Commander Series

RENOGY 60A
Maximum Power Point Tracking Solar Charge Controller

RENOGY

Version 3.0

⚠ <u>Important Safety Instructions</u> ⚠
Please save these instructions.

This manual contains important safety, installation, and operating instructions for the charge controller. The following symbols are used throughout the manual to indicate potentially dangerous conditions or important safety information.

⚠ **WARNING: Indicates a potentially dangerous condition. Use extreme caution when performing this task.**

CAUTION: Indicates a critical procedure for safe and proper operation of the controller

NOTE: Indicates a procedure or function that is important to the safe and proper operation of the controller.

<u>General Safety Information</u>

- Read all of the instructions and cautions in the manual before beginning the installation.

- There are no serviceable parts for this controller. Do **NOT** disassemble or attempt to repair the controller.

- Do **NOT** allow water to enter the controller.

- Make sure all connections going into and from the controller are tight.

<u>Charge Controller Safety</u>

- **NEVER** connect the solar panel array to the controller without a battery. Battery must be connected first.

- Ensure input voltage does not exceed 150 VDC to prevent permanent damage. Use the Open Circuit (V_{oc}) to make sure the voltage does not exceed this value when connecting panels together.

- Do not exceed 60A for the charge controller The Short Circuit (I_{sc}) of the solar array should be less than 60A.

Battery Safety

- Use only sealed lead-acid, flooded, or gel batteries which **must be deep cycle**.

- Explosive battery gases may be present while charging. Be certain there is enough ventilation to release the gases.

- Be careful when working with large lead acid batteries. Wear eye protection and have fresh water available in case there is contact with the battery acid.

- Carefully read battery manuals before operation.

- Do **NOT** let the positive (+) and negative (-) terminals of the battery touch each other.

- Recycle battery when it is replaced.

- Over-charging and excessive gas precipitation may damage the battery plates and activate material shedding on them. Too high of an equalizing charge or too long of one may cause damage. Please carefully review the specific requirements of the battery used in the system.

- Equalization is carried out only for non-sealed / vented/ flooded / wet cell lead acid batteries.

- Do **NOT** equalize VRLA type AGM / Gel cell batteries **UNLESS** permitted by battery manufacturer.

WARNING: Connect battery terminals to the charge controller BEFORE connecting the solar panel(s) to the charge controller. NEVER connect solar panels to charge controller until the battery is connected.

WARNING: Do NOT connect any inverters or battery charger into the load terminal of the charge controller.

WARNING: Once equalization is active in the battery charging, it will not exit this stage unless there is adequate charging current from the solar panel. There should be NO load on the batteries when in equalization charging stage.

Table of Contents

General Information

The RENOGY Commander MPPT controller is suitable for off-grid solar applications. It protects the battery from being over-charged by the solar modules and over-discharged by the loads. The controller features a smart tracking algorithm that maximizes the energy from the solar PV module(s) and charge the battery.

The MPPT Charge Controller charging process has been optimized for long battery life and improved system performance. The comprehensive self-diagnostics and electronic protection functions can prevent damage from installation mistakes or system faults. In addition, the controller is a high-end industrial class product based on multiphase synchronous rectification technology and has features of high efficiency and reliability.

Key Features

- LCD display with 6 button combination for easy operation.
- 12V / 24V / 36V / 48V DC systems.
- Advanced maximum power point tracking technology with the tracking efficiency as high as 99.5%
- Multiphase synchronous rectification technology ensuring peak conversion efficiency up to 98%
- Excellent heat dissipation with integration of the cast aluminum radiator shell. The controller can be natural cooling.
- Unique dual timer function; enhance the flexibility lighting systems.
- Deep cycle Sealed, Gel, Flooded or User battery option.
- Adopting temperature compensation and correcting the charging and discharging parameters automatically, improving battery lifetime.
- Electronic protection: Overcharging, over-discharging, overload, and short circuit.
- Protection against over-temperature, over-charging, PV short, reverse polarity, and over current.
- RS-232, RS-485, and CAN port compatible for extra features.
- Remote Temperature Sensor adaptable and Battery Voltage Sensor adaptable

MPPT Technology

The Commander MPPT Charge Controller utilizes Maximum Power Point Tracking technology to extract maximum power from the solar module(s). The tracking algorithm is fully automatic and does not require user adjustment. MPPT technology will track the array's maximum power point voltage (V_{mp}) as it varies with weather conditions, ensuring that the maximum power is harvested from the array throughout the course of the day.

Current Boost

In many cases, the Commander MPPT charge controller will "boost" up the current in the solar system. The current does not come out of thin air. Instead, the power

generated in the solar panels is the same power that is transmitted into the battery bank. Power is the product of Voltage (V) x Amperage (A). Therefore, assuming 100% efficiency:

$$Power\ In = Power\ Out$$

$$Volts\ In * Amps\ In = Volts\ out * Amps\ out$$

Although MPPT controllers are not 100% efficient, they are very close at about 92-95% efficient. Therefore, when the user has a solar system whose Vmp is greater than the battery bank voltage, then that potential difference is proportional to the current boost. The voltage generated at the solar module needs to be stepped down to a rate that could charge the battery in a stable fashion by which the amperage is boosted accordingly to the drop. It is entirely possible to have a solar module generate 8 amps going into the charge controller and likewise have the charge controller send 10 amps to the battery bank. This is the essence of the MPPT charge controllers and their advantage over traditional charge controllers. In traditional charge controllers, that stepped down voltage amount is wasted because the controller algorithm can only dissipate it as heat. The following demonstrates a graphical point regarding the output of MPPT technology.

Current vs. Voltage (12V System)   **Output Power (12V System)**

Typical Battery Voltage Range   Maximum Power Point   Traditional Controller Operating Range   Maximum Power Point

CURRENT   10   15 17   VOLTAGE

POWER   10   15 17   VOLTAGE
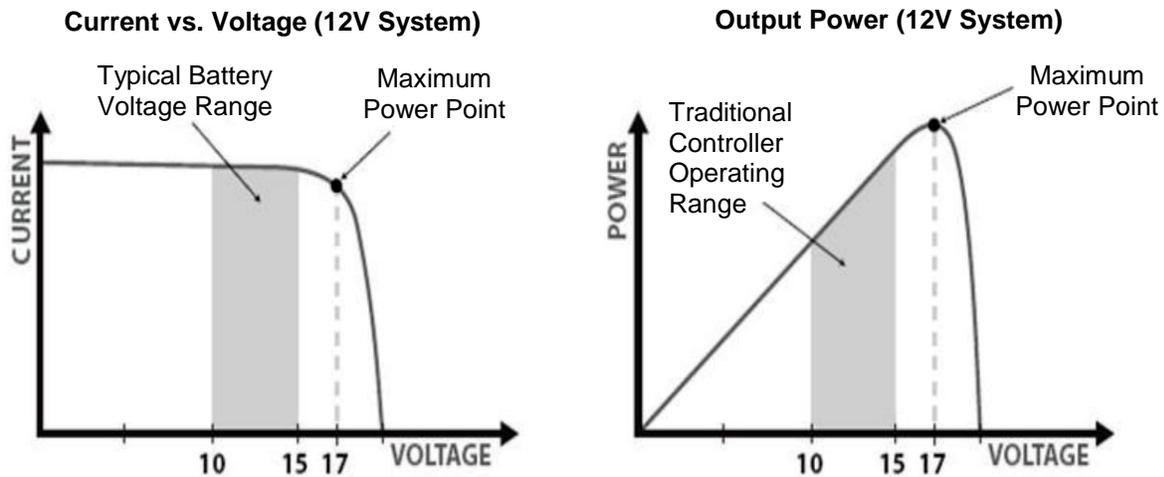
Limiting Effectiveness

Temperature is a huge enemy of solar modules. As the environmental temperature increases, the operating voltage (Vmp) is reduced and limits the power generation of the solar module. Despite the effectiveness of MPPT technology, the charging algorithm will possibly not have much to work with and therefore there is an inevitable decrease in performance. In this scenario, it would be preferred to have modules with higher nominal voltage, so that despite the drop in performance of the panel, the battery is still receiving a current boost because of the proportional drop in module voltage.

Four Charging Stages

The Commander MPPT charge controller has a 4-stage battery charging algorithm for a rapid, efficient, and safe battery charging. They include: Bulk Charge, Boost Charge, Float Charge, and Equalization*.
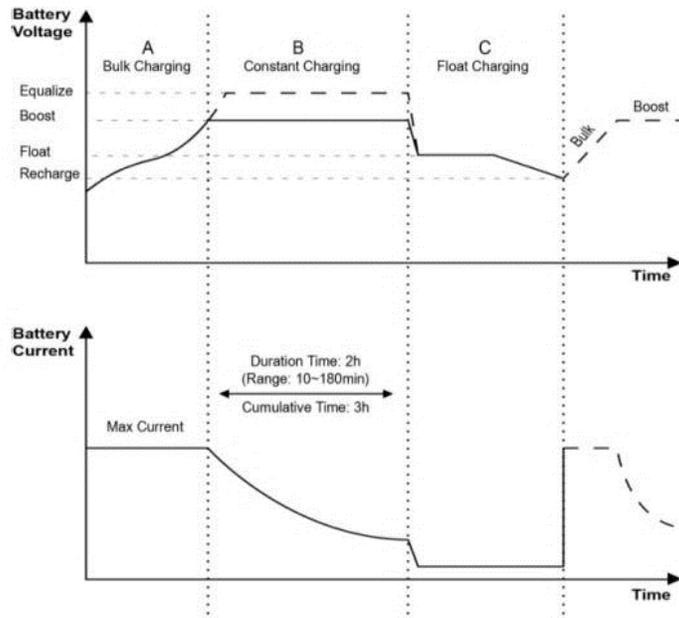
Bulk Charge: This algorithm is used for day to day charging. It uses 100% of available solar power to recharge the battery and is equivalent to constant current. In this stage the battery voltage has not yet reached constant voltage (Equalize or Boost), the controller operates in constant current mode, delivering its maximum current to the batteries (MPPT Charging)

Constant Charging: When the battery reaches the constant voltage set point, the controller will start to operate in constant charging mode, where it is no longer MPPT charging. The current will drop gradually. This has two stages, equalize and boost and they are not carried out constantly in a full charge process to avoid too much gas precipitation or overheating of the battery.

➢ **Boost Charge:** Boost stage maintains a charge for 2 hours by default. The user can adjust the constant time and preset value of boost per their demand.

Float Charge: After the constant voltage stage, the controller will reduce the battery voltage to a float voltage set point. Once the battery is fully charged, there will be no more

chemical reactions and all the charge current would turn into heat or gas. Because of this, the charge controller will reduce the voltage charge to smaller quantity, while lightly charging the battery. The purpose for this is to offset the power consumption while maintaining a full battery storage capacity. In the event that a load drawn from the battery exceeds the charge current, the controller will no longer be able to maintain the battery to a Float set point and the controller will end the float charge stage and refer back to bulk charging.

⚠ **Equalization:** Is carried out every 28 days of the month. It is intentional overcharging of the battery for a controlled period of time. Certain types of batteries benefit from periodic equalizing charge, which can stir the electrolyte, balance battery voltage and complete chemical reaction. Equalizing charge increases the battery voltage, higher than the standard complement voltage, which gasifies the battery electrolyte.

WARNING: Once equalization is active in the battery charging, it will not exit this stage unless there is adequate charging current from the solar panel. There should be NO load on the batteries when in equalization charging stage.

WARNING: Over-charging and excessive gas precipitation may damage the battery plates and activate material shedding on them. Too high of equalizing charge or for too long may cause damage. Please carefully review the specific requirements of the battery used in the system.

WARNING: Equalization may increase battery voltage to a level damaging to sensitive DC loads. Ensure that all load allowable input voltages are greater than the equalizing charging set point voltage.

Additional Components

<u>Remote Temperature Sensor (TS-R):</u> Measures the temperature at the battery and uses this data for very accurate temperature compensation. It is not polarity sensitive.

<u>USB to RS-485 Converter:</u> The USB to RS-485 converter is used to monitor each controller on the network using Solar Station Monitor PC software and update the firmware. It connects to the RS-485 port on the controller. Download the PC software through Renogy's website under the "Downloads" section

Optional Components

Optional components that require a separate purchase:

<u>External Battery (RTC):</u> Allows for the access to the charge controller's saved settings, charge accumulation, and discharge accumulation without connecting to a deep cycle battery. It keeps track of the date/time (once set) for automatic equalization processes.

Identification of Parts
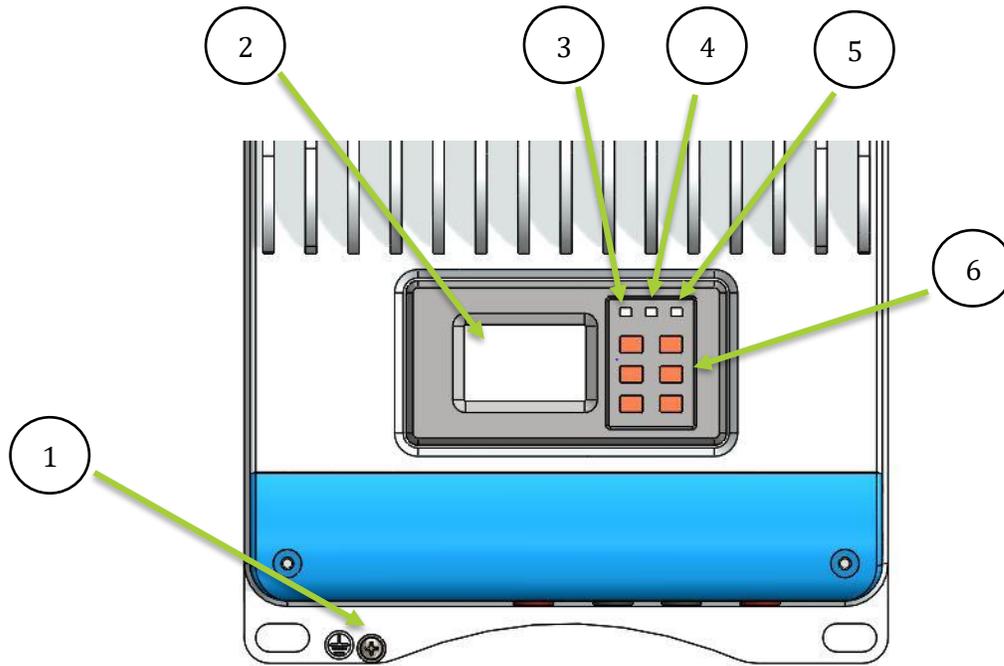
Top View
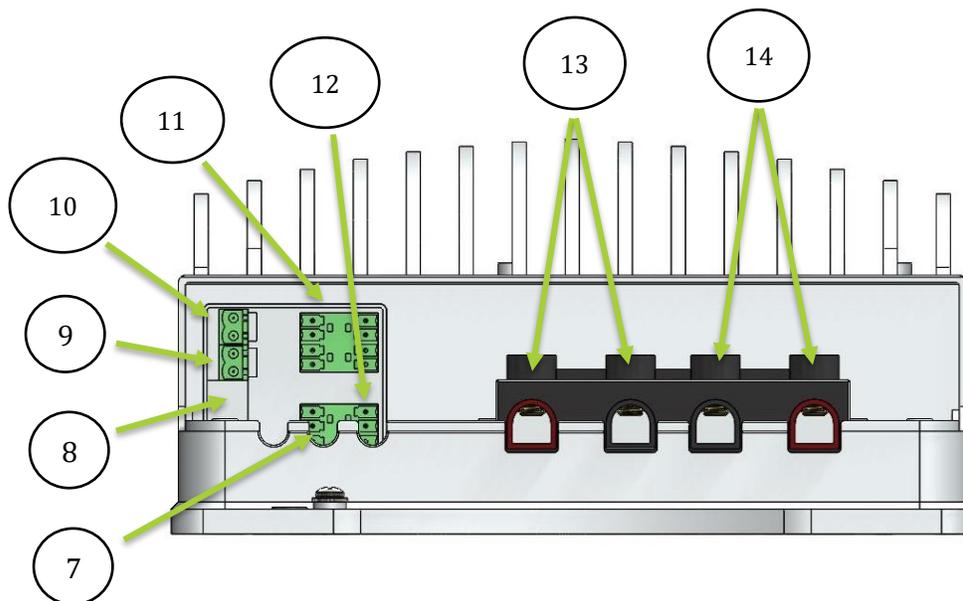
Front View (Hatch Removed)

Key Parts

1. **Grounding Bolt**
2. **LCD Display**
3. **Battery LED**
4. **PV LED**
5. **Fault LED**
6. **Navigation Buttons**
7. **RS-485 port—**monitor controller through PC and update firmware
8. **RTC Battery Slot—**model is CR2032
9. **Remote Temperature Sensor Port—**optional accessory to remotely monitor battery temperature
10. **Remote Battery Voltage Sensor Port—**Provides accurate battery voltage measurement
11. **Reserved Port—**Reserved port for future development. Special accessory currently not sold.
12. **RS-232 port—**monitor controller through PC and update firmware
13. **PV Terminal**
14. **Battery Terminal**

PV Array Requirements

PV Strings

The commander is suitable for various types of PV configurations to maximize electrical energy. Configurations are dependent on the open circuit voltage (Voc) and maximum power point voltage (Vmp) located in solar panel specifications. The following table is to serve as a reference only.

System Voltage	36 Cell Module (Voc < 23V)		60 Cell Module (Voc < 38V)		72 Cell Module (Voc < 46V)	
	Max	Best	Max	Best	Max	Best
12V	4	2	2	1	2	1
24V	6	3	3	2	3	2
48V	6	5	3	3	3	2

Note: The above parameter values are calculated under the STC conditions: Irradiance 1000W/m², Temperature 25°C, Air Mass 1.5

PV Max Power

The Commanders have a limiting current function, where the current is limited within a range, and therefore allows battery charging at the correct value despite oversized input power. The power operation follows the following conditions:

1. PV Actual Power ≤ controller rated charge power, the controller charge battery at the actual maximum power point.
2. PV Actual Power ≤ controller rated charge power, the controller charges the battery at the rated power.

> **WARNING: The Commander will be damaged if the PV array is <u>3X</u> greater than the actual operating power of the controller.**
>
> **WARNING: The Commander's reverse polarity is no longer warranted if the PV array size is <u>1.5X</u> greater than the rated power of the controller.**

The following tables serves as the reference guide for the statements above:

Model	Rated Charge Current	Rated Charge Power	Max PV Array Power	Max PV Voc Input
Commander	60A	800W @ 12V 1600W @ 24V 2400W @ 36V 3200W @ 48V	2400W @ 12V 4800W @ 24V 7200W @ 36V 9600W @ 48V	**<u>150V</u>** @ minimum operating environmental temperature **<u>OR</u>** **<u>138V</u>** @ 25°C environmental temperature

Installation

Recommended tools to have before installation:

Flathead Screwdriver	Multi-Meter

WARNING: Connect battery terminal wires to the charge controller FIRST then connect the solar panel(s) to the charge controller. NEVER connect solar panel to charge controller before the battery.

CAUTION: Do not over-torque or over tighten the screw terminals. This could potentially break the piece that holds the wire to the charge controller.

CAUTION: Refer to the technical specifications for max wire sizes on the controller and for the maximum amperage going through wires.

You are now ready to begin connecting your battery to your charge controller.

Battery
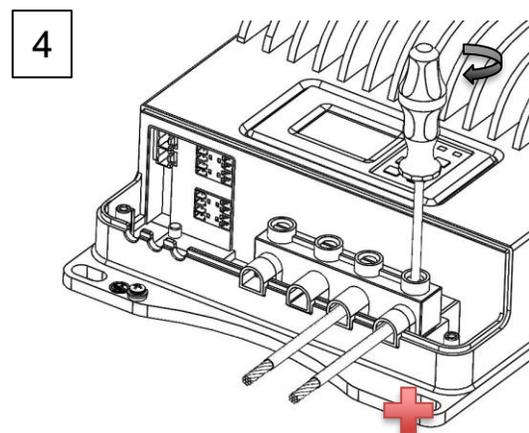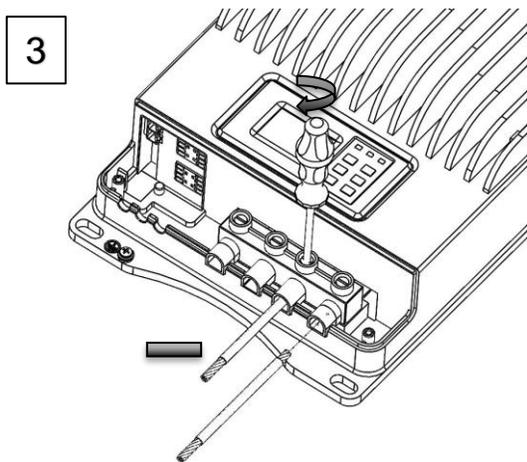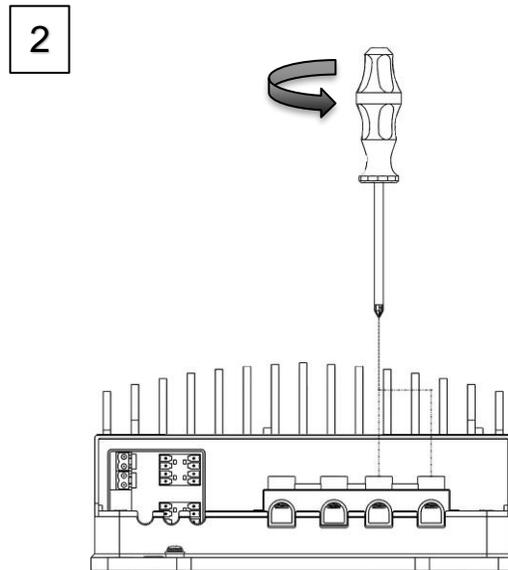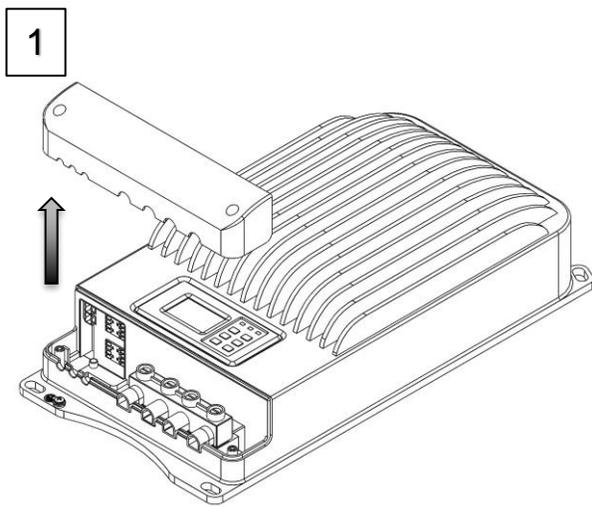
Solar Panels
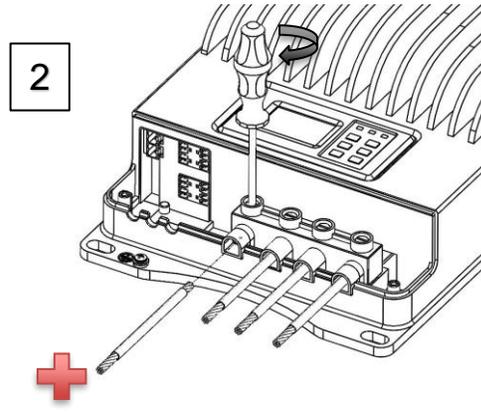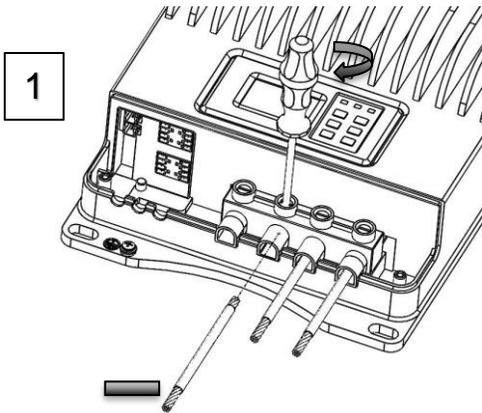
Computer connection
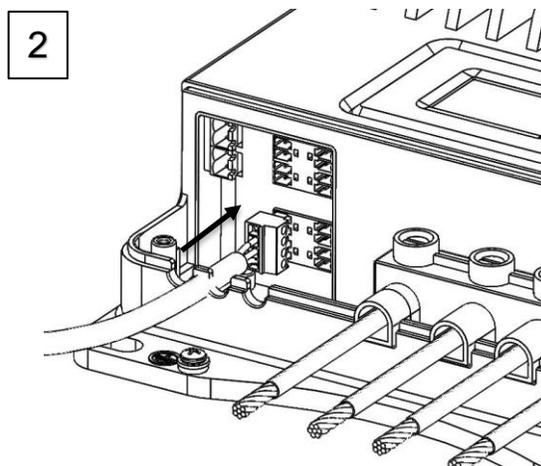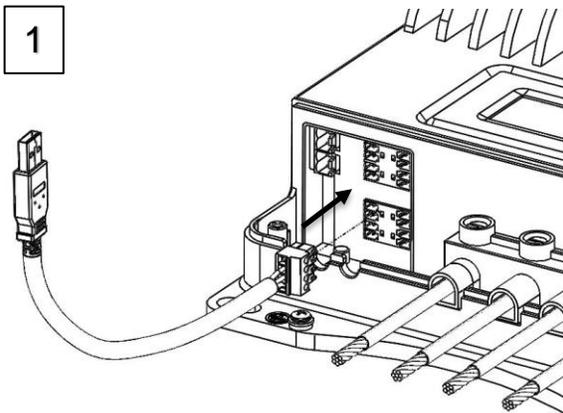
Temperature sensor (Not Polarity Sensitive)
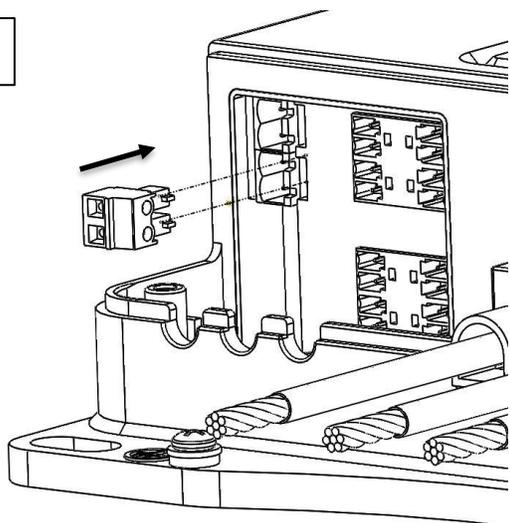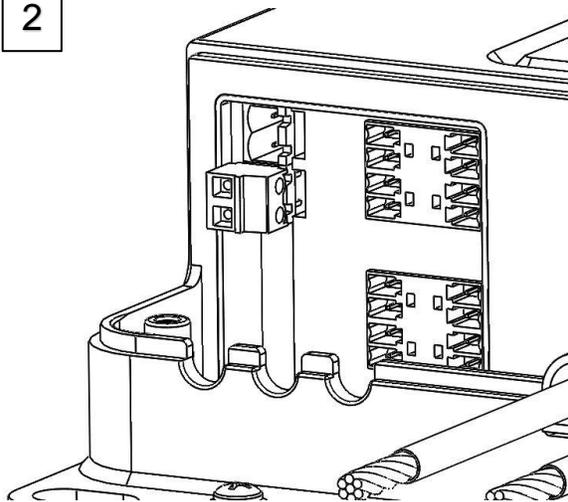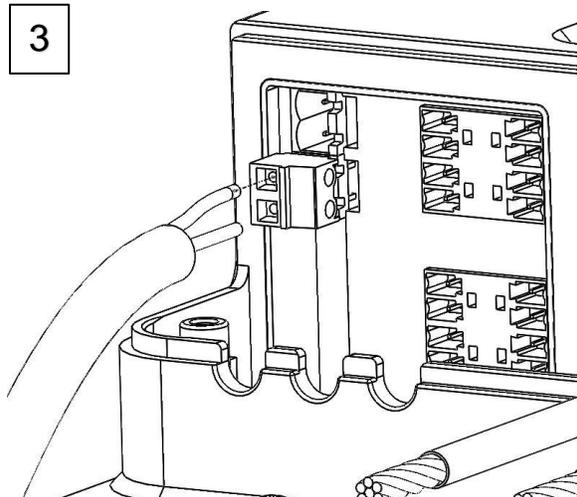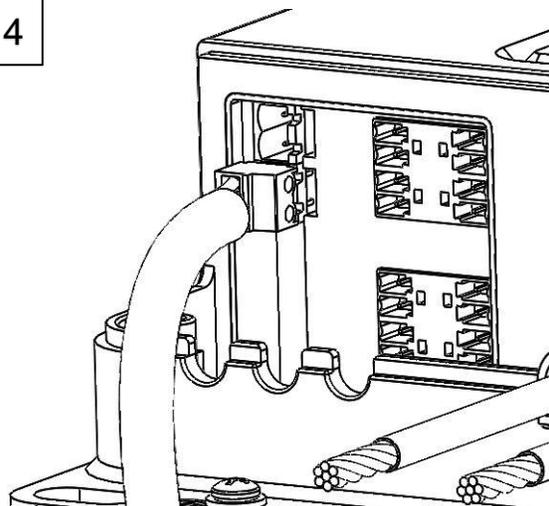
Mounting Recommendations

NOTE: The Commander MPPT 60 controller requires at least 6 inches(150mm) of clearance above and below for proper air flow. Ventilation is highly recommended if mounted in an enclosure.

WARNING: Never install the controller in a sealed enclosure with flooded batteries. Gas can accumulate and there is a risk of explosion.

1. **Choose Mounting Location—**place the controller on a vertical surface protected from direct sunlight, high temperatures, and water. Make sure there is good ventilation.
2. **Check for Clearance—**verify that there is sufficient room to run wires, as well as clearance above and below the controller for ventilation. The clearance should be at least 6 inches (150mm).
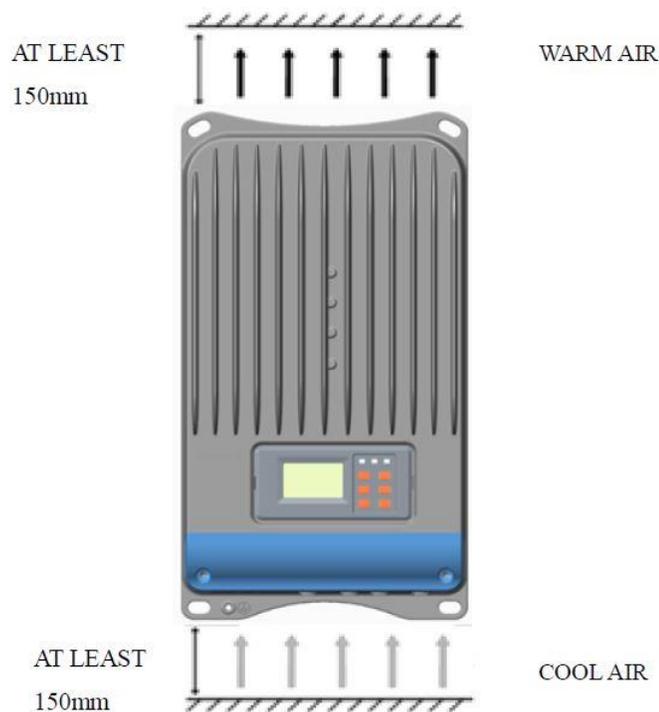
3. **Mark Holes—**Mark the four mounting holes locations on the mounting surface.
4. **Drill Holes—**Remove the controller and drill four sizeable holes at the marked locations.
5. **Secure the charge controller—**Place the controller on the surface and align the mounting holes with the drilled holes in step 4. Secure the controller in place using the mounting screws.

Operation

After connecting the battery to the charge controller, the controller will turn on automatically. The user will be prompted by an initialization screen, followed by the charge controller's rated parameters, and finally the default monitoring screen.

Rated Parameters	
Rat.Volt	48.0V
Charg.Cur	60.0A
Disc.Curr	60.0A

```
 ☽      🔋      💡
0.00A  12.65V  0.00A

Jan    12:12: 12   ☺
10
```

Use the following buttons to maneuver through the menu:

↑	Cycle through the menu
↓	Cycle through the menu
ESC	Return to main menu in any monitoring interface
+	Modify any value and set period of Log to browse
-	Modify any value and set period of Log to browse
OK	Selecting certain parameters

Select **ESC** to display the menu screen selection. The user will have 9 interfaces to choose from.

```
1.  Monitoring
2.  Log Info
3.  Clock Set
4.  Local Para Set
5.  Control Para
6.  Sys Password
7.  Default Set
8.  Device Msg
```

NOTE: You might be prompted to enter a password. Simply put "0" all the way through by pressing OK

NOTE: To customize charge parameters, BATT TYPE must be set to <u>USER</u> under 5. Control Param

NOTE: The values found in your controller are default values and will not necessarily match the ones listed. The values on this table are to show the user what the different screens are used for.

NOTE: You do **NOT** have to program the control. These parameters are for extra features. Once you connect the battery the settings are automatically synced.

1. Monitoring

Use the [↑] [↓] keys to maneuver through the screens and [ESC] to access the menu

0.00A　12.65V　0.00A Jan　12:12: 12 10	Default monitoring screen displaying charge controller system status through icons.
[↓]	
Batt Volt. 12.6 V Batt Cur. 0.0 A	Indicates battery voltage and battery current
[↓]	
Batt Day'Max 12.8 V Batt Day'Min 12.6 V	Indicates the maximum and minimum battery values since the charge controller has been turned on. When battery is charging, the values are expected to change.
[↓]	
Batt State Normal Batt SOC 51%	Displays the battery state as well as the state of charge of the battery. **NOTE:** The Battery SOC% is an estimation based on the charging voltage.
[↓]	
Charge State No Charge PV Volt 0.0 V	Displays the charging state of the battery as well as the voltage coming from the PV module(s). **NOTE: Make sure PV input is not more than 150 VDC**
[↓]	

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Generated Energy 55 kWh/D PV Power 0.0 W	Indicates the amount of energy that has been generated for the day in terms of kilowatt-hours per day. The PV power indicates how much power the PV modules have generated.
↓	
Total Generated 55 kWh/D	Indicates the total amount of energy generated and in kilowatt-hours per day.
↓	
Batt Temp 25.0 °C Temp Coefficient -3mV / °C / 2V	Indicates the batteries temperature as well as the temperature compensation. Temperature fluctuation can affect performance in the system. The purpose of temperature compensation is to adjust the performance of the system to keep the system functioning normally.
↓	
Local Temperature 23.4 °C	Indicates the local temperature of the charge controller.

2. Log Info

Use the ↑ ↓ **keys to maneuver through the screens and** ESC **to access the menu**

<1>Work Log <2> Alarm Log OK	Users will be able to see segments of how Commander is performing when the whole system is connected through the work log. Any time there is a change in voltage or amperage it will be logged onto the Work Log Query. It is recommended that the date and time be set correctly so that a range of dates can be selected and analyze solar performance.
Work Log Query From **2015-01-23** To **2015-02-01** Total: **121**	
↓	
No. 1/121 2015-01-23 1:01 Batt Vol 51.6 V Batt Curr 0.0A ESC	Depending on the total amount of Work Logs, users can cycle through the logs using the (up) and (down) arrows. Press ESC to go back to the previous log menu. The logs display battery voltage and battery current.

	The Alarm Log will display any kind of faults or warnings that the charge controller experienced while having the solar system connected. As in the previous Log, users can cycle through how many alarm logs are available and observe the data.

```
<1>Work Log
<2> Alarm Log

   OK

Alarm Log Query
From   2015-01-23
To        2015-02-01
Total:              0
```
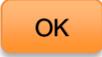
3. Clock Set

Press **OK** to highlight the month in the clock set menu and use the **+** **-** keys to change the parameter. Press **OK** to confirm and save the settings.

```
Clock Set
Aug-05-2015
13:16:51
```

Users can set the date and time. The clock uses a 24 hour clock.
NOTE: In some models, users might be prompted to enter a password. Simply put "0" all the way through and press OK.

4. Local Para Set

Use the **↑** **↓** keys to maneuver through the screens and **ESC** to access the Menu

Press **OK** to highlight the parameter and use the **+** **-** keys to change the parameters. Press **OK** to confirm and save the settings.

```
Local ID
T03-0001

   ↓

Backlight Time
60 s
Storage Interval
10 min
```

The Local ID number is the charge controller's unique ID when identifying it in a network or utilizing the PC software to search for the charge controller.

The charge controller's LCD interface is backlit and this interface lets you know the amount of seconds the LCD will be illuminated once the last button is pressed. The range is from 1-90 seconds and the "–"symbol indicates the backlight is never off. The storage log is from 1-30 minutes. It relates to how often the charge controller collects data and inputs into the Work Log or Alarm log.

	NOTE: In some models, users might be prompted to enter a password. Simply put "0" all the way through and press OK.

5. Control Para Set

Use the ↑ ↓ keys to maneuver through the screens and ESC to access the Menu

Press OK to highlight the parameter and use the + - keys to change the parameter. Press OK to confirm and save the settings.

Batt Type SEALED **Batt AH** 10 AH ↓	Choose between SEALED, FLOODED, GEL, or **USER** for Battery type.
Temp Coefficient -3mV / C ° / 2V **Rated Volt** AUTO ↓	Indicates Temperature Compensation. Temperature fluctuation can affect performance in the system. Therefore, the purpose of temperature compensation is to adjust the performance of the system to keep the system functioning normally. **Choose 12V, 24V, 36V, 48V or AUTO for Rated voltage.**
Over Volt. Disc. 16.0 V **Charge Limit** 15.0 V ↓	Parameters for Over-Voltage Disconnect and Charging Limit.
Over Volt. Rect. 15.0 V **Equalize Charge** 14.6 V ↓	Parameters for Over-Voltage Reconnect and Equalization Charge Voltage
Boost Charge 14.4 V **Float Charge** 13.8 V	Parameters for Boost Charge and Float Charge voltage

↓	
Boost Rect Vol 13.2 V **Low Volt Rect** 12.6 V	Parameters for Boost Voltage Reconnect and Boost Under-Voltage Reconnect.
↓	
Under Volt Rect 12.2 V **Under Volt Warn** 12.0 V	Parameters for under voltage reconnect and under voltage warning.
↓	
Low Volt Dis 11.1 V **Discharge Limit** 10.6 V	Parameters for low voltage disconnect and the discharging limit.
↓	
Equalize Time 120 min **Boost Time** 120 min	Parameters for the equalization duration time and the boost duration time.
↓	
Batt. Manag. Char.SOC 100% Disc.SOC: 30% Vol.Com. SOC	Parameters for what constitutes the range for state of charge and users can select battery managing mode to be using voltage compensation or SOC.
ESC	

NOTE:

It is not possible to measure actual SOC, but rather express it as a percentage of some reference. In this case it is voltage alone (VC) or battery capacity over a time span (SOC).

VC. converts a reading from battery voltage to determine SOC by utilizing the charge controller's algorithm for known discharge. It is highly sensitive to temperature changes and battery disturbances thus having less accurate battery charge statuses.

SOC is more accurate by keeping track of the voltage and current flow in and out of the battery when reporting battery charge status. The SOC is determined by multiplying current by the time for which it flowed.

6. Sys Password

Use the [↑] [↓] keys to maneuver through the screens and [ESC] to access the Menu

Press [OK] to highlight the parameter and use the [+] [-] keys to change the parameter. Press [OK] to confirm and save the settings.

```
Sys Password
Ori.PSW: 000000
NewPSW: 000000
```

Setting a password for the controller prohibits the user from programming the controller unless the password is set.

NOTE: Default Password is "000000" if it prompts the user to enter a password before they set one.

7. Default Set

Use the [↑] [↓] keys to maneuver through the screens and [ESC] to access the Menu

Press [OK] to highlight the parameter and use the [+] [-] keys to change the parameter. Press [OK] to confirm and save the settings.

```
Default Set
No      Yes
Clr Log Record
Retain  Clear
```

This interface restores the charge controller to factory settings which is mainly for user parameters that might have been set. The second option is to clear the Work Log which the controller has been keeping track of thus far.

NOTE: Once parameters are reset, they cannot be recovered.

8. Dev Msg

```
ARM Msg.
Type: IT6415ND
Ver: v01.00+v02.60
SN: 0420131210000001
```

[↓]

```
DSP Msg.
Type: IT6415ND
Ver: v01.00+v02.60
SN: 0420131210000001
```

This screen provides information regarding the model type of the charge controller. It includes the model, software, and SKU number.

System Status Icons

☽ 0.00A	🔋 12.65V	💡 0.00A
Jan 10	12:12: 12	☺
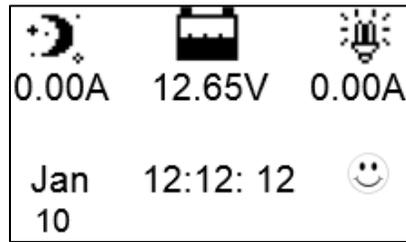
PV	BATTERY	SYSTEM
(solar panel icon)	(battery icon)	☺
Day/ PV Charging	Battery Charging	System Normal
(moon icon)	(battery full icon)	😐
Night/ PV Not Charging	Battery Level Full	System Fault
	(battery crossed out icon)	
	Battery Over Discharge	

LED Indicators

🔲 Charging LED	
Indicator	**Status**
🟩 Green (Blinking)	Charging
⬜ Green (Off)	Not Charging
🔋 Battery LED	
Indicator	**Status**
🟩 Green (Solid)	Normal
🟩 Green (Slow Blinking)	Battery Full
🟧 Orange (Solid)	Under voltage warning

Red (Solid)	Low voltage disconnect
Red (Blinking)	Battery over temperature
Green (Fast Blinking)	High voltage disconnect
⚠ Fault LED	
Indicator	**Status**
Red (Off)	Normal
Red (Blinking)	Current is abnormal Charging overcurrent PV Overvoltage

The following LED indicators must be occurring at the same time for the Charging LED and Battery LED

Charging LED	Battery LED	Status
Green (Blinking)	Red (Blinking)	System Voltage Error
Green (Blinking)	Orange (Blinking)	Controller Over Temperature

Commander Protections

Protection	Behavior
PV Array Short Circuit	When PV shot circuit occurs, the controller will stop charging. Clear it to resume normal operation
PV Overvoltage	If the PV voltage is larger than maximum input open voltage 150VDC, PV will remain disconnected and warning until the voltage falls safely below 145V. PV voltage cannot be too high, otherwise it may damage the controller.
PV Overcurrent	The controller will limit the battery charging current to the maximum battery current rating. Therefore an over-sized solar array will not operate at peak power.
PV Reverse Polarity	The controller will not operate if the PV wires are switched. Wire them correctly to resume normal controller operation.

Battery Reverse Polarity	The controller will not operate if the battery wires are switched. Wire them correctly to resume normal controller operation.
Over-Temperature	If the temperature of the controller heat sink exceeds 85°C, the controller will automatically start the protection and recover once conditions are below 75°C

System Status Troubleshooting

Description	Troubleshoot
Charging LED off during daylight.	Ensure that the PV wires are correctly and tightly secured inside the charge controller PV terminals. Use a multi-meter to make sure the poles are correctly connected to the charge controller.
Battery LED orange (solid)	Use a multi-meter to check the battery voltage to confirm reading. NEVER disconnect battery without disconnecting the solar panels first. Turn off all loads connected to the battery (if applicable) and let the battery charge.
Battery LED orange (blinking)	The charge controller is operating above the maximum temperature range. Change the location of the charge controller to a cooler environment. Follow proper installation procedures to not damage the system.
Battery LED is green and blinking fast. LCD is displaying "OVD"	Battery voltage may be larger than over voltage disconnect voltage. Use a multi-meter to check the battery voltage and disconnect the PV modules for a more accurate reading.
Fault LED is blinking red and LCD displays "Over Volt"	The solar input may be too high. Use a multi-meter to determine whether the solar panels are sized appropriately to the controller and battery bank. The charge controller will pause all activity and resume work activity once it detects a proper voltage range.
Users cannot connect RS-485 cable	Check that the correct cable is being used and the correct port is being used. Verify that the correct software is installed.

Maintenance

WARNING: **Risk of Electric Shock! Make sure that all power is turned off before touching the terminals on the charge controller.**

For best controller performance, it is recommended that these tasks be performed from time to time.

1. Check that controller is mounted in a clean, dry, and ventilated area.
2. Check wiring going into the charge controller and make sure there is no wire damage or wear.
3. Tighten all terminals and inspect any loose, broken, or burnt up connections.
4. Make sure readings in the LCD and LED are consistent. Take necessary corrective action.
5. Check to make sure none of the terminals have any corrosion, insulation damage, high temperature, or any burnt/discoloration marks.

Fusing

Fusing is a recommended in PV systems to provide a safety measure for connections going from panel to controller and controller to battery. Remember to always use the recommended wire gauge size based on the PV system and the controller.

NEC Maximum Current for different Copper Wire Sizes									
AWG	16	14	12	10	8	6	4	2	0
Max. Current	18A	25A	30A	40A	55A	75A	95A	130A	170A

Note: The NEC code requires the overcurrent protection shall not exceed 15A for 14AWG, 20A for 12 AWG, and 30A for 10AWG copper wire.

Fuse from Controller to Battery
Controller to Battery Fuse = Current Rating of Charge Controller   **Ex. 60A MPPT CC = 60A fuse from Controller to Battery**

Fuse from Solar Panel(s) to Controller
Ex. 200W; 2 X 100 W panels   ****Utilize 1.56 Sizing Factor**

Series:
Total Amperage = I_{sc1} = I_{sc2} = 5.75A * 1.56
Fuse = minimum of 5.75 * 1.56 = 8.97 = **9A fuse**

Parallel
Total Amperage = I_{sc1} + I_{sc2} = (5.75A + 5.75A) * 1.56
Fuse = minimum of 11.5 * 1.56 = 17.94 **= 18A fuse**

Technical Specifications

Electrical Parameters

Model	Commander 60A MPPT
Nominal system voltage	12v/24v/36v/48v/ Auto Recognition
Rated Battery Current	60A
Max. Input Short Current	75A
Battery Voltage Range	8-68V
Max Solar Input Voltage	150 VDC @ Minimum Working Temperature 138 VDC @ 25°C
MPPT Voltage Range	Vbattery + 2V ~ 108V
Max. Solar Input Power	12V @ 800W | 24V @ 1600W | 36V @ 2400W | 48V @ 3200W
Self-Consumption	1.4W to 2.6W
Grounding	Negative
Communication	RS485 Cable
PV Wire Size	4 AWG

Charging Parameters
NOTE: Under the <u>USER</u> battery setting, the parameters can be adjusted within the boundaries of the max and min values listed below. All of the following coefficients assume 25°C Standard Testing Conditions (STC). The following parameters will be (x2) for 24V systems, (x3) for 36V systems, and (x4) for 48V systems.

Battery Type	SEALED	GEL	FLOODED	USER
High Volt Disconnect	16V	16V	16V	9~17V
Charging limit voltage	15V	15V	15V	9~17V
Over Voltage Reconnect	15V	15V	15V	9~17V
Equalization voltage	14.6V	——	14.8V	9~17V
Boost voltage	14.2V	14.4V	14.6V	9~17V

Float voltage	13.8V	13.8V	13.8V	9~17V
Boost return voltage	13.2V	13.2V	13.2V	9~17V
Low voltage reconnect	12.6V	12.6V	12.6V	9~17V
Under voltage recover	12.2V	12.2V	12.2V	9~17V
Under voltage warning	12V	12V	12V	9~17V
Low Voltage Disconnect	11.1V	11.1V	11.1V	9~17V
Discharging Limit Voltage	10.6V	10.6V	10.6V	9~17V
Equalize duration	120min	——	120min	0~180min
Boost duration	120min	120min	120min	10~180min

NOTE: The following rules MUST be obliged when setting custom parameters.

<u>Rule 1:</u> High Volt Disconnect > Charging limit voltage ≥ Equalization voltage ≥ Boost voltage ≥ Float voltage > Boost return voltage;

<u>Rule 2:</u> High Volt Disconnect > Over Voltage Reconnect;

<u>Rule 3:</u> Charging Limit Voltage > Low voltage reconnect > Low voltage disconnect;

<u>Rule 4:</u> Charging Limit Voltage > Under voltage recover > Under voltage warning;

<u>Rule 5:</u> Boost return voltage > Low voltage reconnect;

Charging Parameters Glossary

High Volt Disconnect—users can use the default parameters or assign a rated voltage value that the charge controller will operate. When and if the charge controller experiences a voltage higher than what is assigned, it will disconnect itself from the circuit; ceasing charge.

Charging Limit Voltage—depending on the batteries used, there might be a battery charging limit voltage that is recommended for the battery. This parameter ensures that the charge controller does not exceed the default or assigned rated charging limit voltage. This is usually put into play to optimize and extend the life of the battery. Relatively speaking, the higher the charging voltage then there is a correlation for reduced battery efficiency. (Likewise the lower the discharge voltage affects battery efficiency.

Over-voltage Reconnect—In the event a charge controller experiences an over-voltage condition set by the previous two parameters, then this reconnecting parameter is put into play to direct the controller when it can connect and safely charge again. Typically over-voltage reconnection is achieved when time has passed (ex. The sun setting), or when

the over-voltage condition is remedied ultimately reducing the voltage to a user defined charging voltage.

Equalization Voltage—equalization voltage is a corrective over-charge of the battery. The user should consult their battery manufacturer regarding specific battery equalization capacity. This parameter sets the equalization voltage to set the battery at when it reaches the equalization state.

Boost Voltage—users should check with their battery manufacturer for proper charging parameters. In this stage, users set the boost voltage where the battery will reach a voltage level and remain there until the battery undergoes an absorption stage

Float Voltage—once the charge controller recognizes the set float voltage, it will commence floating. The battery is supposed to be fully charged in his state, and the charge current is reduced to maintain battery stability levels.

Boost Return Voltage—if at any point, the battery voltage levels registers to be below the boost return voltage for an extended period amount of time, then the charge controller will commence the boost stage once again.

Low Voltage Reconnect—this parameter allows loads connected to the system will be able to operate (not fully) again.

Under-voltage Recover—deals with the loads connected to the system. When batteries are determined to be low due to them approaching low voltage disconnect, then the loads will be shut off to give the batteries time to recover. This parameter sets the controller to shut off the loads until it can reach the low voltage reconnect stage.

Under-voltage Warning—this parameter deals with the batteries themselves approaching the under-voltage recovery state. The user should minimize loads before the charge controller approaches a level where it will do this automatically to protect the battery from discharging

State of Charge	12 V Battery	Volts per Cell
100%	12.7	2.12
90%	12.5	2.08
80%	12.42	2.07
70%	12.32	2.05
60%	12.20	2.03
50%	12.06	2.01
40%	11.9	1.98
30%	11.75	1.96
20%	11.58	1.93
10%	11.31	1.89
0	10.5	1.75

Mechanical Parameters

Model	Commander 60A MPPT
Overall Dimension	449mm x 208mm x 107mm | 17.7in x 8.2in x 4.2in
Mounting	430mm x 180mm | 16.9in x 7.1in
Max Terminal	4 AWG
Net Weight	5.5 kg | 12.1 lbs.
Mounting Holes	Φ10

Environment Parameters

Model	Commander 60A MPPT
LCD Temperature	-20°C to +70°C | -4ºF to 158ºF
Working Temperature	-25°C to +55°C | -13ºF to 131ºF
Storage Temperature	-30°C to +85°C | -22ºF to 185ºF
Humidity	≤95% N.C.
Enclosure	IP20
Altitude	< 5000m (Derate to operate according to IEC60146 at a height exceeding 1000m)

Conversion Efficiency Curves

1. Solar MPPT Voltage (36V, 54V, 72V) / System Voltage (12V)

12V Conversion Efficiency Curves

2. Solar MPPT Voltage (36V, 54V, 72V) / System Voltage (24V)

24V Conversion Efficiency Curves
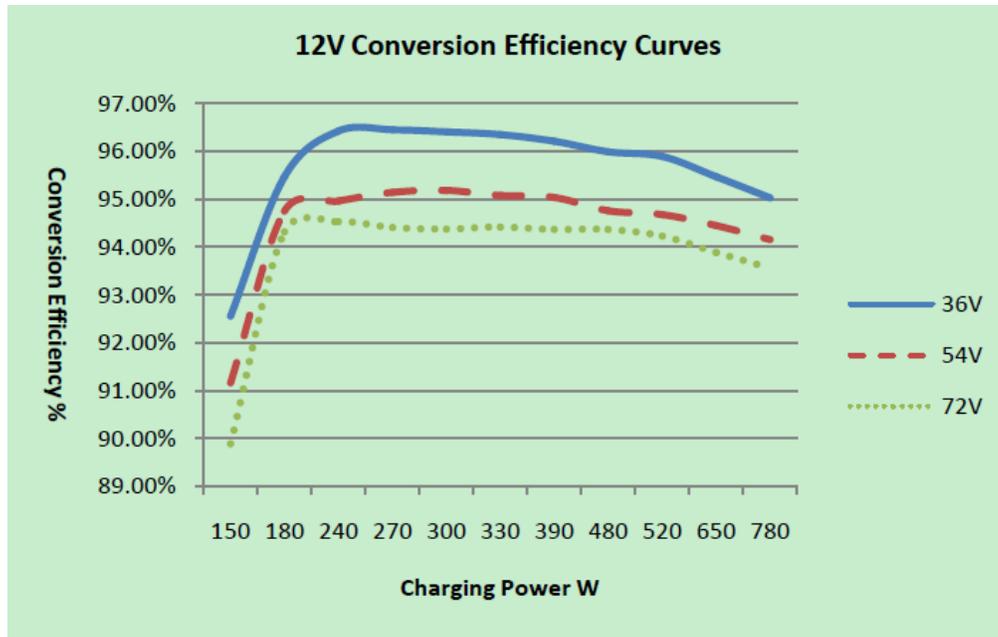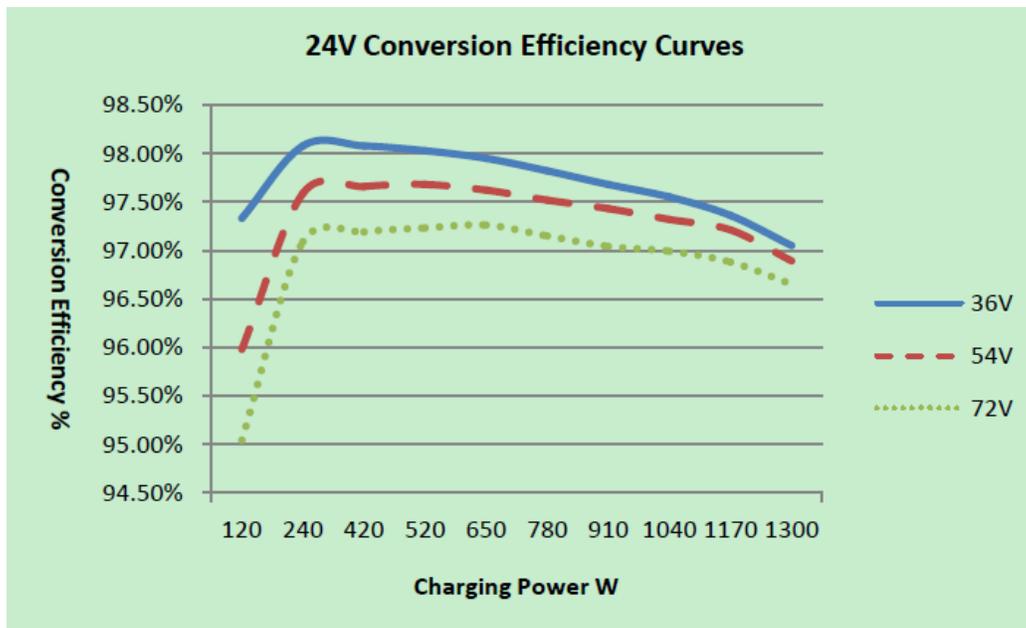
3. Solar MPPT Voltage (54V, 72V, 90V) / System Voltage (36V)

36V Conversion Efficiency Curves
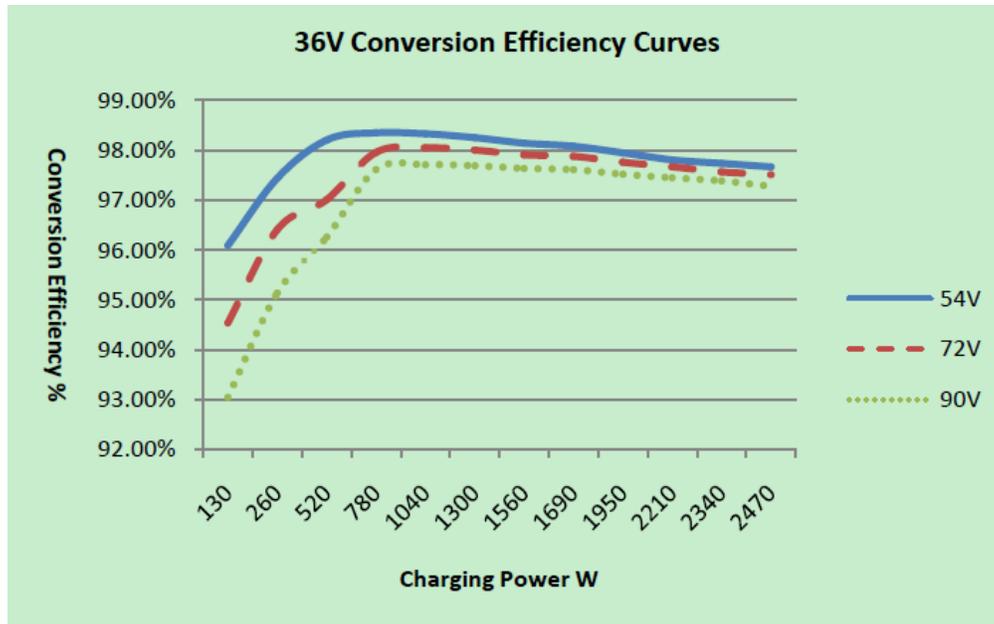
4. Solar MPPT Voltage (72V, 90V, 108V) / System Voltage (48V)

48V Conversion Efficiency Curves

PC Software

The Commander MPPT charge controller has a special feature where users are able to remotely monitor the status of their charge controller through the USB connection cable provided. Remote monitoring can be applied to more than one Commander MPPT charge controller with their unique identification numbers. Simply plug the USB into your PC and follow the downloadable instructions.

NOTE: For PC monitoring users will need to enter a username and password.
Username: administrator
Password: 111111

Globe Monitoring

Real Time Monitoring

Control Parameter

Load Configuration

Dimensions

4.2in

8.2in

17.7in