# Solar Charge Controller with Maximum Power Point Tracking

Installation & Operation Manual

# Contents

Dear Consumer :

Thank you very much for using our product! We will offer you the permanent and reliable service for your solar system!

The manual gives important recommendations for installing and using the MPPT controller. Please read the manual carefully and thoroughly before using this product.

# 1. Safety Instructions

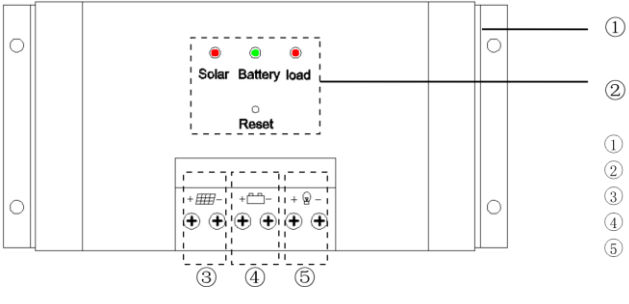
(1) The controller is only designed to be connected to the off-grid solar system. It offers the management of charging and discharging for the lead-acid battery of flooded, gel and AGM chemistries from 12V to 24V nominal only. Do not connect this controller to other system, such as mains supply and windmill generator.
(2) The controller is intended for indoor use only. Protect it from direct sunlight and place it in a dry environment.
(3) Batteries generate explosive gases during normal operation. It is important never allow a spark or flame in vicinity of battery.
(4) Be sure to always keep children away from batteries and acid!
(5) Do not disassemble the MPPT controller, it does not have any user-serviceable parts.
(6) The controller warms up during normal operation. Do not touch the heatsink at the bottom of the controller.
**Note**: **It is important that the battery is fully charged frequently (at least monthly). Otherwise the battery will be permanently damaged.**

# 2. Controller Instructions

## 2.1 Overview

The solar charge controller is multi-stage Maximum Power Point Tracking (MPPT) photovoltaic battery charge controller with our own technology. It's main topology adopts in Buck conversion circuit, and uses MCU to adjust the solar panels working point intelligently in order to make the solar panels output its maximum power. When the circumstances change, the working point of solar panels deviate from the maximum power point, MCU will adjust the solar panels working point based on MPPT calculation to make the solar panels back to the maximum power point again(refer to Chapter 2.4 about MPPT technology introduction). Compared with PWM controller, MPPT controller can increase the output power of solar panels by 5%~30%. The output power increasing proportion is affected by the factors such as solar panels property, humidity and light intensity. The controller uses wall-mount installing (refer to Chapter 4.1). Connecting terminal makes the wiring area bigger and wiring loss less.

## 2.2 Structure




① Bottom Heatsink
② Indicators and Reset key
③ Solar Terminal Block
④ Battery Terminal Block
⑤ Load Terminal Block

Figure 2-1: Controller Structure Diagram

## 2.3 Functions

**(1) Maximum Power Point Tracking Technology**

The controller uses Buck conversion circuit and MCU technology to track the maximum power point to implement the maximum output power of solar panels in different illumination intensity and temperature. The MPPT algorithm increases efficiency of your PV system and decreases the quantity of solar panels.

**(2) Multi-stage Charge Control**

The starting charging voltage of battery is different, the controller will use the different charging strategies to finalize the charging process. When starting charging voltage of battery is lower than 12.4V (for 12V battery), battery will go through three stages as Bulk, Absorption and Float charging. When starting charging voltage of battery is higher than 12.4V (for 12V battery), battery will go through two stages as Bulk and Float charging.

**Bulk Charge:**

The controller charges the battery by it's maximum output current. It is at maximum power point tracking state at this phrase.

**Absorption Charge:**

The controller begins to limit the charging current to make the battery voltage fixed at a settled absorption voltage (this voltage has temperature compensation) for 2 hours. It increases the charging saturation level of battery and prevents battery from leaking gas, and this can increase the lifetime of battery.

**Float Charge:**

The battery is at saturation state, and the controller charges the battery at a trickle current to make the battery voltage fixed at the settled float charging voltage (this voltage has temperature compensation).

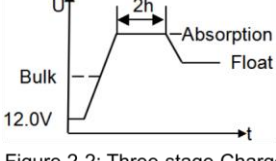



Figure 2-2: Three-stage Charge

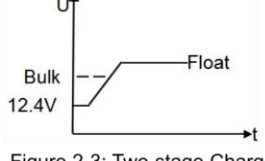



Figure 2-3: Two-stage Charge

**(3) Charge Voltage Temperature-compensated**

The controller will compensate the Float charging voltage and Absorption charging voltage by -4mV/Cell/°C based on the current battery temperature.

For 12V battery, the compensated voltage U=(t-25)*6*(-0.004)V

For 24V battery, the compensated voltage U=(t-25)*12*(-0.004)V

**(4) Discharge Control**

The controller monitors the battery voltage all the time. The load will be switched off when the voltage less than the Low Voltage Disconnect (LVD) point, and it won't be switched on until the voltage more than the Low Voltage Reconnect (LVR) point.

**(5) Protection against Reverse Connected Battery**

Connecting the battery to the controller by reversed polarity (under the circumstances of solar panels disconnected) will not damage the controller. The controller will work normally after connecting with correct polarity.

**(6) Protection Against Reverse Connected Solar Modules**

Connecting the solar modules with the controller by reserved connection will not damage the controller. The

controller will work normally after connecting with correct polarity.

**(7) Reverse Current Protection**

The controller prevents reverse current from flowing into the solar modules at night. An additional reverse current diode is not required.

**(8) Over Temperature Protection**

If the temperature inside the controller becomes too high, then the controller will stop charging to the battery, and it will restart charging the battery again when the temperature decreases to a certain value.

**(9) PV Over Voltage Protection**

If the input voltage of solar panels exceeds the maximum voltage permitted by the controller, it will enter into protection state automatically and stop charging. When the input voltage recovers to the normal range, the controller will start charging again.

**(10) Current-limited for Excessive Charging Current**

If the permissible charge current is exceed, the controller will deviate from the maximum power point to limit the output current to prevent the controller being damaged.

**(11) Load Output Overload Protection**

If the permissible load current is exceed, then the load output is switched off. The overload current vs. duration shows as follows:

The controller restarts the load every 5 minutes automatically, but the user can also restart the load by the restart key.

| Rate of Current | Duration (s) |
|---|---|
| 1.1Irate ≤I< 1.2Irate | 120 |
| 1.2Irate ≤I< 1.5Irate | 60 |
| 1.5Irate ≤I< 1.8Irate | 10 |
| I≥ 1.8Irate | 0.2 |
| *Note:* Irate=20A, nominal load current | |

## 2.4 MPPT Technology Instructions

Solar panels are nonlinear materials, and the output power is mainly affected by illumination intensity, solar panels temperature and load impedance. When the illumination intensity and solar panels temperature are fixed, the output power of solar panels is only affected by load impedance. Different load impedance will make the solar panels work at different point and put out the different power. The following figure will mark the four working points A, B, C, D, and the working point features as follows:

**Working point D:**

Output voltage is 22.3V, output power is 0W. This point is the open circuit point of solar panels.

**Working point C:**

Output voltage is 0V, output power is 0W. This point is the short circuit working point of solar panels.

**Working point A:**

Output voltage is 13V, output power is 74W. This working point is the state when using normal controller, and the solar panels voltage is clamped to 13V by battery.

**Working point B:**

Output voltage is 17.6V, output power is 92W. This point is the state when using MPPT controller. Because of using power conversion technology, the solar panels voltage is not clamped by battery and still works at maximum power point.

Compare working point A & B, it is easy to find using MPPT controller can increase the using efficiency of solar panels. Compared to normal controller, MPPT controller can generate more power.

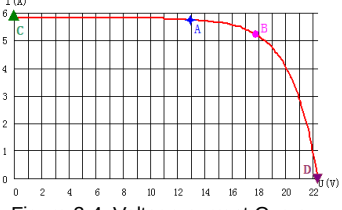



Figure 2-4: Voltage-current Curve


Figure 2-5: Voltage-power Curve

# 3. PV System Planning Reference

## 3.1 System Voltage

The common system voltage of solar system has 3 types: 12V, 24V and 48V. The higher the system voltage, the more power the system can handle. In reality application, user should consider the load power, and the voltage scope permitted by load, and then confirms which system voltage you should use. The power range for each system voltage is as follows:

| System Voltage | Recommended Power Range |
|---|---|
| 12V | ＜800W |
| 24V | ＜2000W |
| 48V | ＜6000W |

Table 3-1: System voltage vs. Power range

## 3.2 Solar Modules Configuration

| Model | Category | Pmax | Voc | Isc | Vpmax | Ipmax |
|---|---|---|---|---|---|---|
| STP140D-12/TEA | Single Crystalline Silicon Module | 140W | 22.4V | 8.33A | 17.6V | 7.95A |
| MS140GG-02 | Thin-film Module | 140W | 29.0V | 7.12A | 23.0V | 6.52A |
| STP190S-24/Ad+ | Single Crystalline Silicon Module | 190W | 45.2V | 5.65A | 36.6V | 5.2A |
| NS-F130G5 | Thin-film Module | 130W | 60.4V | 3.41A | 46.1V | 2.82A |
| The above parameters are for condition of 25°C, AM1.5 spectrum, and 1000W/$m^2$ illumination intensity. | | | | | | |

Table 3-2: Solar Panels Model and Parameters

| Model | For 12V System | For 24V System | For 48V System |
|---|---|---|---|
| STP140D-12/TEA | N in parallel | two in series, N in parallel | four in series, N in parallel |
| MS140GG-02 | N in parallel | two in series, N in parallel | four in series, N in parallel |
| STP190S-24/Ad+ | N in parallel | N in parallel | two in series, N in parallel |
| NS-F130G5 | N in parallel | N in parallel | two in series, N in parallel |
| N means the quantity number required by the output current. | | | |

Table 3-3: Solar Panels Model and System Configuration Solution

## 3.3 Wire Sizing

The rated current of the controller is 10A and 20A. To ensure the cable temperature does not exceed the safety range, the copper cable's area must be at least 2.5mm$^2$ and 4mm$^2$. In reality application, user can choose the appropriate cables according to the system voltage, permitted cable temperature, cable voltage drop and also cable material. We suggest customer to control the maximum battery voltage loss under 1.5%, and control the maximum voltage loss of solar panels under 2.5%.

The following is the cable length between controller and battery, and the suggested copper cables:

| Cable Length | Cable Size in mm$^2$ | Cable Size in AWG | Voltage Loss at 20A(a pair) | Battery Voltage Loss | | |
|---|---|---|---|---|---|---|
| | | | | 12V | 24V | 48V |
| 1m | 4mm$^2$ | #11 AWG | 0.18V | 1.5% | 0.75% | 0.35% |
| 2m | 6mm$^2$ | #9 AWG | 0.24V | 2.0% | 1.0% | 0.50% |
| 4m | 10mm$^2$ | #7 AWG | 0.29V | 2.4% | 1.2% | 0.61% |

Table 3-4: Cable Length & Cable Voltage Drop

The following is the cable length between solar panels and controller, and also the suggested copper cables:

| Cable Length | Cable Size in $mm^2$ | Cable Size in AWG | Voltage Loss at 20A (a pair) | Solar Panels Voltage Loss | | |
|---|---|---|---|---|---|---|
| | | | | 17V | 34V | 68V |
| 2m | $4mm^2$ | #11 AWG | 0.35V | 2.1% | 1.03% | 0.50% |
| 4m | $6mm^2$ | #9 AWG | 0.48V | 2.8% | 1.41% | 0.71% |
| 8m | $10mm^2$ | #7 AWG | 0.58V | 3.4% | 1.71% | 0.85% |

Table 3-5: Cable Length & Cable Voltage Drop

## 3.4 Over Current Protection

The electrical equipment used in power circuit must be equipped with over current and short-circuit protection devices, and there is no exception for MPPT controller. The controller adopts in the design of common positive pole inside. We suggest users to install over-current breaker or fuse on the negative loop of solar panels input, and also the negative loop of battery output. The capacity of over-current breaker or fuse is 1.25 times of the rated current.

## 3.5 Lightning Protection

It is the same as other electrical devices that MPPT controller will be damaged by lightning. The controller has limited surge absorption capacity. We strongly suggest users to install lightning surge absorption devices to increase the reliability of the system.

## 3.6 Grounding

Use 4 $mm^2$ yellow and green cable to connect any of the positive terminal of the controller to the ground bus of the system. This can decrease the electromagnetic interference in a certain value.

## 3.7 System Expansion

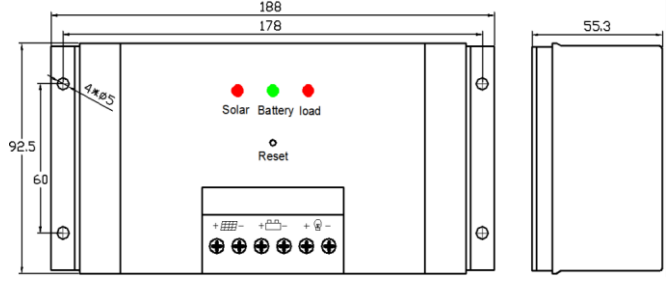
If you want to deploy a bigger system, you can expand the system by paralleling several sets of the same

controller. More controllers can share with one battery group, but each controller must be connected with the independent solar panels array and the independent load. (Please contact the local distributor for further information.)

# 4. Installation

1. Protect the controller from direct sunlight or other source of heat.
2. Place the controller in a dry environment.
3. A free space of at least 15cm on all side of the controller must be provided.
4. Mount the controller as close as possible to the batteries.

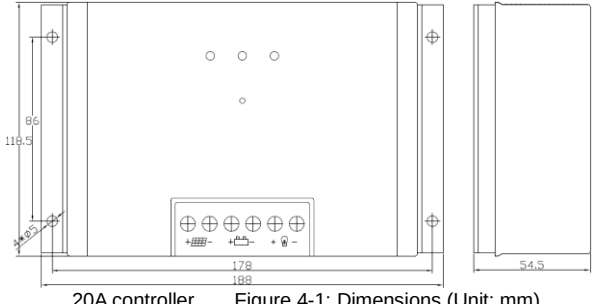
## 4.1 Dimensions




10A controller Figure 4-1: Dimensions (Unit: mm)

Mounting hole pitch: 60mm*178mm Mounting hole diameter: Φ5mm

Height*Width*Thickness: 92.5mm*188mm*55.3mm Connecting terminals: Maximum 10mm²




20A controller Figure 4-1: Dimensions (Unit: mm)

Mounting hole pitch: 86mm*178mm Mounting hole diameter: Φ5mm

Height*Width*Thickness: 118.5mm*188mm*54.5mm Connecting terminals: Maximum 10mm²

## 4.2 Connecting Diagram

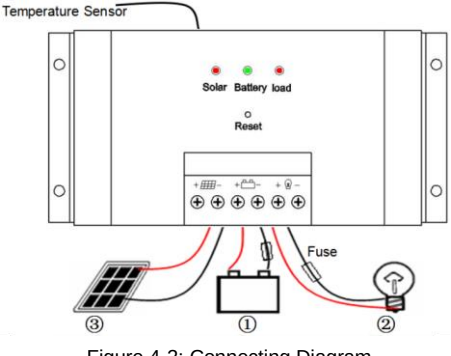



Figure 4-2: Connecting Diagram

### 4.3 Wiring

(1) Choose the appropriate cables requested as Chapter 3. Prepare 4 sets of M5 screws (used to fix the controller on the wall or other vertical plane).
(2) Prepare cutting pliers, cross screwdriver and multi-meter, etc.

### 4.4 Installation Process

**Note:** Please switch off the breakers of battery, solar panels array before installing the controller. Do not touch the positive and negative pole of solar panels or battery at the same time when installing, otherwise you have the risk of electrical shock.

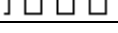
A. Mount the controller on the wall and fasten the screws.
B. Check whether the battery voltage and solar panels array voltage is within the requested range.
C. Switch off the over-current breaker or fuse of the battery, solar panels array and load.
D. Wiring.
(1) Connect the battery with the battery terminal on the controller by cables and fasten the screws.
(2) C onnect the load with the load terminal on the controller by cables and fasten the screws.
(3) Connect the solar panels array with the solar panel terminal on controller by cables and fasten the screws.
E. Switch on the breaker or fuse of the battery, then the 3 indicators indicate the system status. Switch on the breaker or fuse of the load. (more information about the indicators see Chapter 5.2 and 5.3)
F. Switch on the breaker or fuse of the battery, then the controller starts to charge the battery.

# 5. Operation Instructions

## 5.1 Button Function

There is only one concealed button on the controller, which used to restart the load when the controller is in overload protection state. The second function of the button is to control the load. Press the button and hold about 3 seconds, then the load will be switched off. This can also switch on the load.

## 5.2 LED Displays

| LED | Meaning | Status |
|---|---|---|
| **Solar (Red)** | PV Voltage Low | off |
| | MPPT Charge | illuminates |
| | Absorption Charge |  T=2s |
| | Float Charge |  T=1s |

| | | |
|---|---|---|
| | PV Overvoltage Protection |  T=0.5s |
| **Battery (Green)** | Battery Disconnect | off |
| | Normal Operation | illuminates |
| | Undervoltage Protection |  T=2s |
| | Overvoltage Protection |  T=1s |
| | Overtemperature Protection |  T=0.5s |
| **Load (Red)** | Load Off | off |
| | Load On | illuminates |
| | Heatsink Temperature Sensor Error |  T=2.2s |
| | Overload Protection |  T=1s |
| | Load Short-circuit Protection |  T=0.5s |

## 5.3 System Voltage Indication

The controller adjusts itself to 12V or 24V system voltage automatically. The system type indicates by the green led when the controller start up every time. Details show as follows:

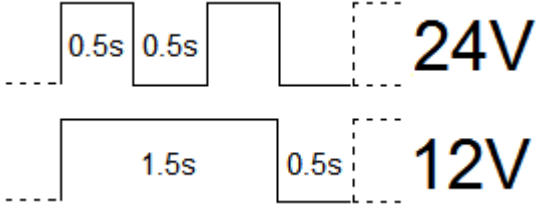



Figure 5-3: System Voltage Indication Diagram

# 6. Faults and Remedies

## 6.1 Protection Remedies

| Fault | Phenomenon | Cause / Remedy |
|---|---|---|
| **Battery voltage too low** | Load off Charging on | Check the battery voltage and manually recharge the battery if necessary. Loads directly connected to the battery can cause deep discharge. |
| **Battery voltage too high** | Load off Charging off | Check installation. Check the battery voltage and check any additional charging sources if present. |
| **PV voltage too high** | Load on Charging off | Check the PV system configuration. The PV open circuit voltage increases while the ambient temperature decreases. |
| **Excessive load current** | Load off<br>Charging on | Reduce the load current at the load output.<br>The load may cause current peaks. |

| | | |
|---|---|---|
| **Load output short circuit** | Load off<br>Charging on | Rectify short circuit. Disconnect and reconnect the load. |
| **Controller inside temperature too high** | Load on<br>Charging off | Allow the controller to cool down. Check for possible causes of overheating (mounting location, other heat sources). Possibly reduce the charge current. Make sure the controller is adequately ventilated. |
| **Inside temperature sensor error** | Load on<br>Charging on | Disconnect the load, solar modules and battery. Re-install the controller. If the error recurs, then please contact your specialist dealer. |
| **Self-test error** | Load<br>charging indefinite | Disconnect the load, solar modules and battery. Re-install the controller. If the error recurs, then please contact your specialist dealer. |

## 6.2 Common Faults and Remedies

| Phenomenon | Cause | Remedy |
|---|---|---|
| **LED no indication** | The battery is connected to the controller with the wrong polarity. The fuse burns out. | Check the fuse.<br>Disconnect the battery and reconnect it to the controller with the correct polarity. |
| **Battery overvoltage protection when start up** | The controller adjusts to the wrong system voltage. | Disconnect the load, solar modules and battery. Waiting for about 10 seconds and then re-install the controller. |
| **Stay in direct charging mode** | The PV MPP voltage too low. | It's normal. If possible you can re-configure the PV system to enlarge the PV open circuit voltage. |

# 7. Technical Data

| Model | | 10A | 20A |
|---|---|---|---|
| Input | Maximum PV Voltage | ≤70V | |
| | MPPT Voltage Range | 12V~70V (12V)<br>/24V~70V (24V) | |
| Output | System Voltage | 12V (24V) | |
| | Maximum Battery Voltage | 16V (32V) | |
| | Maximum Charging Current | 10A | 20A |
| | Maximum Load Current | 10A | 20A |
| | Own Consumption | ≤15mA | |
| | Charging Control Mode | 3-stage (Bulk, Absorption, Float) | |
| | Float Charge | 13.8V (27.6V) | |
| | Absorption Charge | 14.4V (28.8V), for 2 hours | |

| | | | |
|---|---|---|---|
| | Load Disconnection (LVD) | 11.5V (23.0V) | |
| | Load Reconnection (LVR) | 12.6V (25.2V) | |
| | Temperature Compensation | -4mV/ cell/ °C | |
| | Battery type | Lead acid (GEL, AGM, Flooded) | |
| **Other** | Maximum Efficiency | 97% | |
| | Human Interface | LEDs, button | |
| | Cooling Style | Passive cooling | |
| | Maximum Wire Size | 6 $mm^2$ | 10 $mm^2$ |
| | Ambient Temperature Range | -10°C~+50 °C | |
| | Storage Temperature Range | -30°C~+80 °C | |
| | Humidity | 0~90%, no condensation | |
| | Dimensions | 92.5 x 188 x 55.3 mm | 118.5 x 188 x 54.5 mm |
| | Weight | 0.46Kg | 0.8 Kg |

| | | |
|---|---|---|
| | Grounding | Positive grounding |
| | Degree of Protection | IP32 |

*Note: Technical data at 25 °C / 77 °F*

# 8. Quality Assurance

## 8.1 Quality assurance should be carried out according to the following rules:

- The product is guaranteed of replacement, returning and repairing within 7 days after sale.
- The product is guaranteed of replacement and repairing within 1 month after sale.
- The product is guaranteed of repairing within 12 months after sale.

**8.2 If it is impossible to identify the using date of the controller, we would refer to the ex-work date, and prescribe 18 months as the warranty period. We need to charge beyond the warranty period. The controller can be repaired for life no matter when and where you use it.**

**8.3 If the controller is damaged by the following causes, we need to charge even if it is in the guarantee period:**

● Do not operate according to the user's manual.
● Use the controller under the condition which is beyond the using standard and technical requirements.
● Repair by yourself or reform by yourself.
● The improper environmental condition which can cause the breakdown and aging of the apparatus.
● Improper carrying or storage.
● Regarding to the service of replacement, returning and repairing, you need to retreat the product to our company, and we decide whether to replace or repair after we make clear who should be responsible.

## 8.4 We will not notice if there is any change of this product.