Commander Series

Commander 20A | 40A
Maximum Power Point Tracking Solar Charge Controller

RENOGY

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Version 2.6

⚠ Important Safety Instructions ⚠

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.

General Safety Information

- 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.

Charge Controller Safety

- **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.

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 sealed / 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.

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General Information

The Commander Series MPPT charge controllers are suitable for various 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. At the same time, the low voltage disconnect function (LVD) will prevent the battery from over discharging.

The Commander's 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 charge controller has an RJ45 interface to allow communication with the MT-50 meter.

Key Features

- Automatically detect 12V or 24V DC system voltages.
- Innovative MPPT technology with high tracking efficiency up to 99% and peak conversion efficiency of 97%
- Deep cycle Sealed, Gel, and Flooded battery option ready
- Electronic protection: Overcharging, over-discharging, overload, and short circuit.
- Reverse protection: Any combination of solar module and battery, without causing damage to any component.
- Die-cast aluminum design allowing for natural heat dissipation
- RS-485 port and MT-50 Tracer Meter compatible for extra features

MPPT Technology

The 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

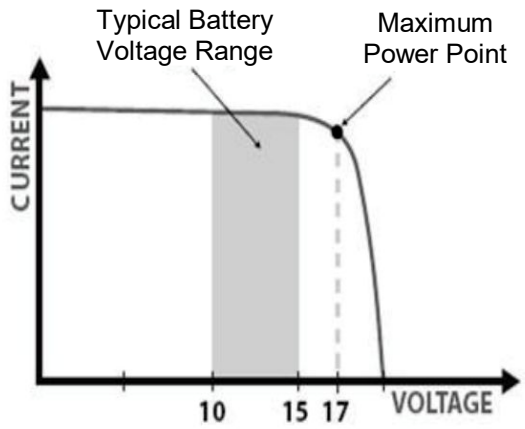
In many cases, the MPPT charge controller will "boost" up the current in the solar system. The current does not come out of thin air. Instead, the power generated in the solar panels is the same power that is transmitted into the battery bank. Power is the product of Voltage (V) x Amperage (A).

Therefore, assuming 100% efficiency:

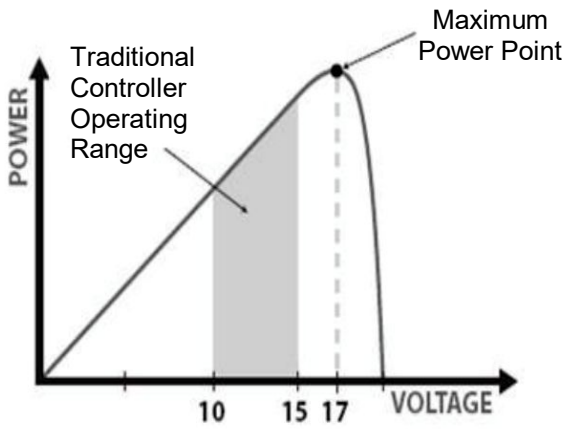
Power In = Power Out
Volts In * Amps In = Volts out * Amps out

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)

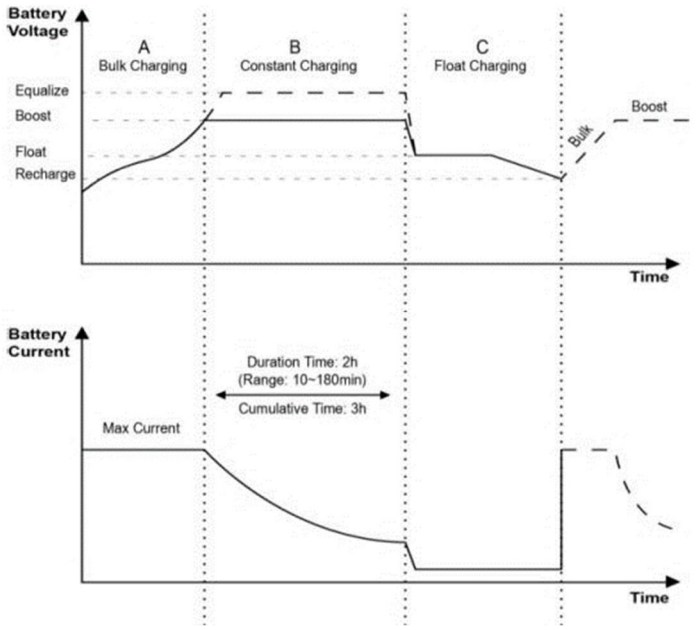


Limiting Effectiveness

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.

Optional Components

***The CMD20/CMD40 is shipped with the MT-50 Tracer Meter**

MT-50 Tracer Meter: The MT-50 is required to make any changes on the commander. Modify battery type, charge parameters and take advantage of this self-diagnostics meter ideal for monitoring and displaying the current solar system status information and any error indications the system might be experiencing. The meter also allows users to program loads for different time intervals.

Optional components that require a separate purchase:

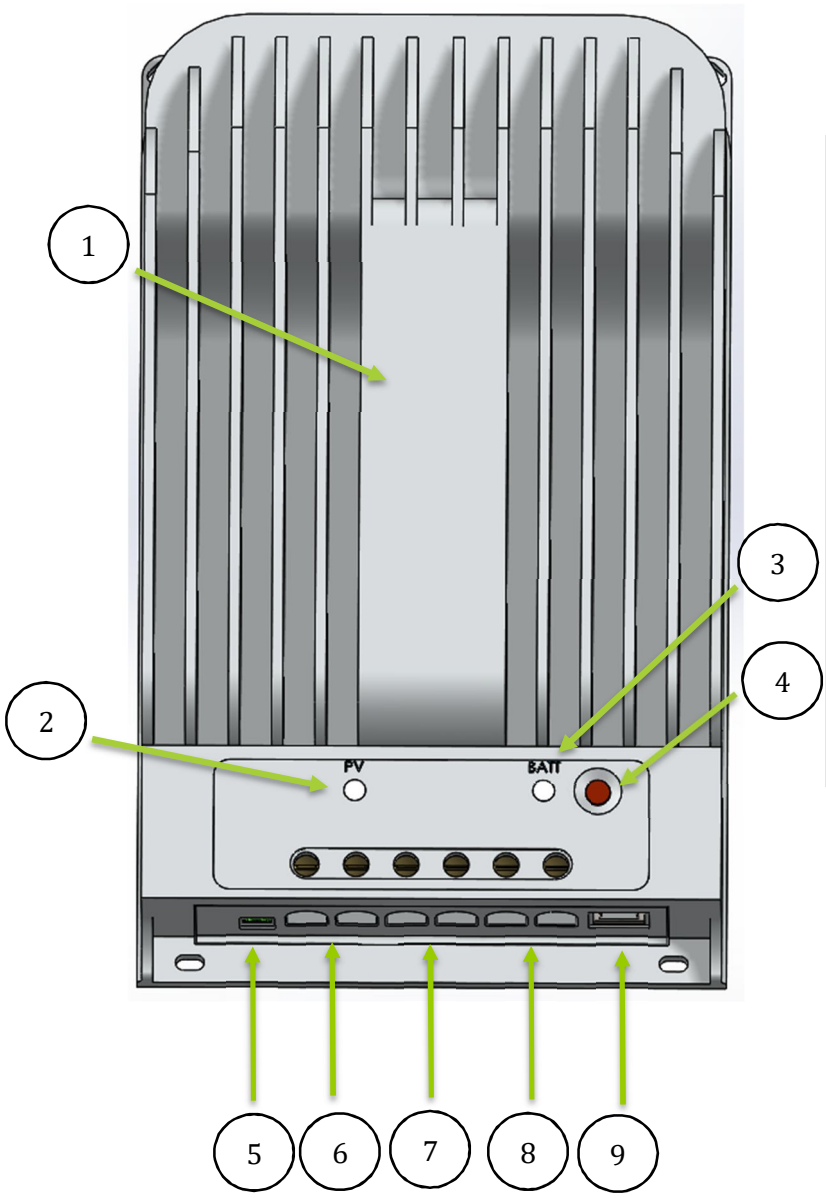
Remote Temperature Sensor: This sensor measures the temperature at the battery and uses this data for very accurate temperature compensation. Accurate temperature compensation is important in ensuring proper battery charging regardless of the temperature.

USB to RS-485 Converter Cable: This PC communication cable is needed for remote monitoring using an optional PC software. Through the software, users could customize their charge parameters and other settings. Download the PC software through Renogy's website under the "Downloads" section.

NOTE: PC Communication requires the USB be connected at all times. Wireless capability not available.

WARNING: Do NOT use a PC Ethernet cable. This can and will cause permanent damage to a computer.

Identification of Parts



Key Parts

1. Heat Sink
2. Charging LED Indicator
3. Battery LED Indicator
4. Set Button
5. Remote Temperature Sensor Port (optional accessory)
6. PV Terminals
7. Battery Terminals
8. Load Terminals
9. RS-485 Port or MT-50 Tracer Port (optional accessories)

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

Note: The above parameter values are calculated under the STC conditions: Irradiance 1000W/m^2, 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 3X 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 1.5X 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 20A	20A	260W @ 12V 520W @ 24V	780W @ 12V 1560W @ 24V	**150V** @ minimum operating environmental temperature **OR** **138V** @ 25°C environmental temperature
Commander 40A	40A	520W @ 12V 1040W @ 24V	1560W @ 12V 3120W @ 24V	

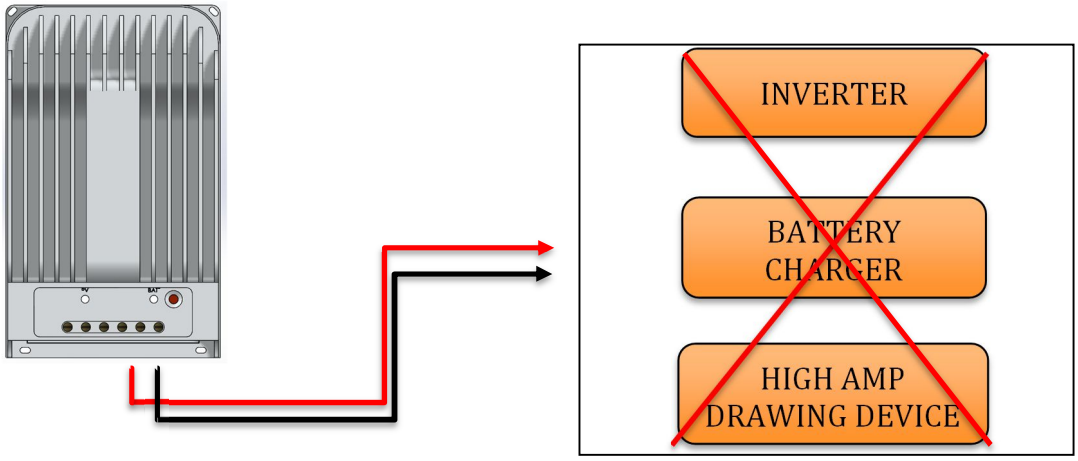
Installation

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.

WARNING: Do NOT connect any inverters or battery chargers into the LOAD TERMINAL of the charge controller



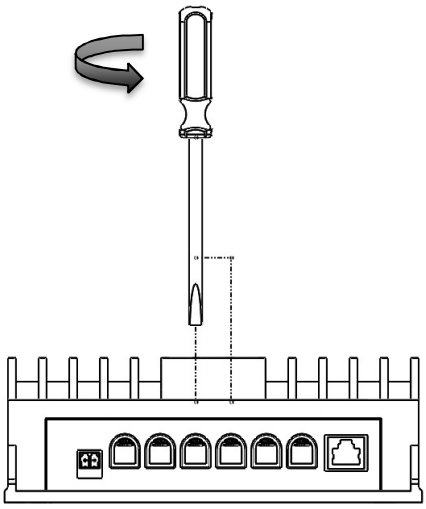
CAUTION: **Do not over-torque or over tighten the screw terminals. This could potentially break the piece that holds the wire to the charge controller.**

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

1



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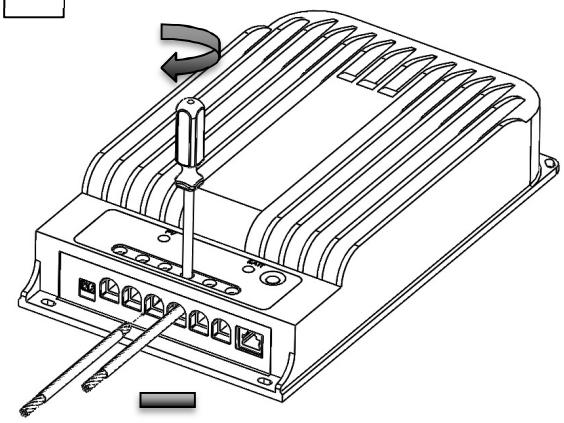
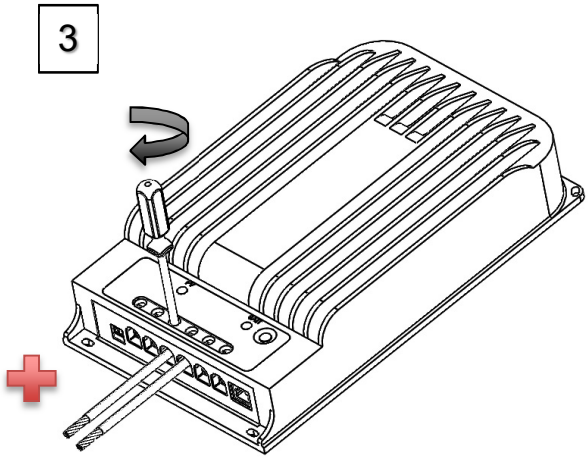
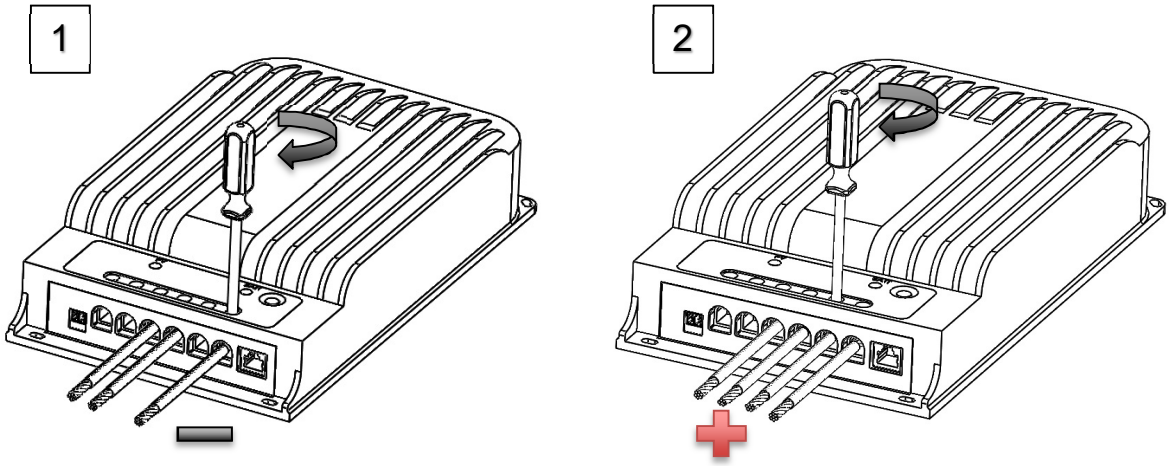
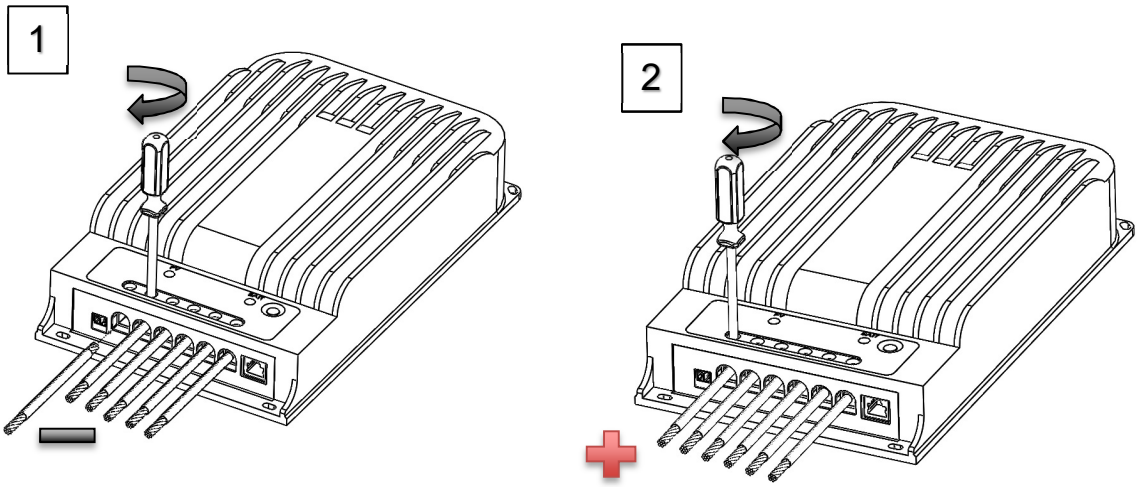




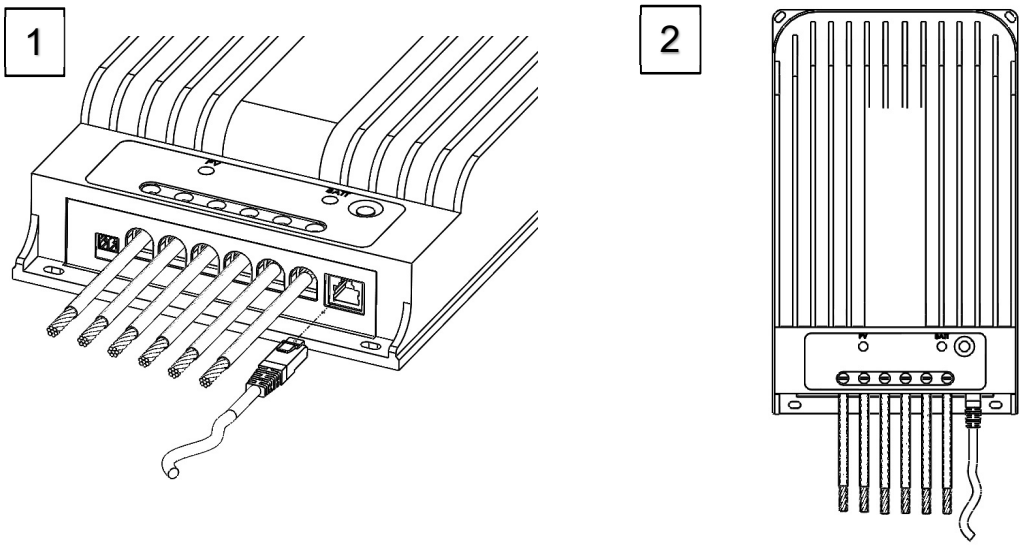
Load (optional)



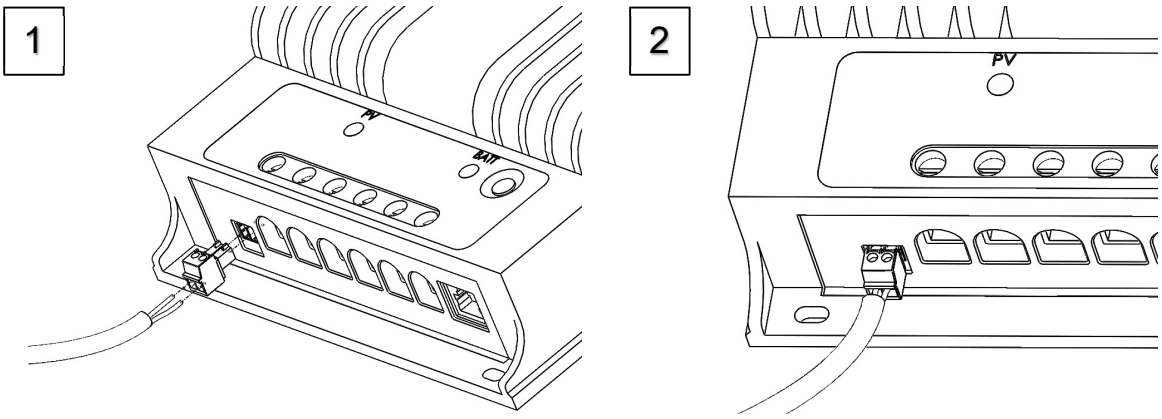
Solar Panels



MT-50 Tracer (optional)



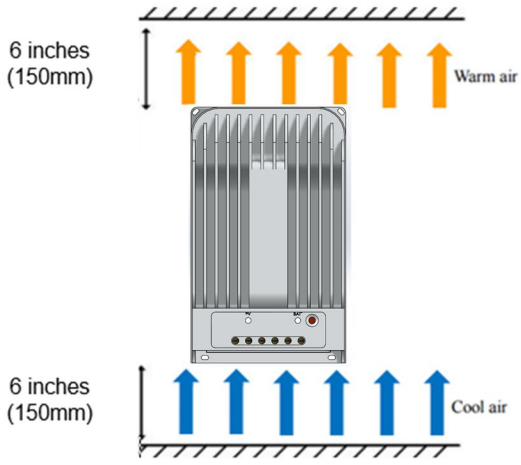
Temperature Sensor (optional, not polarity sensitive)



Mounting Recommendations

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**
4. **Drill Holes**
5. **Secure the charge controller**



Operation

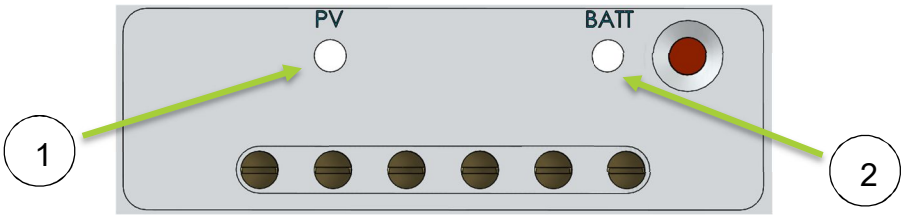
The CMD-20 and CMD-40 is very simple to use. Simply connect the batteries, and the controller will automatically determine the battery voltage. If there is a load connected, use the red-orange button in front of the charge controller to manually turn the load on or off.

NOTE: Refer to the Technical Specifications to make sure the device connected to the load terminal does not exceed the rated voltage and amperage limitations for this terminal.

NOTE: For programmable functions, the MT-50 Tracer Meter or the PC Communication Cable is needed.

Press to turn Load on or off

LED Indications



PV Indicator (1)		Status
	Green Flashing	The PV system is charging the battery bank
	Green Solid	The PV system is charging the battery bank at a slow rate. Make sure panels are not shaded. Low Amperage.
	Off	The PV system is not charging the battery bank. PV not detected.
BATT Indicator (2)		**Status**
	Green Solid	Battery is normal
	Green Flashing	Battery fully charged
	Orange Solid	Battery under voltage warning

	Red Solid	Battery Low voltage disconnect
	Green Flashing quickly	Battery High voltage disconnect
	Red Flashing	Battery is over-temperature.

PV Indicator (1)		BATT Indicator (2)		Controller Status
	Green Flashing		Red Flashing	Work voltage error
	Green Flashing		Orange Flashing	charge controller is over-temperature
	Off		Off	Controller needs 9V minimum to turn on. Check connections

NOTE: This table demonstrates controller status based on both PV and BATT indicator

Commander Protections

Protection	Behavior
PV Array Short Circuit	When PV short circuit occurs, the controller will stop charging. Clear it to resume normal operation
PV Overvoltage	If the PV voltage is larger than the maximum input open voltage 150VDC, PV will remain disconnected 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.
Load Overload	If the current exceeds the maximum load current rating 1.05 times, the controller will disconnect the load. Overloading must be cleared up by reducing the load and restarting the controller.
Load Short Circuit	Fully protected against the load wiring short-circuit. Once the load short (more than quadruple rate current), the load short

	protection will start automatically. After 5 automatic load reconnect attempts, the faults must be cleared by restarting the controller.
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^{O}C, the controller will automatically start the protection and recover once conditions are below 75^{O}C

System Status Troubleshooting

PV indicator	Troubleshoot
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.
BATT Indicator	**Troubleshoot**
Solid orange	Disconnect loads, if any, and let the PV modules charge the battery bank. Use a multi-meter to frequently check on any change in battery voltage to see if condition improves. This should ensure a fast charge. Otherwise, monitor the system and check to see if system improves.
Solid Red	The controller will have cutoff the output of the battery to ensure that it charges. Make sure there are no excessive loads and give the system appropriate time and sunlight to charge. Monitor readings with a multi-meter to see if they system improves. If system does not charge, then the user must find another means for charging battery since it is too low for the controller to register.

Flashing Red	Battery is over-temperature and must be secured in a cooler location. Disconnect PV panel(s), then disconnect the battery before changing the battery's location to a cooler area.
Quickly flashing green	The battery voltage is higher than the over voltage disconnect. Use a multi-meter to check the battery voltage to determine whether it is too high. Then disconnect and reconnect the PV modules.
Work Mode	**Troubleshoot**
All LED flashing (battery LED orange)	The temperature of the controller is too high and is probably exceeding 85ºC. The controller will automatically cut the input and output of the circuit. Once the controller registers a lower temperature, it will resume functioning normally.
All LED flashing (battery LED red)	This indicates a system voltage error. Check whether the battery voltage matches the controller's working voltage. If correct, disconnect and reconnect all connections. Solar modules are first when disconnecting and battery is first when reconnecting.

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 LED readings 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. 20A MPPT CC = 20A fuse from Controller to Battery**

Fuse from Solar Panel(s) to Controller	
Ex. 200W; 2 X 100 W panels ****Utilize 1.56 Sizing Factor (SF)** **NOTE: Different safety factors could be used. The purpose is to oversize.**	
Series:	**Parallel**
Total Amperage = $I_{sc1} = I_{sc2}$ * SF = 5.75A * 1.56 = 8.97 **Fuse** = **9A fuse**	**Total Amperage** = $(I_{sc1} + I_{sc2})$ * SF (5.75A + 5.75A) * 1.56 = 17.94 **Fuse** = **18A fuse**

Technical Specifications

Electrical Parameters

Model	CMD-20	CMD-40
Nominal system voltage	12V/24V Auto Recognition	
Rated Battery Current	20A	40A
Rated Load Current	20A	20A
Max. PV Input Short Current	25A	50A
Battery Voltage Range	8V-32V	
Max Solar Input Voltage	150 VDC @ Minimum Working Temperature 138 VDC @ 25°C	
Max. Solar Input Power	12V @ 260W	12V @ 520W
	24V @ 520W	24V @ 1040W
Self-Consumption	≤60mA @ 12V ≤30mA @ 24V	
Grounding	Negative	
Charge circuit voltage drop	≤ 0.26V	
Discharge circuit voltage drop	≤ 0.15V	
Temp. Compensation	-3mV/°C/2V (default)	
Communication	RSJ45	

Battery Charging Parameters

Battery	GEL	SEALED	FLOODED
High Voltage Disconnect	16 V	16 V	16 V
Charging Limit Voltage	15 V	15 V	15 V
Over Voltage Reconnect	15 V	15 V	15 V
Equalization Voltage	-----	14.6 V	14.8 V
Boost Voltage	14.2 V	14.4 V	14.6 V
Float Voltage	13.8 V	13.8 V	13.8 V
Boost Return Voltage	13.2 V	13.2 V	13.2 V
Low Voltage Reconnect	12.6 V	12.6 V	12.6 V
Under Voltage Recover	12.2 V	12.2 V	12.2 V
Under Voltage Warning	12 V	12 V	12 V
Low Voltage Disconnect	11.1 V	11.1 V	11.1 V
Discharging Limit Voltage	10.6 V	10.6 V	10.6 V
Equalization Duration	-----	2 hours	2 hours
Boost Duration	2 hours	2 hours	2 hours

****Parameters are multiplied by 2 for 24V systems.**

Environment Parameters

Model	CMD-20	CMD-40
Working Temperature	-35°C to +55°C	
Storage Temperature	-35°C to +80°C	
Rated Load Current	10% to 90% NC	
Humidity Range	≤ 95% (NC)	
Enclosure	IP30	
Altitude	< 3000	

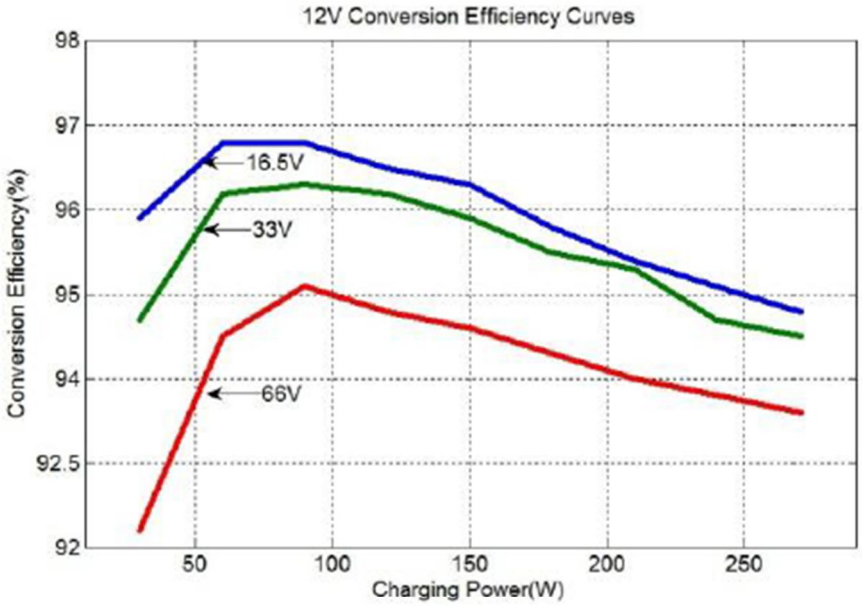
Mechanical Parameters

Model	CMD-20	CMD-40
Overall Dimension	216.6 x 142.6 x 56mm 8.52 x 5.61 x 2.20in	302.5 x 182.7 x 63.5mm 11.90 x 7.19 x 2.50in
Mounting Oval	7.66 x 4.70mm 0.30 x 0.18in	
Max Terminal Size	$10mm^2$ 8 AWG	$25mm^2$ 4 AWG
Net Weight	1.5 kg 3.3 lb.	2.9 kg 6.39 lb.

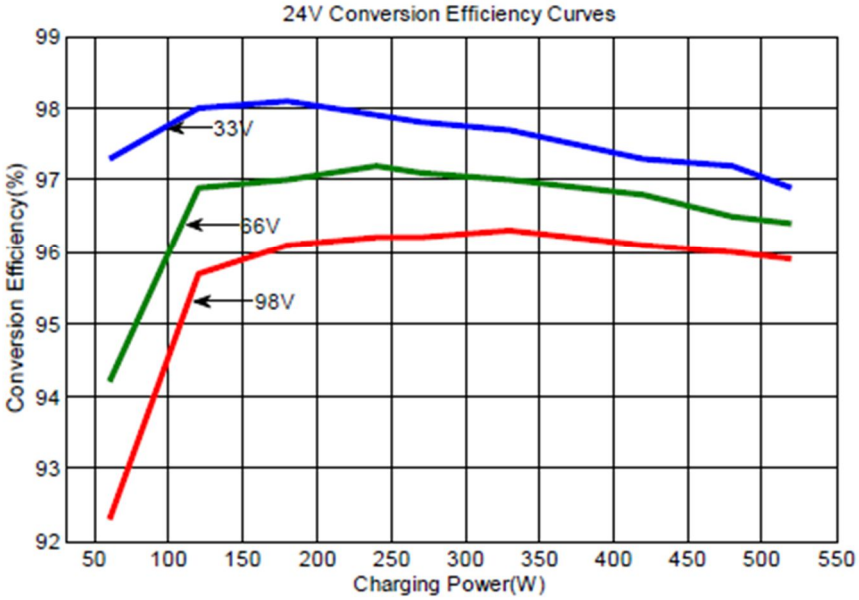
CMD-20: PV Power – Conversion Efficiency Curves

Illumination Intensity: 1000W/ m^2 Temp 25°C

1. Solar Module MPP Voltage(16.5V, 33V, 66V) / Nominal System Voltage(12V)



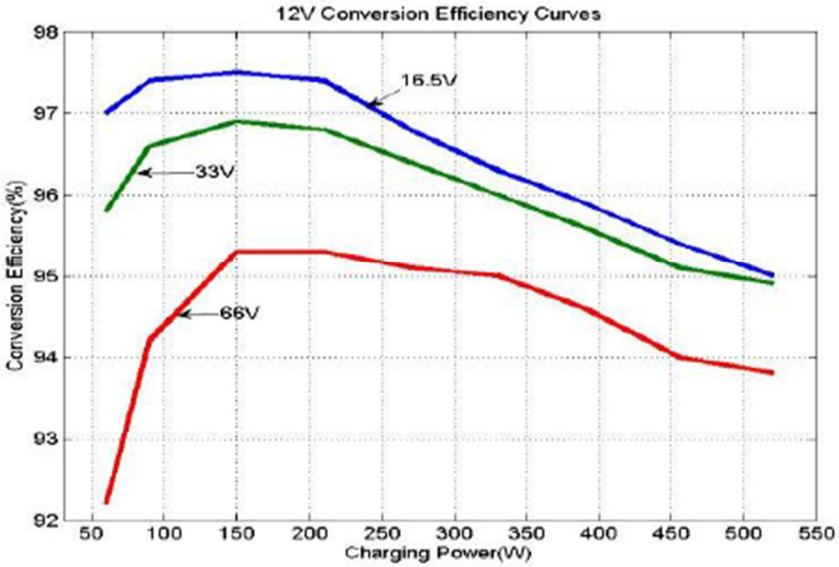
2. Solar Module MPP Voltage(33V, 66V, 98V) / Nominal System Voltage(24V)



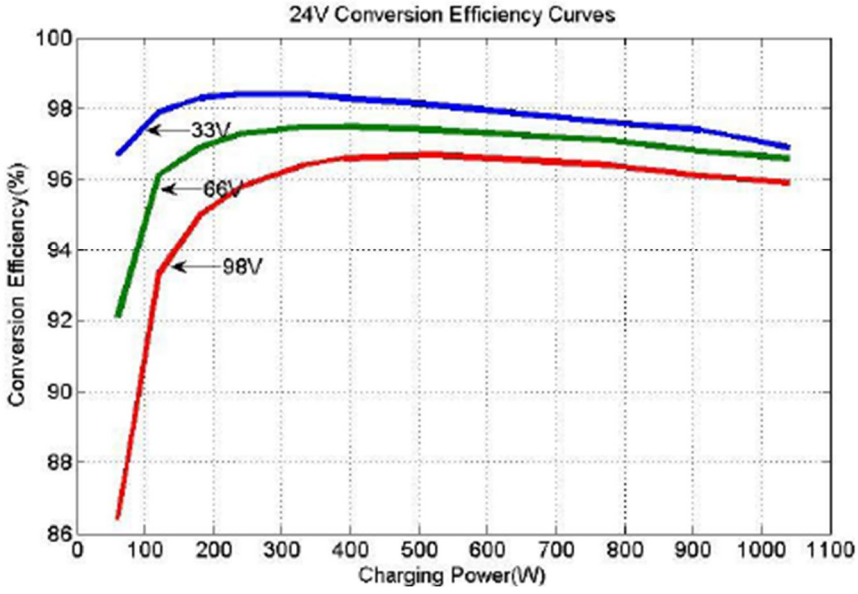
CMD-40: PV Power – Conversion Efficiency Curves

Illumination Intensity: 1000W/ m^2 Temp 25°C

1. Solar Module MPP Voltage(16.5V, 33V, 66V) / Nominal System Voltage(12V)

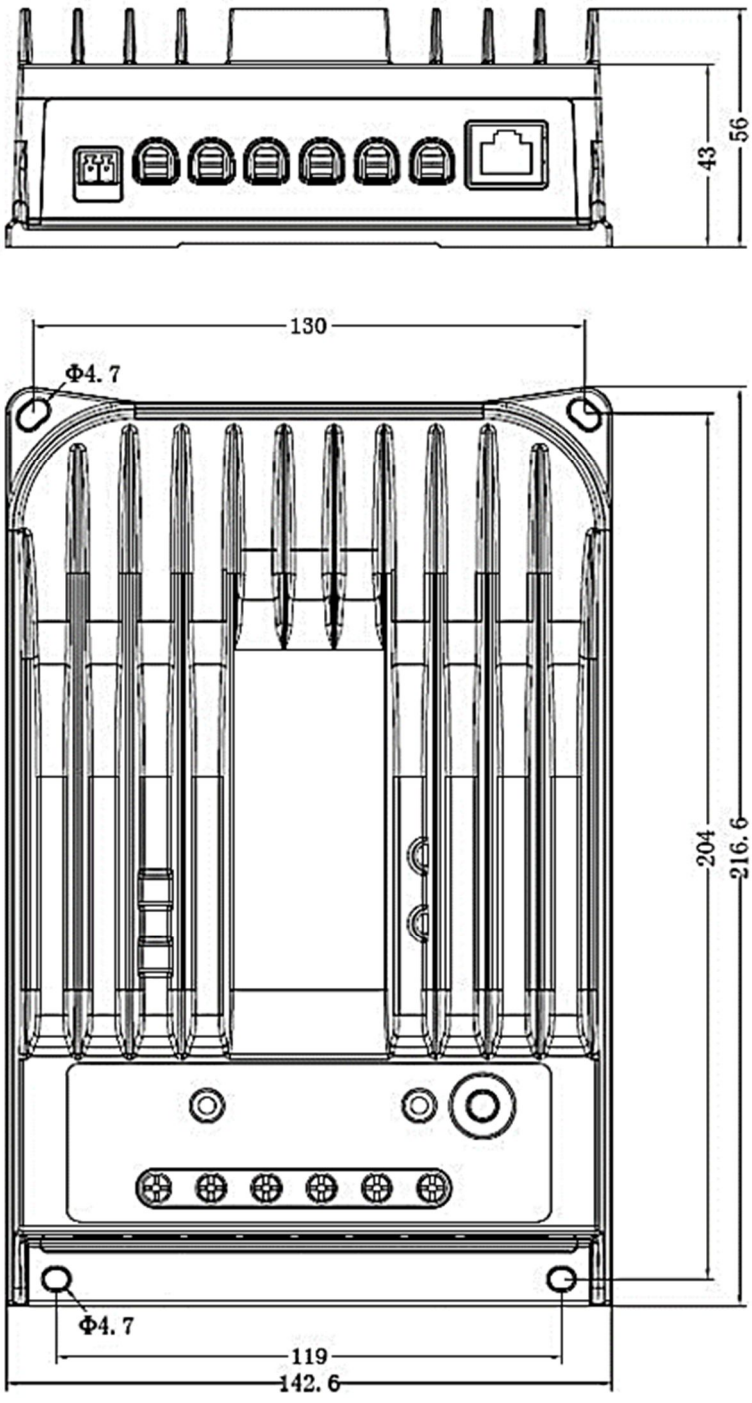


2. Solar Module MPP Voltage(33V, 66V, 98V) / Nominal System Voltage(24V)



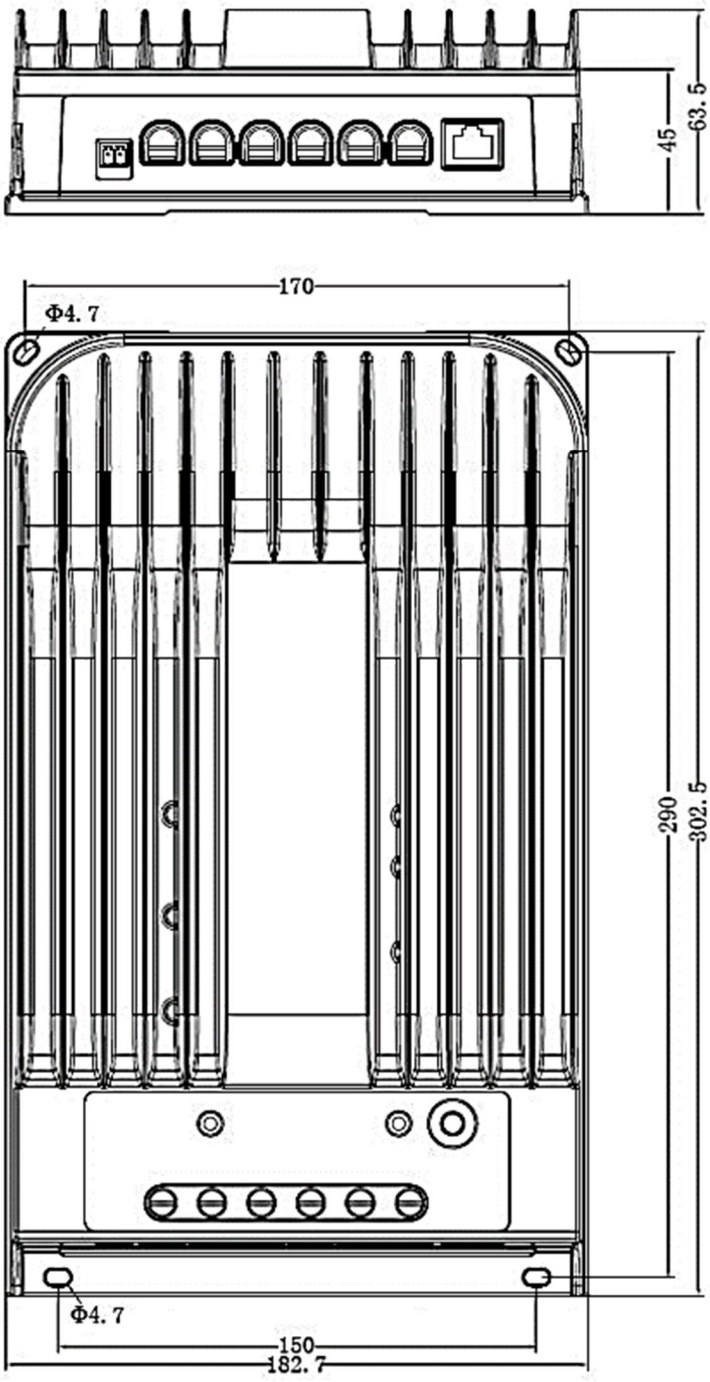
Dimensions

CMD-20



NOTE: **Dimensions in millimeters (mm)**

CMD-40



NOTE: **Dimensions in millimeters (mm)**

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