to #6 AWG (13.3 mm^2) maximum. No crimp-on terminals or lugs are required.

Each model of the C–Series controller is rated for a maximum continuous current of 35, 40 or 60 amps. Since PV outputs can vary due to the array size or sunlight striking it, the safe minimum wire size should be based on the maximum current ratings. The NEC requires conductors and over-current devices be operated at no more than 80% of their rating. Refer to Table 3 below for a listing of the minimum wire size to use for each model.

CONTROLLER	MINIMUM WIRE SIZE	OVER-CURRENT DEVICE RATING
C35	#8 AWG	45 amps
C40	#8 AWG	50 amps
C60*	#6 AWG (90 °C wire)	60 amps (listed 100% duty)
C60**	#4 AWG (75 °C wire)	60 amps (listed 100% duty)

Table 3
Minimum Wire Size

NOTE: *To meet UL requirements, use #6 AWG, 90 °C wire and a 60 amp LISTED 100% DUTY over-current device for the C60 controller.

** Not approved by UL for direct connection into the controller. Use a splicer block as specified below and #6 AWG (90 °C wire) to connect to the controller terminals.

If there is a significant distance between the PV array and the controller and/or the controller and the battery, larger wires can be used to reduce the voltage drop and improve performance. Refer to Table 4.

To use a larger size wire, use a splicer block (terminal block) intended for this purpose. This allows the larger cable size from the batteries to be "spliced" to the smaller wire size connected to the controller. Split-bolt kerneys can also be used for wire splices. Follow manufactures recommendations for torque and mounting (if required). Splicer blocks and split-bolt kerneys are available from alternative energy suppliers.

Maximum One-way Distance and Wire Size

NOTE: NEC article 690 and local electrical codes should be consulted for wire sizing and any additional installation requirements. For a C60 use a 60 amp, 100% Continuous Duty breaker and #6 AWG, 90 °C wire. Larger wire sizes may be used to improve performance, but are NOT approved by UL to be installed in the controller (use a splicer block as previously described on page 13 of this manual). Match the breaker to the wire if using larger gauge wire.

Refer to Table 4 and find your maximum current in the left column, and the one way distance from your power source (feet/meters) to the C-Series controller (or the distance from the C-Series controller to your load) on the same line, then read the wire size required at the top of the column.

The wiring, over-current protection devices (fuses and circuit breakers) and installation methods used must conform to all national and local electrical codes requirements.

Wiring should be protected from physical damage with conduit or a strain relief clamp. You should pull the temperature sensor cable through the conduit first as the connector may not fit if other wires have been pulled first.

As a minimum, a 60 amp DC rated current limiting fuse or circuit breaker should be provided near the battery for protection from short circuits. To meet NEC requirements, use a 60 amp circuit breaker listed for 100% duty for the C60. To meet UL requirements, use #6 AWG copper wires rated for 90 °C for the C60.

Maximum One-way Wire Distance for a < 3% Voltage drop
12 VDC Application Shown
For 24 VDC Systems, Multiply distance by 2
For 48 VDC Systems, Multiply distance by 4

	Distance in Feet (meters)				Distance in Feet (meters) These Wire Sizes are not approved by UL as it exceeds their maximum wire size specification					
Amps	**12 AWG**	**10 AWG**	**8 AWG**	**6 AWG**	**4 AWG**	**3 AWG**	**2 AWG**	**1 AWG**	**1/0 AWG**	**2/0 AWG**
10	8.8 ft. (2.68 m)	14 ft. (4.27 m)	22.2 ft. (6.77 m)	35.3 ft. (10.76 m)	56.1 ft. (17.09 m)	70.9 ft. (2.68 m)	89.6 ft. (27.31 m)	112.5 ft. (34.29 m)	141.7 ft. (43.19 m)	225.8 ft. (68.82 m)
12	7.3 ft. (2.23 m)	11.6 ft. (3.54 m)	18.5 ft. (5.64 m)	29.4 ft. (8.96 m)	46.7 ft. (14.23 m)	59.1 ft. (21.61 m)	74.6 ft. (22.74 m)	93.7 ft. (28.56 m)	118.1 ft. (36.00 m)	188.2 ft. (57.36 m)
14	6.3 ft. (1.92 m)	10 ft. (3.05 m)	15.9 ft. (4.85 m)	25.2 ft. (7.68 m)	40.1 ft. (12.22 m)	50.6 ft. (15.42 m)	64.0 ft. (19.51 m)	80.4 ft. (24.39 m)	101.2 ft. (30.85 m)	161.3 ft. (49.16 m)
16	5.5 ft. (1.68 m)	8.7 ft. (2.44 m)	13.9 ft. (4.24 m)	22.1 ft. (6.74 m)	35.0 ft. (10.67 m)	44.3 ft. (13.50 m)	56.0 ft. (17.07 m)	70.3 ft. (21.43 m)	88.6 ft. (27.01 m)	141.2 ft. (43.04 m)
18	4.9 ft. (1.49 m)	7.8 ft. (2.38 m)	12.4 ft. (3.78 m)	19.6 ft. (5.97 m)	31.2 ft. (9.51 m)	39.4 ft. (12.01 m)	49.8 ft. (15.18 m)	62.5 ft. (19.05 m)	78.7 ft. (23.99 m)	125.5 ft. (38.25 m)
20	4.4 ft. (1.34 m)	7 ft. (2.13 m)	11.1 ft. (3.38 m)	17.6 ft. (5.36 m)	28.0 ft. (8.53 m)	35.4 ft. (10.79 m)	44.8 ft. (13.66 m)	56.2 ft. (17.13 m)	70.9 ft. (21.61 m)	112.9 ft. (34.41 m)
25		5.6 ft. (1.71 m)	8.9 ft. (2.71 m)	14.1 ft. (4.30 m)	22.4 ft. (6.83 m)	28.3 ft. (8.63 m)	35.8 ft. (10.91 m)	45.0 ft. (2.68 m)	56.7 ft. (17.28 m)	90.3 ft. (27.52 m)
30		4.7 ft. (1.43 m)	7.4 ft. (2.26 m)	11.8 ft. (3.59 m)	18.7 ft. (5.67 m)	23.6 ft. (7.19 m)	29.9 ft. (9.11 m)	37.5 ft. (13.7 m)	47.2 ft. (14.39 m)	75.3 ft. (22.95 m)
35			6.4 ft. (1.95 m)	10.1 ft. (3.08 m)	16.0 ft. (4.88 m)	20.2 ft. (6.16 m)	25.6 ft. (7.80 m)	32.1 ft. (9.78 m)	40.5 ft. (12.34 m)	64.5 ft. (19.66 m)
40			5.6 ft. (1.71 m)	8.8 ft. (2.68 m)	14.0 ft. (4.27 m)	17.7 ft. (2.68 m)	22.4 ft. (6.83 m)	28.1 ft. (8.56 m)	35.4 ft. (10.79 m)	56.5 ft. (17.22 m)
45				7.8 ft. (2.38 m)	12.5 ft. (3.81 m)	15.7 ft. (4.79 m)	19.9 ft. (6.07 m)	25.0 ft. (7.62 m)	31.5 ft. (9.60 m)	50.2 ft. (15.30 m)
50				7.1 ft. (2.16 m)	11.2 ft. (3.41 m)	14.2 ft. (4.33 m)	17.9 ft. (5.46 m)	22.5 ft. (6.86 m)	28.3 ft. (8.63 m)	45.2 ft. (13.78 m)
60				6.3 ft. (1.92 m)	9.3 ft. (2.83 m)	11.8 ft. (3.60 m)	14.9 ft. (4.54 m)	18.7 ft. (5.7 m)	23.6 ft. (7.19 m)	37.6 ft. (11.5 m)

Table 4
One-way Wire Distance and Wire Size

PV Charge Control Mode Cabling

Photovoltaic arrays generate current whenever light strikes the surface of the array. Before connecting the C-Series controller, cover or disconnect the array to prevent any current from being generated.

- Remove one or more of the knockout plugs on the controller's case and feed the connecting wires through it.
- Connect the PV array's positive (+) output to the terminal marked PV POS/ LOAD at the bottom of C-Series's circuit board and tighten the lugs.
- Connect the PV array's negative (–) output to the terminal marked COMMON NEGATIVES and tighten the lugs.
- Connect the battery positive (+) cable to the terminal marked BAT POS and tighten the lugs.
- Connect the negative (–) battery cable to the terminal marked COMMON NEGATIVES and tighten the lugs.
- Secure the cabling with strain reliefs after allowing a little slack inside the case to prevent damage to the controller's circuit board.

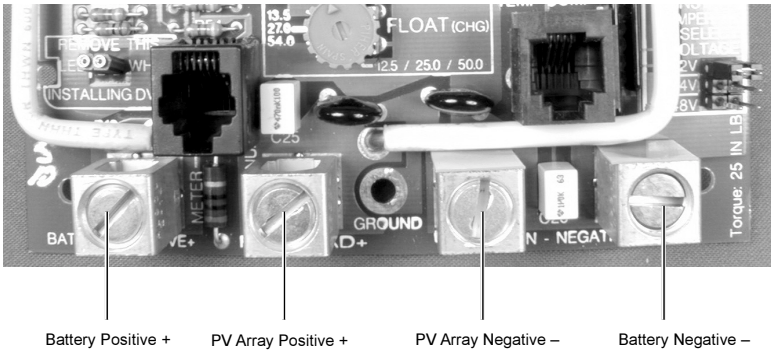


Figure 5
PV Charge Control Mode Wiring

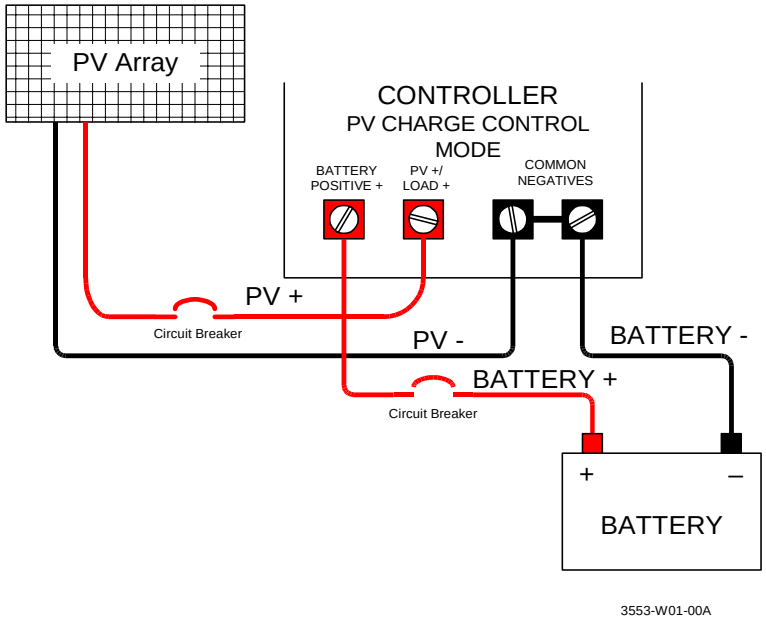


Figure 6
PV Charge Control Wiring Diagram

Diversion Control Mode Cabling

When using the C-Series unit as a diversion or DC load controller, the DC load needs to be connected to the controller terminals marked as PV POS/LOAD and COMMON NEGATIVE. The common negatives can be reversed or wired with an appropriately sized single conductor to a more convenient location such as a DC load center negative bus.

- Connect your DC current source (PV, wind, hydro, etc.) directly to a battery.
- Connect an appropriately-sized cable from the positive battery terminal to the controller terminal marked BAT POS.
- Connect a cable from the negative battery terminal to the terminal marked COMMON NEGATIVES on the controller's circuit board.
- Connect a cable from the controller's terminal marked PV POS/LOAD to the positive terminal of your DC diversion load.
- Connect a cable from the controller's terminal marked COMMON NEGATIVES to the negative terminal of your DC diversion load.
- Tighten the terminal lugs to 20 inch-pounds for #14-10 AWG (25 for #8 AWG, 35 for #6 AWG). Allow a little slack on the cables within the controller and secure the wiring with strain reliefs.

NOTE: Do not use light bulbs for diversion loads. Use only resistive loads such as air- or water-cooled heating elements.

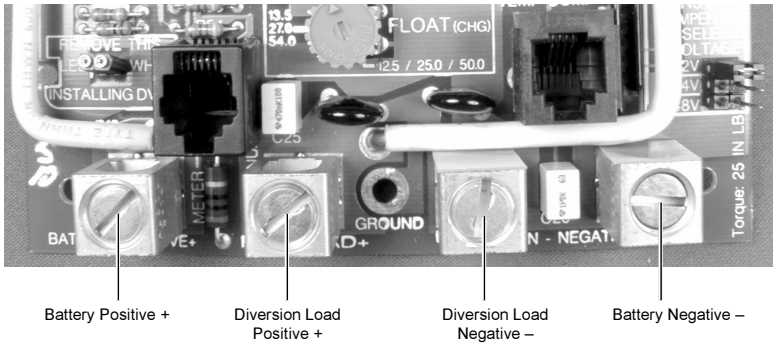


Figure 7
PV Load Diversion Wiring

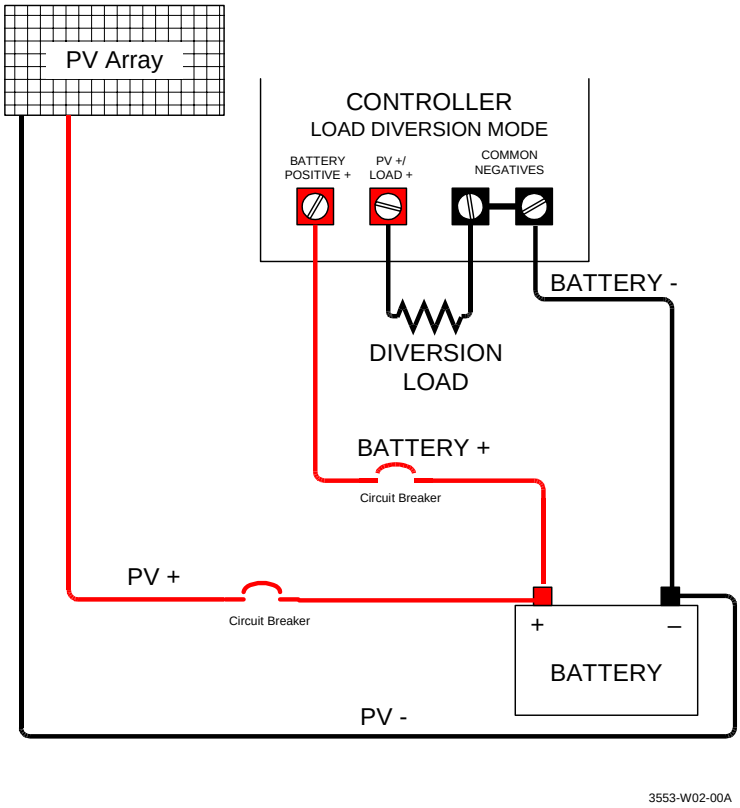


Figure 8
Load Diversion Wiring Diagram

DC Load Control Mode Cabling

- Connect the positive battery cable to the terminal marked BAT POSITIVE on the controller.
- Connect the negative battery cable to the terminal marked COMMON NEGATIVES.
- Connect a cable between the PV POS/LOAD terminal on the controller and the positive terminal on the DC load.
- Connect a cable between the controller's COMMON NEGATIVES terminal and to the negative terminal of the load.

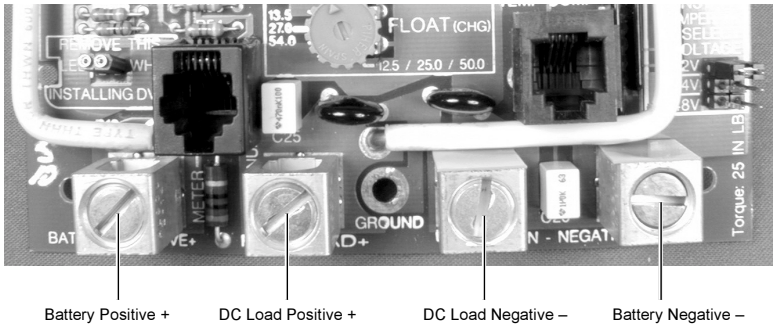


Figure 9
Load Control Wiring

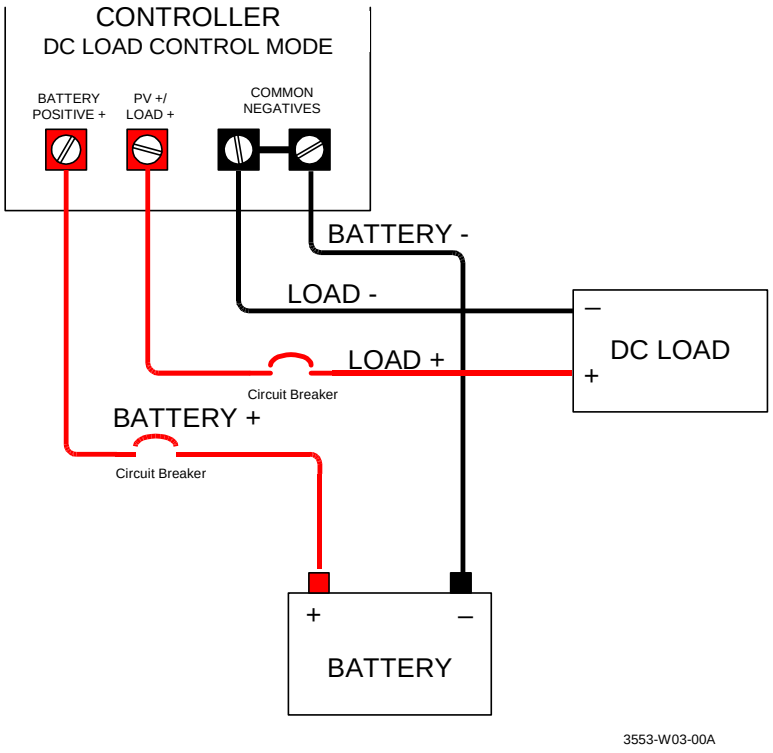


Figure 10
Load Control Wiring Diagram

3.0 INSTALLATION

Grounding

The C-series controllers are designed to work with both negative ground and ungrounded electrical systems. The metal chassis of this charge/load controller must be grounded for either system by connecting it with a copper wire to a grounding electrode such as a ground rod driven into the earth.

If a negative ground system is desired, connect the negative current carrying conductor to the grounding system at one point in the system. Consult local and national electrical codes for more information and any additional requirements.

Configuring the C-Series

Three sets of jumpers are located on the right side of the controller's circuit board. These jumpers control equalization, low voltage reconnect, battery voltage, and operating modes. They must be set correctly for the unit to operate to its maximum potential.

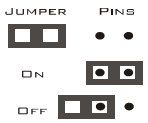


Figure 11
Jumpers

The C-Series controllers are equipped with several of these jumpers. Each are discussed in the appropriate section of this manual. The factory default settings are shown below.

	C40	C35, C60
Battery Voltage	12 volts DC	12 volts DC
Equalize/LVR	Manual Equalization	Manual Equalization
Operating Mode	Charge Control	Charge Control

Table 5
Factory Default Settings for C-Series Controllers

3.0 INSTALLATION

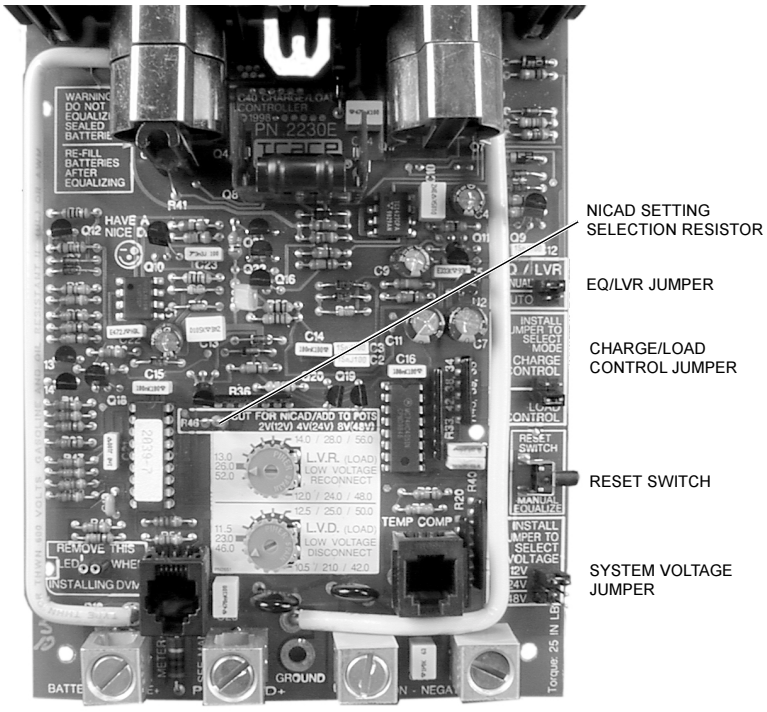
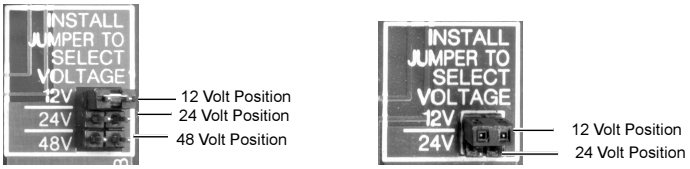


Figure 12
Configuration Jumpers Location

Automatic/Manual Battery Equalization (EQ) and Low Voltage Reconnect (LVR)

Enables automatic or manual battery equalization in Charge Control mode, and automatic or manual reconnect in the event of low voltage at the BAT POS terminal in Load Control mode. When AUTO is enabled in Load Control mode, the unit will reconnect automatically when voltage at the BATTERY POSITIVE terminal exceeds the LVR setting. Factory setting is *manual equalization* and *manual reconnect*.



C40 C35 and C60

Figure 13
Voltage Selection Jumper

Operating Mode

This jumper determines the operating mode: PV Charge Control and Diversion Control mode, or Load Control mode. Factory setting is Charge Control mode.

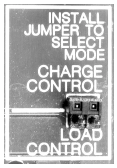


Figure 14
Operating Mode Jumper

Reset Switch

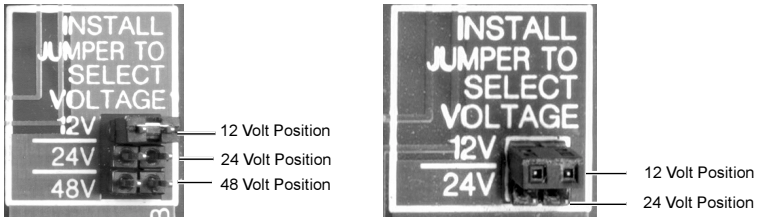
Press and hold to manually initiate or suspend battery equalization in Charge Control mode. Press and release to reset following an error condition. Press and release to reconnect following a low-voltage disconnect event. If voltage remains below the LVD setting, the unit will disconnect after a 6-minute 'grace' period.

Figure 15
Reset Switch Jumper

Voltage

This jumper determines the voltage of the system that the controller will be used with. Connect the two pins adjacent to the legend for the voltage of your system: 12, 24, 48. Factory setting is 12 volts for the C35, C40 and C60. The maximum DC voltage allowed is 125 VDC for a C40, and 55 VDC for the C35 and C60.

If the optional LCD meter (DVM/C40 or CM/R) is attached to the C-Series controller, be sure to set the jumper on the back of it for the appropriate system voltage. The jumper for limiting power consumption and dimming the CM display is also located on the back of the LCD Displays.



C40 C35 and C60

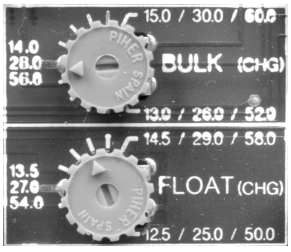
Figure 16
Voltage Selection Jumper

Adjusting the C-Series

The charging rate and voltage reconnect/disconnect setting of the controller are adjustable via two rotary potentiometer controls. The knobs are removable to reduce the likelihood of tampering with the settings. Calibrated scales are provided to allow setting of the control without requiring the use of a digital voltmeter. Visual adjustment allows an accuracy of ± 0.1 volts.

Setting Voltage Parameters

In Charge Control mode, you can adjust the bulk and float charging voltage by adjusting the potentiometers (pots) located in the bottom center of the controller's circuit board (for more information regarding bulk and float charging rates, see the *Three-Stage Battery Charging Process* section of this manual). The potentiometer scale for bulk charge voltage is calibrated from 13.0 to 15.0 volts (when the voltage jumper is set for a 12 volt system) in increments of 0.2 volts, from 26.0 to 30.0 volts (24 volt system) in increments of 0.4 volts, or from 52.0 to 60.0 volts (48 volt system) in increments of 0.8 volts. For float charge voltage, the potentiometer scale is calibrated from 12.5 to 14.5 volts (12 volt system), 25.0 to 29.0 volts (24 volt system), and from 50.0 to 58.0 volts (48 volt system) with the same increments as above.



Charge/Diversion Control Mode

Figure 17
BULK and FLOAT Voltage Adjustment Potentiometers

Testpoints for Voltage Settings

At midrange on these scales, a testpoint is provided for use with a DC digital voltmeter for assuring more accurate adjustment. The pots are equipped with removable knobs to prevent accidental adjustments by the curious or uninformed. If the knobs are missing, a 5/64" hex-head driver can be used to adjust the settings. A digital voltmeter can be connected from the COMMON NEGATIVE terminal on the circuit board and the small testpoint located to the left of each adjustment pot at the nine o'clock position. The testpoint provides a reading from 0 to 2 volts; this value must be added to the lower value of the adjustment range (Bulk=13.0, Float=12.5, LVR=12.0, LVD=10.5). Multiply this value by 2 for 24 V and by 4 for 48 V.

For example, to set the bulk voltage to 14.4 volts, adjust the potentiometer until the DVM displays 1.4 volts (13.0 V + 1.4 V = 14.4 V). To set bulk to 28.2, adjust the pot until the DVM displays 1.10 volts (1.10 x 2 [24 volt] = 2.2 + 26.0 = 28.2). When using NiCad type batteries, add another 2 (12-volt), 4 (24-volt) or 8 (48-volts) to the settings.

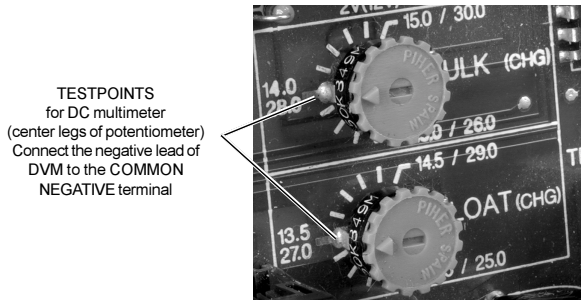
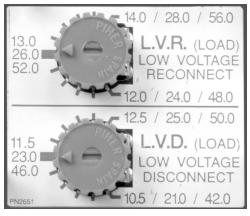


Figure 18
DC Testpoints for Bulk and Float

If you are using the unit as a DC load controller, be sure to set the potentiometers as shown in the *DC Load Control* section of this manual. The upper knob's settings are reduced by 1 volt, resulting in a range of 14.0 VDC to 12.0 VDC (for a 12-volt system). The lower knob's settings are reduced by 2 volts, resulting a range of 12.5 to 10.5 VDC (for a 12-volt system).



Load Control Mode (sticker)

Figure 19
DC Load Control Adjustment Sticker

Equalization

CAUTION: DO NOT EQUALIZE GEL OR SEALED TYPE BATTERIES!

The C-Series offers either manual or automatic triggering of the equalization process (the default setting is manual). Automatic equalization is enabled by moving the jumper located on the right side of the circuit board above the reset switch. When automatic has been selected, an equalization charge will occur every 30 days (holding the voltage 1 volt for 12-volt systems, 2 volts for 24-volt systems, and 4 volts for 48-volt systems, above the bulk setting for 2 hours). During the equalization process the status LED indicates equalization by alternately blinking green and red. (Equalization is not recommended for NiCad batteries and is disabled when the R46 resistor is cut).

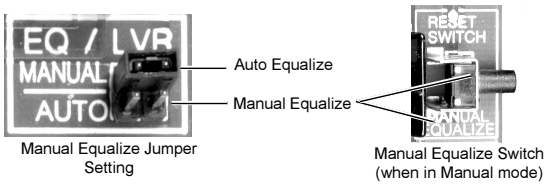


Figure 20
Equalization Settings

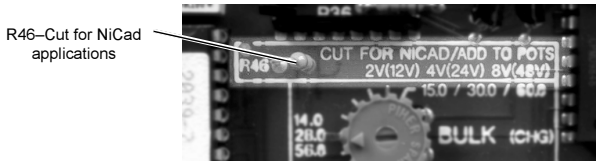


Figure 21
Equalization Settings

Manual Equalization

Manual equalization of the battery can be enabled by pressing the reset switch on the right side of the C-Series for 10 seconds. The status LED indicator will begin to alternate between red and green once equalization is enabled. The equalization process will continue until the batteries have been held at or above the bulk setting for two hours of accumulated time. During the equalization process, the battery voltage will be limited to 1 volt above the bulk setting for 12-volt systems (2 volts for 24-volt systems, and 4 volts for 48-volt systems). Once the battery voltage has been at or above the bulk setting for a cumulative period of two hours, the C-Series will return to the float stage of the charging process.

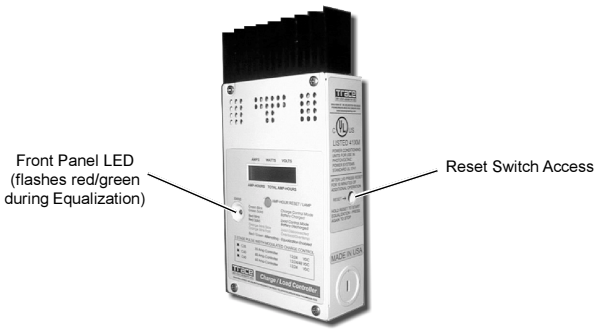


Figure 22
C40 Front and Side Panel

To stop the equalization process, press the reset switch. The status LED will stop alternating between red and green. If the equalization process was shorter than one hour, the controller will continue with a bulk charge cycle and then hold the battery at the bulk setting for one hour (the absorption stage) before returning to the float setting.

During the equalization process the status LED will alternate between red and green and will not provide any other mode/status indication. Large battery banks may need several equalization cycles to fully stir the electrolyte and charge the cells. These cycles should follow one another until the battery voltage reaches the upper limit for the full two hours.

Automatic Equalization

CAUTION: DO NOT EQUALIZE GEL OR SEALED TYPE BATTERIES!

The C-Series controllers can automatically trigger an equalization charge every 30 days. The status LED will indicate that the equalization process is occurring. The equalization process will continue until the voltage has been held above the bulk setting for a cumulative period of two hours. This might take several days on larger systems with big batteries and small PV arrays. The battery voltage only needs to exceed the bulk setting for the timer to start counting–the voltage may not reach the equalization voltage setting.

To enable automatic equalization, the jumper located on the right side of the circuit board must be moved to the AUTO setting. The default setting of the C-Series controllers is for manual equalization. To disable the automatic equalization system, move the equalize jumper.

To manually stop the equalization process, press the reset switch on the right side of the unit until the status LED stops alternating between red and green. If the equalization process was shorter than one hour, the controller will continue with a bulk charge cycle and then hold the battery at the bulk setting for one hour (the absorption stage) before returning to the float setting. Once a manual equalization has been triggered, the 30-day period to the next automatic equalization will be restarted. To prevent automatic equalization, move the equalize jumper to the manual position.

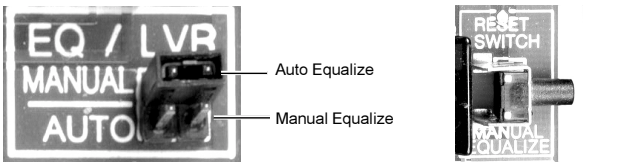


Figure 23
Equalize Jumper and Reset Switch

Temperature Compensation

If a Battery Temperature Sensor (BTS) is installed, the charge controlling process will be automatically adjusted for the battery temperature. Set bulk and float voltage for a battery at normal room temperature 74–80 °F (23–27 °C). Actual voltage may vary above or below these settings due to adjustment for battery temperature.

If no Battery Temperature Sensor (BTS) is installed and the batteries will be operating in very hot or very cold conditions, adjust the bulk and float settings to allow for the battery temperature. The recommended adjustments can be found in the table below. The setting should be lowered for ambient temperatures above 80 °F (27 °C) and raised for ambient temperature below 75 °F (23 °C). If significant seasonal variations are common, you will have to change the settings several times a year to prevent battery damage and ensure proper operation.

NOTE: Do NOT compensate the settings when using the C-Series controller as a DC load controller.

CHARGER SETPOINT TEMPERATURE COMPENSATION CHART			
Battery Type	**System Voltage**		
	12 VDC	**24 VDC**	**48 VDC**
Lead Acid	0.030 volts/°C	0.060 volts/°C	0.120 volts/°C
NiCad	0.020 volts/°C	0.040 volts/°C	0.080 volts/°C

Table 6
Temperature Compensation

Temperature compensation is based on battery type: 5 mV/cell for lead acid type batteries and 2 mV/cell for alkaline type batteries (NiCad or NiFe).

Setting LVR and LVD (Load Control Mode)

To change the low voltage disconnect (LVD) and low voltage reconnect (LVR) settings, use the same BULK and FLOAT potentiometers.

When the C-Series is wired for **DC Load Control** mode, the potentiometer's scale calibration is altered from what is printed on the circuit board. A sticker is provided with the C-Series with the proper scale calibrations for the Load Control mode. The BULK potentiometer becomes the Low Voltage Reconnect (LVR), and the FLOAT potentiometer becomes the Low Voltage Disconnect (LVD). Place the sticker provided over the potentiometers. The knobs may have to be removed for sticker placement, then reinstalled. The sticker is packed inside the C-Series (bottom of unit).

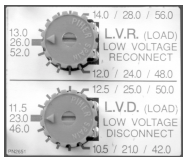


Figure 24
DC Load Control Adjustment Sticker

If the sticker is lost, follow these instructions for voltage calibration using the scale printed on the C-Series circuit board.

From the scale shown on the circuit board for the LVR setting (BULK setting when in Charge Control mode), subtract 1 volt for 12-volt systems, 2 volts (for 24-volt systems), and 4 volts (for 48-volt systems).

From the scale shown for the LVD setting (FLOAT setting in Charge Control mode), subtract 2 volts for the 12-volt system, 4 volts for a 24-volt system, and 8 volts for a 48-volt system.

Subtract the proper voltages from the values printed on the circuit board, if the sticker is missing

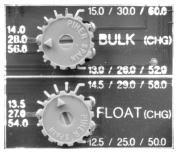


Figure 25
DC Load Control Adjustment Sticker

MANUAL reconnect of the loads is allowed when voltage has not exceeded the LVR setting. To reconnect the loads, press the reset button on the right side of the unit. If the voltage is below the LVR level, the DC load can be reconnected for approximately 6 minutes. Multiple reconnects are allowed, but the "on" time duration will vary with battery voltage. The EQUALIZE jumper allows the controller to be set for AUTO reconnect of the dc load when the voltage exceeds the LVR setting.

NOTE: The LED will light red only in Load Control mode; never in Charge or Diversion mode (unless it is reversed upon reinstallation).

Setting Diversion Control Mode

When the C-Series controller is configured for Diversion Control mode, you can set the voltage at which the unit begins diverting current (high voltage diversion). The unit will continue diverting excess current to the diversion load until the source voltage falls to the Bulk setting. After two hours at the Bulk setting, the unit will reduce the battery charging voltage to the Float voltage setting. This will usually result in more current being diverted to the diversion load.

The flashing rate of the LED indicates the battery state of charge. Solid green indicates the battery is fully charged (float mode). Five flashes indicates the battery is in Bulk mode. As the flashing rate decreases, the battery is discharged to a lower voltage level (i.e., somewhere below the Bulk voltage setting). Table 7 indicates the approximate level the battery is below the Bulk voltage setting.

As an example, if the system battery voltage is 24 volts and the internal Bulk voltage setting is set for 26 volts, you can calculate approximately how much below the Bulk setting the batteries are by subtracting the number in Table 7 from 26 (the internal Bulk setting). With the LED indicating two blinks, the battery voltage is approximately 24.5 volts (26 volts Bulk setting minus 1.50 volts in the table). With the LED indicating one blink, the battery voltage is somewhere below the 24.5 volts, indicating the battery may be seriously damaged.

NOTE: The LED will light green only in Diversion and Charge Control mode (unless it is reinstalled backwards).

BATTERY VOLTAGE (Using LED Status Indicator)						
Green LED(Charge/Diversion Mode)			LED STATUS	Red LED (Load Control Mode)		
Battery at FLOAT Setting			Always ON	Battery at LVD Setting (for 6 minutes = LVD)		
Battery at BULK Setting			5 Blinks	> 0.15 above LVD	>0.30 above LVD	>0.45 above LVD
Bulk Setting Minus (-)				LVD Setting Plus (+)		
0.25 VDC	0.50 VDC	1.00 VDC	4 Blinks	0.15 VDC	0.30 VDC	0.45 VDC
0.50 VDC	1.00 VDC	2.00 VDC	3 Blinks	0.30 VDC	0.60 VDC	0.90 VDC
0.75 VDC	1.50 VDC	3.00 VDC	2 Blinks	0.45 VDC	0.90 VDC	1.35 VDC
> 0.75 below Bulk	> 1.50 below Bulk	> 3.00 below Bulk	1 Blink	> 0.45 above LVD	> 0.90 above LVD	> 1.35 above LVD
12 volts	24 volts	48 volts	DC Voltage	12 volts	24 volts	48 volts

Table 7
Battery Voltage LED Indications

C-Series LCD Meter Displays

Two optional LCD digital meter displays are available for the C-Series controllers; the DVM/C40 replaces the standard faceplate on the C-Series controller and the CMR/50 or CMR/100 mounts remotely. The remote version is available with either 50 foot or 100 foot cables. Longer runs may be possible (up to 1000 ft/305 m) because the communication is a serial-data type link.

These displays include a two-line, 32-character LCD and a status LED indicator.

The LCD displays provide the following information:

- PV Array or DC load pass-through current: 0 to 85 amps DC
- Battery voltage: 4 to 100 volts DC
- Watts: 0 to 3600 watts (volts times amps)
- Amp-hours: 0 to 65536 Ah; can be reset to 0
- Totalizing amp-hours: 0 to 65536 Ah; resets to zero when power is disconnected
- Status LED: green, red, or orange

If the C-Series controller is disconnected from the battery or the meter cable, the meter will be reset when it is powered up. Press and hold the push-button on the front of the meter to manually reset the amp-hour meter. Press and release this button to turn the backlight on or off. An adjustable potentiometer on the back of the meter enables you to adjust the contrast of the LCD display. When installing the meter, be sure to set the jumper on the printed circuit board over the pin set to match the controller board for the system voltage, either 12, 24, or 48 volts.

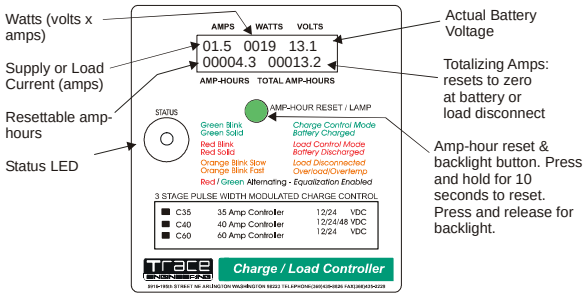


Figure 26
DVM/C40 Front Panel

Installing the DVM/C40

To install the faceplate LCD:

- Disconnect all power sources and remove the factory-installed faceplate by removing the four Phillips-head screws.
- Pull out the LED indicator near the bottom left corner of the controller's printed circuit board (PCB) just above the BATTERY POSITIVE + connector.
- Plug the yellow cable on the CM display into the six-conductor modular RJ15 connector adjacent to the LED that you just removed.
- Align the faceplate and reinstall the screws.

If the LED must be replaced in the future, it will operate in either orientation, except if replaced incorrectly, the color of the status LED will be reversed.

The connecting cable for the display is a six-conductor telephone cable with modular type connectors (RJ15). Although any telephone-type cable will work, the cables provided with the displays use stranded and tin plated wire for better performance and longer life.

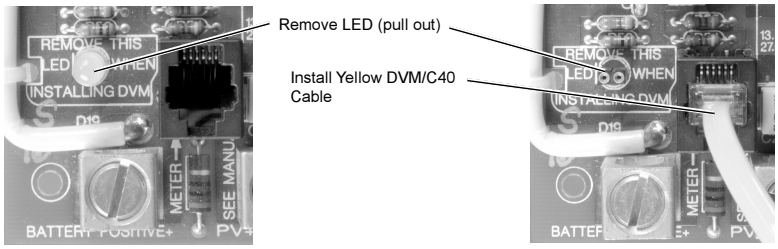


Figure 27
Remove LED and Install Cable

Mounting the CM/R

The CM/R is a remotely-mounted digital LCD multimeter, which can be permanently installed in a wall or cabinet. The unit can also be surface-mounted with relief behind it, and it can be located up to 1000 feet (305 meters) from the C-Series controller itself. If the CMR appears inaccurate or unusual on runs over 100 feet from the controller, remove the jumper located below the voltage configuration pins on the back of the CM/R. This dims the LCD backlight, reduces power consumption and improves meter accuracy.

Three-Stage Battery Charging

Battery voltage and current vary during the three-stage charging process as follows.

BULK

During this stage, the batteries are charged at the bulk voltage setting and maximum current output of the DC source. When the battery voltage reaches the BULK voltage setting, the controller activates the next stage (absorption). During the bulk charging process, the status LED (green) may blink from one to five times before pausing. The more times it blinks consecutively, the closer the battery voltage is to the BULK voltage setting.

ABSORPTION

During this stage, the voltage of the battery is held at the BULK voltage setting until an internal timer has accumulated one hour. Current gradually declines as the battery capacity is reached. During the ABSORPTION stage, the status LED (green) blinks five times, then pauses and repeats.

FLOAT

During this stage, the voltage of the battery is held at the FLOAT voltage setting. Full current can be provided to the loads connected to the battery during the float stage from the PV array. When the controller has reached the FLOAT stage, the status LED (green) will be solid green.

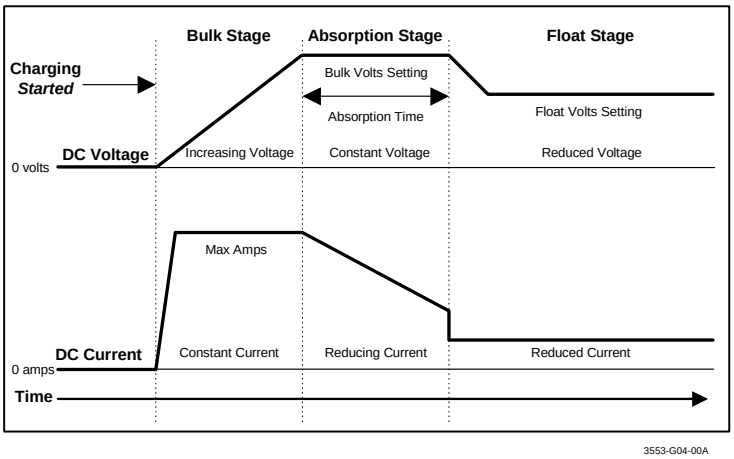


Figure 28
Charging Parameters

BATTERY VOLTAGE (Using LED Status Indicator)						
Green LED(Charge/Diversion Mode)			**LED STATUS**	**Red LED (Load Control Mode)**		
Battery at FLOAT Setting			**Always ON**	Battery at LVD Setting (for 6 minutes = LVD)		
Battery at BULK Setting			**5 Blinks**	> 0.15 above LVD	>0.30 above LVD	>0.45 above LVD
Bulk Setting Minus (-)				LVD Setting Plus (+)		
0.25 VDC	0.50 VDC	1.00 VDC	**4 Blinks**	0.15 VDC	0.30 VDC	0.45 VDC
0.50 VDC	1.00 VDC	2.00 VDC	**3 Blinks**	0.30 VDC	0.60 VDC	0.90 VDC
0.75 VDC	1.50 VDC	3.00 VDC	**2 Blinks**	0.45 VDC	0.90 VDC	1.35 VDC
> 0.75 below Bulk	> 1.50 below Bulk	> 3.00 below Bulk	**1 Blink**	> 0.45 above LVD	> 0.90 above LVD	> 1.35 above LVD
12 volts	**24 volts**	**48 volts**	**DC Voltage**	**12 volts**	**24 volts**	**48 volts**

Table 8
Battery Voltage LED Indications

When battery voltage drops below the FLOAT setting for a cumulative period of one hour, a new BULK cycle will be triggered. This typically occurs each night. If the battery is full at the start of the day, it will receive an ABSORPTION charge for one hour and then be held at the FLOAT setting for the remaining period of the day. Should the battery voltage drop below the FLOAT setting for a cumulative period of one hour, another BULK and ABSORPTION cycle will be initiated.

This three-stage charging process results in faster charging compared to on-off relay type or constant voltage solid state regulators. Faster recharging increases the performance of the system by storing more of the PV array's limited output. The final FLOAT voltage setting reduces battery gassing, minimizes watering requirements and ensures complete battery recharging.

TYPICAL BULK AND FLOAT SETPOINTS FOR BATTERIES			
Battery Type	**Bulk Volts**	**Float Volts**	**Equalizing Charge Process**
Default Settings (knobs at nine o'clock position)	14.0 VDC	13.5 VDC	Disabled (manual jumper)
Sealed Gel Lead Acid Battery	14.1 VDC	13.6 VDC	Not recommended. Consult manufacturer.
AGM Lead Acid Battery	14.4 VDC	13.4 VDC	Charge to 15.5 VDC or per manufacturer.
Maintenance-Free RVI Marine	14.4 VDC	13.4 VDC	Limited appropriateness - if water level can be checked.
Deep-Cycle, Liquid Electrolyte Lead Antimony Battery	14.6 VDC	13.4 VDC	Charge to 15.5 VDC or per manufacturer.
NiCad or NiFe Alkaline Battery*	16.0 VDC	14.5 VDC	No recommended. Consult manufacturer.
Values shown are for 12-volt systems. For 24-volt systems, multiply the settings shown by 2. For 48-volt systems, multiply the settings shown by 4.			
*For NiCad and NiFe batteries, you must clip R46 and add 2 V to the values for BULK and FLOAT shown on the circuit board. For example, to set the BULK for 16.0 V, adjust the BULK knob to 14.0 V after clipping R46. Values above are for batteries at room temperature. For applications with significant temperature variations or systems with sealed batteries, install a battery temperature sensor.			

Table 9
Typical Setpoints for Batteries

Equalization (Non-Sealed Batteries Only)

Approximately every month, some batteries may need to be "equalized." Since the individual cells of the battery are not identical, some cells may not be fully charged when the charging process is completed. If the batteries have been left in a discharged condition for long periods of time, the plates will have sulfates on them from the electrolyte. If the sulfate remains on the plates for an extended period of time, it will harden and seal off a percentage of the plate area, reducing the capacity of the battery. By equalizing the batteries before the sulfate hardens, the sulfate is removed from the plates.

Batteries with liquid electrolyte may become stratified. Stratification concentrates the sulfuric acid into the bottom of the cell while the top becomes diluted. This corrodes the lower portion of the plates, reducing battery life. Mixing of the electrolyte by the formation of gas bubbles during the equalization process reduces stratification.

Two methods can be used to determine if a battery needs to be equalized. If possible, measure the voltage of each individual cell while the battery is at rest (not being charged or discharged), a variation of 0.05 volts between cells indicates an imbalance exists. If the battery construction prevents measurement of the individual cell voltages, use a hydrometer. A variation of 0.020 in the specific gravity between cells is considered significant. Both conditions can be corrected by an equalization charge.

A proper equalization charge will not damage a vented, liquid electrolyte type battery. It may, however, cause significant electrolyte usage and require that the battery be refilled with distilled water to the correct level. This may be a problem with unattended systems in remote areas which do not receive regular maintenance. Consult the battery manufacturer for their recommendations.

CAUTION: EQUALIZATION SHOULD BE DONE ONLY ON VENTED (NOT SEALED OR MAINTENANCE FREE) LEAD-ACID, LIQUID-ELECTROLYTE BATTERIES. THE BATTERY MANUFACTURER SHOULD BE CONSULTED BEFORE ATTEMPTING TO EQUALIZE ANY OTHER BATTERY TYPE. ADD CLEAN, DISTILLED WATER TO THE BATTERY FOLLOWING THE EQUALIZATION PROCESS.

DC loads may need to be disconnected by turning off circuit breakers or removing fuses before equalization to prevent damage by the required higher voltages used in the equalization process.

CAUTION: IF THE BATTERIES ARE EQUIPPED WITH HYDROCAPS (CATALYTIC GAS RECOMBINER CAPS), THEY SHOULD BE REMOVED DURING THE EQUALIZATION PROCESS. IF HYDROCAPS ARE USED, YOU SHOULD DISABLE AUTOMATIC EQUALIZATION TO PREVENT POSSIBLE DAMAGE.

Batteries

Batteries come in different sizes, types, amp-hour capacity, voltages and chemistries. Here are a few guidelines that will help in battery selection, and ensure that the batteries are properly maintained. The best source of the most appropriate settings for the C-Series will be from the manufacturer or supplier of the batteries.

Automotive Batteries

Automotive and truck batteries are designed for high cranking power – not deep-cycling. Do not use them unless no other battery type is available. They simply will not last long in a cycling application.

Maintenance-Free Batteries

This type of battery is often sold as a RV or marine battery, but is rarely appropriate for use with a PV system. They typically have an additional reserve of electrolyte, but are vented. This is not the same as a sealed battery.

Deep-Cycle Batteries

Best suited for use with PV systems, this type of battery is designed to be more deeply discharged before being recharged. Deep-cycle batteries are available in many sizes and types. The most common is the vented liquid electrolyte battery.

Vented batteries usually have battery caps. The caps may appear to be sealed, but are not. The caps should be removed periodically to check the level of electrolyte. When a cell is low, distilled water should be added after the battery is fully charged. If the level is extremely low, add only enough distilled water to cover the plates before recharging. The electrolyte volume increases during the charging process and the battery will overflow if it is filled all of the way up before recharging. Use only distilled water because impurities will reduce battery performance.

A popular and inexpensive deep-cycle battery is the “golf cart” battery. It is a 6-volt design, typically rated at 220 amp-hours. RV and marine deep-cycle batteries are also popular for small systems. They are usually referred to as Group 24 or Group 27 batteries and are rated at 80 to 100 amp-hours at 12 volts. Many larger systems use L16 batteries, which are usually rated at 350 amp-hours at 6-volts each. They are 17 inches high and weigh about 130 pounds. 8D batteries are available with either cranking or deep-cycle construction. Purchase only the deep-cycle version. The 8D is typically rated at 220 amp-hours at 12 volts.

Sealed Batteries

Another type of battery construction is the sealed gel cell. They do not use battery caps. The electrolyte is in the form of a gel rather than a liquid, which allows the batteries to be mounted in any position. The advantages are no maintenance, long life (800 cycles claimed) and low self-discharge. Absorbed glass mat (AGM) electrolyte batteries are also acceptable. Their electrolyte is contained in mats between the battery plates.

Sealed batteries reduce the maintenance requirements for the system and are good for remote applications. They are much more sensitive to the charging process and can be ruined in as little as a day of overcharging.

NiCad and NiFe Batteries

The Trace™ C-Series is compatible with NiCad (nickel-cadmium) NiFe (nickel-iron) and alkaline type batteries, which must be charged to a higher voltage level to achieve a full charge. To use the C-Series with NiCad batteries, remove the resistor labeled “R46” in the middle of the C-Series circuit board by cutting it. Avoid damage to neighboring components. This adds 2 volts to the printed scale on the circuit board around the BULK and FLOAT potentiometers.

When NiCad mode is selected, the equalization process is disabled. Adjust the BULK charge voltage to the setting recommended by the battery manufacturer. Add 2 volts to the scale shown when making the adjustment. Float voltage settings for NiCad/NiFe batteries should also be set to the battery manufacturer’s recommendations.

NOTE: In all applications the BULK voltage setting should be adjusted to a level below the maximum operating voltage of the DC loads. This may be as low as 15 volts for some types of electronic loads. Undercharging may occur in this instance, but DC equipment will be protected. Check with the manufacturers of the DC equipment being powered for its maximum DC input voltage tolerance. If equalization is expected to occur, then the DC equipment being used must tolerate the voltages which will occur during the equalization process.

Battery Sizing

Batteries are the fuel tank of the system. The larger the batteries, the longer the system can operate before recharging is necessary. An undersized battery bank results in short battery life and disappointing system performance. To determine the proper battery bank size, compute the number of amp-hours that will be used between charging cycles. Once the required amp-hours are known, size the batteries at approximately twice this amount. Doubling the expected amp-hour usage ensures that the batteries will not be overly discharged and will extend battery life.

The critical formula is Watts = Volts X Amps.

Divide the wattage of the load by the battery voltage to determine the amperage the load will draw from the batteries. Multiply the amperage times the hours of operation and the result is sufficient amp-hours.

Charge Controller

The charge controller is a critical component in any solar, wind or hydro power generation system. The charge controller protects the batteries from over-discharge and over-charge conditions.

Load Controller

A load controller is generally designed to remove a load or loads from the system when an over-discharge or over-load situation occurs.

Diversion Charge Controller

A diversion charge controller is designed to monitor battery voltage and, at the BULK voltage level, divert the power coming out of the source (solar, wind, or hydro generator) to a load which will utilize the excess power. Usually a water heater or some other type of heating element is used for this purpose.

Systems utilizing solar arrays do not have a requirement for diversion loads since a solar module can be open circuited without damage. However, even with a solar-based system, it may be desirable to use excess power to operate DC loads.

When a wind or hydro-generator is operating, a diversion load prevents generator damage if a load is suddenly removed, as the generator may over-spin. The diversion load also diverts excess power away from the batteries preventing over-charge damage.

7.0 DIVERSION LOADS

Diversion Load Types

Several different types of diversion loads are available to the alternative energy market. These loads are designed to operate with the power output levels common to most diversion load controllers. The following are several available diversion loads which may be used successfully for heating water or air.

A 120 VAC, 2000-watt water heater element, available at most hardware stores, may be used with a 12-, 24-, or 48-volt DC system; however do not expect a 2000-watt power dissipation. The power draw is determined by the heater element's DC resistance, the output voltage of the controller, as well as the output current capability of the charging source(s). These heater elements were designed to operate at 120 volts AC. A 48-volt, 40-amp charge controller will operate just fine with this type of a system providing about 500 watts of power dissipation. A 12- or 24-volt diversion load controller will work but doesn't put out enough power to effectively heat water with only one element. The remedy to this type of problem is to parallel several of these heater elements to increase the power output.

Table 10 below shows power dissipation of a 120 VAC, 2000-watt heater element operated at different voltages. Note that the voltages given are roughly the bulk charge stage voltages for a given system. Remember that if you parallel heater elements, the diversion load can handle more current.

System Voltage	Power	Amperage
60 VDC (48 VDC system)	500 W	8.3 amps
30 VDC (24 VDC system)	125 W	4.2 amps
15 VDC (12 VDC system)	31 W	2.1 amps
120 VAC	2000 W	16.7 amps

Table 10
Power Dissipation

A couple of other excellent diversion loads which may be utilized effectively are available from Alternative Energy Engineering (AEE) of Redway, California.

1. A 12/24 volt DC or 24/48 volt DC water heater element (AEE Part #20909 or #20919 (24/48 V)).

2. Open air heater with a fan (AEE Part #2091312 -12 V, 720 W), #2091324 (24 V - 720 W), #20 91412 (12 V - 1440 W), #2091524 (24 V - 1440 W), and #2091648 (48 V -1440 W)).

For more information call AEE at:
1(800) 800-0624, or 1(800) 777-6609, or FAX 1 (800) 777-6648.

7.0 DIVERSION LOADS

Regardless of the type of diversion load you decide to utilize, make sure that the diversion load can handle all the power the charging system is capable of putting out. Paralleling heater elements (whether open air or water heater) will allow more power dissipation. A good rule of thumb is to not have a combined charging source greater than 80% of the diversion load controller's current handling ability. For example, if a Trace™ C-Series, 40-amp diversion load controller is being used, do not place a combination of charging sources which are capable of putting out more than 32 amps (80% of 40 amps) on the load controller's circuit. Sizing a diversion system this way allows a safety margin for unusual conditions (high winds, high water flow, etc.). It is not recommended that light bulbs be used as diversion loads for a couple of reasons:

1. An incandescent light bulb has a substantially lower cold filament resistance than when it is on. This means it draws more power (up to five times) to start the light when it is cold than once the filament has warmed up. Even a 40-watt light bulb may have an in-rush amperage at turn-on of 200 amps. This could cause the load controller to shut down.

2. In the event a light bulb load burns out, a smaller-than-necessary load will be present, and the excess energy will have nowhere to go.

8.0 SPECIFICATIONS

MODEL	C35		C40			C60	
Specific Specifications							
Voltage Configurations	12 VDC	24 VDC	12 VDC	24 VDC	48 VDC	12 VDC	24 VDC
Maximum PV Array Open Circuit Voltage	55 VDC	55 VDC	125 VDC	125 VDC	125 VDC	55 VDC	55 VDC
Charging Load Current	35 amps DC continuous		40 amps DC continuous			60 amps DC continuous	
Recommended Breaker Size with Recommended Wire Size in Conduit	60 amps DC, #6 AWG		60 amps DC, #6 AWG			60 amps DC (100% continuous duty cycle), #6 AWG (90 °C rated)	
Maximum Short Circuit Current	60 amps intermittently		80 amps intermittently			80 amps intermittently	
General Specifications							
Maximum Voltage Drop	0.30 volts - charge control mode						
Total Current Consumption	While operating - 15 mA (typical), at idle - 3 mA (tare)						
Charger Regulation Method	Solid state, 3-stage (Bulk, Absorption and Float) Pulse Width Modulation (PWM)						
Regulation Adjustment Settings	Charge Control Mode Setup for:						
Lead Acid Battery	**12 Volt Configuration:** Float 12.5–14.5 VDC Bulk 13.0–15.0 VDC EQ + 1 VDC above Bulk		**24 Volt Configuration:** Float 25.0–29.0 VDC Bulk 26.0–30.0 VDC EQ + 2 VDC above Bulk			**48 Volt Configuration:** Float 50.0–58.0 VDC Bulk 52.0–60.0 VDC EQ + 4 VDC above Bulk	
NiCad Type Battery (VDC above adjustment setting)	Float or Bulk (add 2 VDC)		Float or Bulk (add 4 VDC)			Float or Bulk (add 8 VDC)	
Regulation Settings	LVR - Subtract 1 V (for 12 VDC systems), 2 V (for 24 VDC systems), and 4 V (for 48 VDC systems) from the Bulk setting.						
Load Control Mode	LVD - Subtract 2 V (for 12 VDC systems), 4 V (for 24 VDC systems), and 8 V (for 48 VDC systems) from the Float setting.						
Standard Features							
Status Indicator	Multicolor LED indicates the operating/battery voltage status.						
Low Voltage Disconnect Load Control Mode	User selectable manual or automatic reconnection - includes warning flash before disconnect and 6 minute "grace" period.						
Equalization Charge Charge Control Mode	User selectable manual or automatic equalization (every 30 days).						
Short Circuit Protection	Fully electronically protected with auto-reset						
Field Adjustable Control Setpoints (test points provided for high accuracy)	Two user-adjustable, voltage setpoints for control of loads or charging sources (settings retained if battery is disconnected)						
Options							
LCD Meter Panel (DVM/C40, CMR/50, CMR/100)	Back-lit, 2-line, 32 character, alpha numeric liquid crystal display panel for remote (CM-R) or front mounting (DCV/C40) on the C-Series controller						
External Battery Temperature Sensor (BTS/15, BTS/35)	Provides automatic adjustment of the charge control setpoints to the battery temperature (may be extended)						
Environmental Limitations							
Enclosure Type	Indoor, ventilated, powder-coated steel with 3/4" and 1" knockouts						
Operating Temperature Range	32 to 104 °F (0 to +40 °C)						
Non-Operating Temperature	-67 to 284 °F (-55 to +75 °C)						
Altitude Limit (operating)	15,000 feet (5,000 meters)						
Altitude Limit (non-operating)	50,000 feet (16,000 meters)						
Dimensions (H x W x D)	C35: 8" x 5" x 2.5" (20.3 cm x 12.7 cm x 6.35 cm) C40, C60: 10" x 5" x 2.5" (25.4 cm x 12.7 cm x 6.35 cm)						
Mounting	Vertical Wall Mount						
Weight (Controller only)	C35: 2.5 lbs. (1.2 kg), C40: 3.0 lbs. (1.4 kg), C60: 3.0 lbs. (1.4 kg)						
Weight (Shipping)	C35: 3.0 lbs. (1.4 kg), C40: 3.5 lbs. (1.6 kg), C60: 3.5 lbs. (1.6 kg)						
Specifications at 25 °C Specifications subject to change without notice							

Service Information

Xantrex Technology Inc. takes great pride in its products and makes every effort to ensure your unit fully meets your independent powering needs.

If your product needs repair, contact our Service department at: (360) 435-8826 to obtain an RMA# and shipping information; or, fax this page with the following information to: (360) 474-0616.

Please provide:

Model Number: _____

Serial Number: _____

Purchase Date: _____

Problem: _____

Include a telephone number where you can be reached during business hours and a complete return shipping address (P.O. Box numbers are not acceptable).

Name: _____

Address: _____

City: _____

State / Province: _____

Zip / Postal Code: _____

Country: _____

Phone: ( ) _____

FAX: ( ) _____

E-mail Address: _____

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Xantrex Technology Inc. warrants its power products against defects in materials and workmanship for a period of two (2) years from the date of purchase, established by proof of purchase or formal warranty registration, and extends this warranty to all purchasers or owners of the product during the warranty period. Xantrex does not warrant its products from any and all defects:

- arising out of material or workmanship not provided by Xantrex or its Authorized Service Centers;
- when the product is installed or exposed to an unsuitable environment as evidenced by generalized corrosion or biological infestation;
- resulting from abnormal use of the product, alteration, or use in violation of the instructions;
- in components, parts, or products expressly warranted by another manufacturer.

Xantrex agrees to supply all parts and labor to repair or replace defects covered by this warranty with parts or products of original or improved design, at the company's option. Xantrex also reserves the right to improve the design of its products without obligation to modify or upgrade those previously manufactured. Defective products must be returned to Xantrex or its Authorized Service Center in the original packaging or equivalent. The cost of transportation and insurance on items returned for service is the responsibility of the customer. Return transportation (UPS Ground or equivalent) as well as insurance on all repaired items is paid by Xantrex Technology Inc.

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Some states or counties do not allow limitations on the term of an implied warranty, or the exclusion or limitation of incidental or consequential damage, which means the limitations and exclusions of this warranty may not apply to you. Even though this warranty gives you specific legal rights, you may also have other rights which vary from state to state.

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