



# MA-4025 Solar Charger



## User Manual

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## General Information

### Specification Summary

Maximum Input Voltage *	60V
Rated Charge Current	4A
Maximum Ambient Temperature	60°C

\* The solar panel's open circuit voltage  $V_{OC}$  must not exceed the maximum input voltage.

### Safety

This manual contains important safety and operating instructions for the MA-4025 Solar Battery Charger. Read all the instructions and cautions of this manual and on the label of the MA-4025 Solar before using it.

To reduce the risk of electrical shock, fire, or injury operate charger in only the prescribed manner and use only with recommended items.

General Safety Guidelines:

- Only use recommended accessories with the MA-4025.
- Do not exceed the maximum input voltage and only charge recommended batteries, not doing so may result in fire, electrical shock, or injury.
- Do not charge battery if the ambient temperature is outside of the recommended battery temperature limits.
- Disconnect the MA-4025 Solar from panel by pulling on the plug, not the cord.
- Do not use the MA-4025 Solar with damaged cables or connector pins.
- Check for proper electrical connections to the panel and battery to avoid excessive heating and power loss from a loose connection.
- Do not try to operate the MA-4025 if any visible damages can be seen on it.
- Make sure all contacts are clean before use.

### Introduction

The MA-4025 Solar Charger is a portable solar battery charger capable of charging MA-4025 rechargeable batteries. The charger features advanced digital control, which enables automatic battery detection, maximum power point tracking (MPPT) of the solar panel, and value-added features such as a fixed DC input mode. The charger is able to operate from any solar panel configuration with  $V_{open\ circuit} < 60V$ . The charger directly plugs onto the top of the supported batteries, and the only wiring needed is the connection to the solar panel or DC source using a polarized SAE plug. The implementation of high-speed MPPT delivers maximum charging current, even in low light or poor weather conditions. The simple LED interface informs the user when the battery has been completely charged, and if there are any fault conditions.



## **What's in the box?**

1x MA-4025 Solar Charger

## **Optional Accessories**

1x Adapter to charge from Lead-Acid batteries, 1x 48" SAE Extension Cable, 1x SAE Y Parallel Cable

## **Solar Panel Selection & Input Power Considerations**

Use "12V" or "24V" solar panels or any other panel as long as its maximum power voltage ( $V_{mp}$ ) is greater than 17V and its open circuit voltage ( $V_{oc}$ ) is below 60V. If available, the MA-4025 Solar will use up to ~80W to charge the MA-4025 battery with its maximum rated charge current. The optional SAE Y cable can be used to parallel two solar panels in order to increase charge speed. There is no minimum input power requirement, only charge speed will decrease when used with lower power solar panels. A list of recommended panels is shown in Table 1 below.

<b><u>Company</u></b>	<b><u>Part #</u></b>	<b><u>Max. Power @ 25°C</u></b>	<b><u>Nominal System Voltage</u></b>
Global Solar Energy, Inc.	P3 124W 12V	124W	12V
	P3 124W 24V	124W	24V
	P3 62W 12V	62W	12V
	P3 62W 24V	62W	24V
	P3 55W 12V	55W	12V
	P3 48W 12V	48W	12V
	P3 48W 24V	48W	24V

**Table 1: Recommended Solar Panels**

## **Battery Selection and Typical Operating Temperatures during Charging**

Table 2 shows the batteries that can be charged with the MA-4025 Solar. Make sure that the battery is charged at its allowable ambient temperature range which is typically between 5°C (41°F) and 38°C (100°F). Refer to the label on each battery for exact values.

**Please note that the data sheet of most of the batteries lists only the operating and storage temperature ranges which are more extended and not the same as the charging temperature range!**

<b><u>Company</u></b>	<b><u>Part #</u></b>	<b><u>Chemistry</u></b>	<b><u>Voltage</u></b>
Mathews Associates, Inc.	MA-4025/A	NiCd	12.0
	MA-4025/D	NiCd	12.0

**Table 2: Recommended Batteries**

## Operation

### Connection Configuration

There are basically two main methods to power the MA-4025 Solar for charging the battery: Solar panels (see Figure 1 and Figure 2) or a DC source such as other batteries (Figure 3 and Figure 4). The most common setup is with one solar panel connected. To increase charging speed or if clouds are limiting available power, solar panels can be paralleled. If available, the MA-4025 Solar will use up to ~80W input power to charge the MA-4025 battery at its maximum charge current. Other batteries can be used as power sources as long as they fulfill the input voltage and power requirements of the MA-4025 Solar. A 24V vehicle bus or two 12V lead-acid batteries in series could serve as a power source.



Figure 1: Charger Setup 1 with one Solar Panel as power source

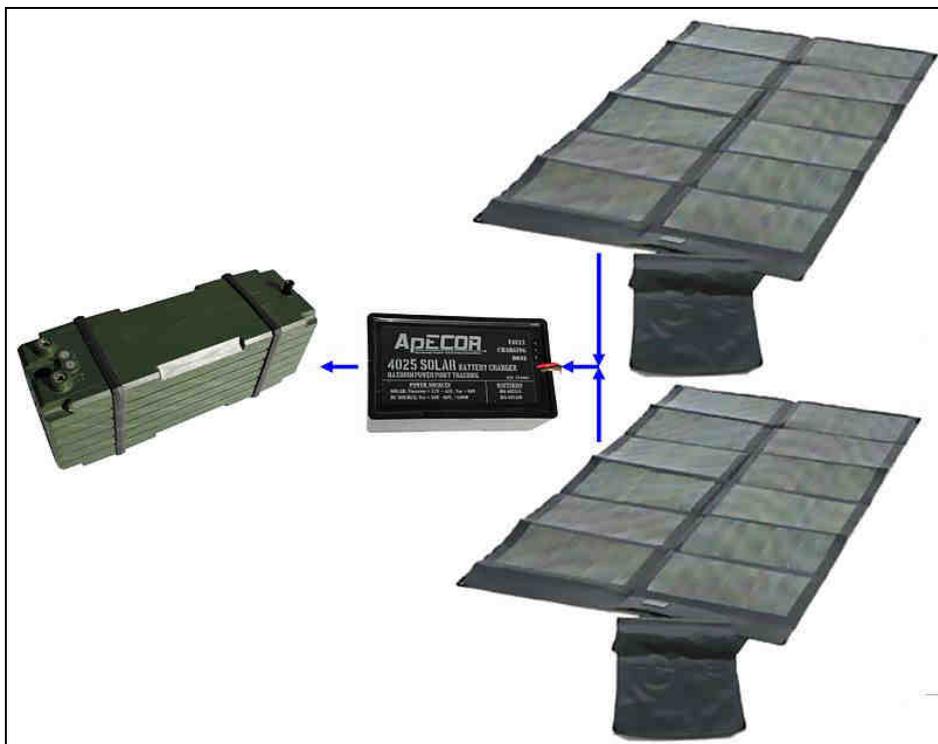


Figure 2: Charger Setup 2 with two Solar Panels in parallel as power source \*

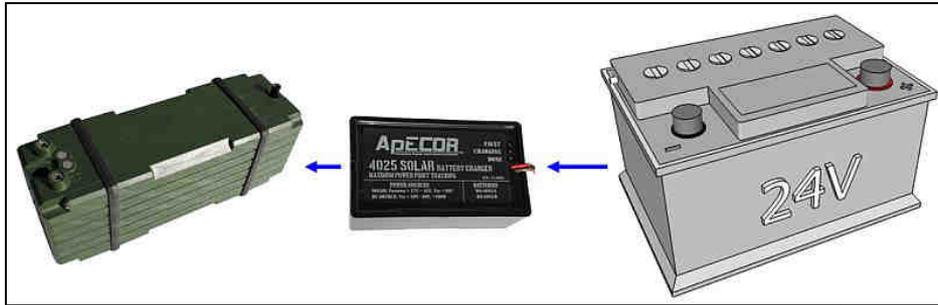


Figure 3: Charger Setup 3 with one 24V Battery as power source \*

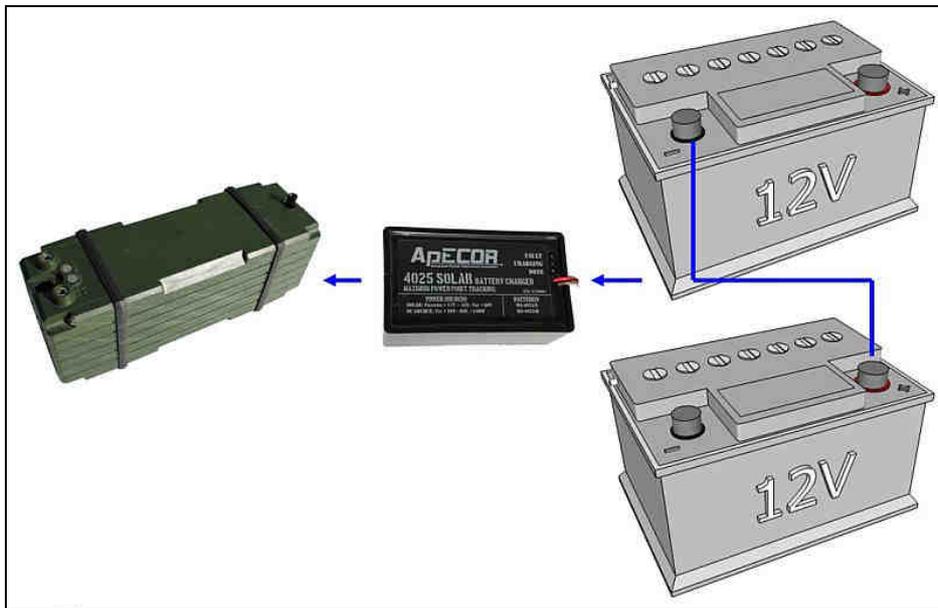


Figure 4: Charger Setup 4 with two 12V batteries in series as power source \*

\* using optional accessories



## **Charging Procedures**

Connect the MA-4025 Solar to the power source to be used and the battery to be charged in any order. If LEDs on top of the charger are still lit up from a previous charge, wait until all lights are off before connecting to another battery. Once everything is connected together, the “Charging LED” blinks at a low rate meaning that the MA-4025 is analyzing the connected battery. If there was no fault, the “Charging LED” will continue to blink and the other two LEDs would be off. The charge is finished once the “Done LED” is on. Then the battery and/or power source can be disconnected or another battery can be charged.

## **General Considerations for Maximum Charging and Battery Performance**

Align solar panel perpendicular to the sun and avoid shading of the panel whenever possible for maximum power. Move the MA-4025 Solar with the battery in the shade wherever possible, especially at high ambient temperatures. Even though the MA-4025 Solar won't be damaged when exposed to full sun while charging, the battery has lower maximum temperature limits while being charged that are typically around 38°C (100°F).

## **Special Considerations for Charging the MA-4025 NiCd Battery**

The MA-4025 battery has an internal temperature sensor which allows the MA-4025 Solar to charge the battery more accurately and protect it from over-charge. Prior to charging, the battery should be kept in a cool place because the charge cannot be started if its temperature is already above 40°C (104°F) in order to protect the battery from over-temperature. Therefore it is also not recommended to repeatedly unplug the MA-4025 Solar from the battery and put it back on. This is because once the battery's temperature during charge is above 40°C (104°F) the MA-4025 will not start charging the battery again unless its temperature has dropped below that point.



**Label on top of charger and LED Status Indicator**



Figure 5: Label on top of charger and LED location

<u>Red LED</u>	<u>Green LED 1</u>	<u>Green LED 2</u>	<u>Meaning</u>	<u>Action to take</u>
Off	Off	Off	Ready to connect	Connect battery
Off	Blinking slowly	Off	Analyzing battery chemistry	-
Off	Blinking <sup>(1)</sup>	Off	Charging	-
Off	Off	On	Finished charging	Disconnect battery
Blinking	Off	Off	Temporary Fault condition, Charger was not running before	The MA-4025 Solar is trying to reset faults. Monitor the MA-4025 Solar since it might not be able to clear the current fault which would lead to a latched fault.
Blinking	Blinking	Off	Temporary Fault condition, Charger was running before	The MA-4025 Solar is trying to reset faults. Monitor the MA-4025 Solar since it might not be able to clear the current fault which would lead to a latched fault.
On	-	-	Latched Fault, Charger not running	Check connections, make sure that operation of converter is within the maximum ratings, unplug and plug in again battery and source

Table 3: LED status information

**Notes:**

<sup>(1)</sup> Blinking speed is based on power delivered to the battery:  
 (~0.8 to 7) blinking cycles per second for an output current range of (~0.2 to 4) Amps



## **Trouble Shooting**

<b><u>Condition</u></b>	<b><u>Possible Causes</u></b>	<b><u>Solutions</u></b>
No lights on	MA-4025 Solar ready to be connected to battery	Connect to battery to charge
	No or very little input power available	Check connection to solar panel Wait for more sunshine Orient panel perpendicular to sun
Fault light blinking for a longer period of time	Input power may be low	Wait for more sunshine Orient panel perpendicular to sun

**Table 4: General Trouble Shooting**

<b><u>Condition</u></b>	<b><u>Possible Causes</u></b>	<b><u>Solutions</u></b>
The MA-4025 Solar finishes charge but battery doesn't seem to be fully charged	Battery temperature got too high because ambient temperature was above 38°C (100°F), therefore charge was terminated early to protect the battery	Find a cool and ventilated place to charge the battery (Battery temperature needs to be below 40°C (104°F) for the MA-4025 Solar to start charging again)
Fault light blinking	Temperature of battery is below 0°C (32°F) or above 40°C (104°F)	Leave MA-4025 Solar connected to battery, the charger will start charging once the battery temperature is okay

**Table 5: Trouble Shooting related to the MA-4025 Battery**

## Maintenance

The MA-4025 Solar has 2 spring pins that can be pulled out and replaced by new ones if necessary. Besides that it has no other serviceable parts. Check for broken, corroded, or otherwise damaged cable or battery contacts. Make sure that all battery contacts are straight and that the two smaller pins (spring pins) can be pushed in and come out again if released. If a defect has been found, replace the MA-4025 Solar. The cable to the solar panel may be repaired; however do **NOT** attempt to repair battery contacts. Make sure that all contacts are free of mud, dirt, dust, oil and grease. If found dirty, they can be cleaned with a damp non-abrasive cloth and allowed to air dry or wiped with a clean dry non-abrasive cloth. In case of oils and grease, use a mild soap/water solution to dampen the cloth.

## Features

The MA-4025 Solar has many features that enhance its core functions, make it safer to operate and increase its reliability.

### Fast Maximum Power Point Tracking (MPPT)

A solar panel has a unique characteristic that is derived from the fact that as more current is drawn from the solar panel the more the voltage will decrease. The respective curves (IV – Current vs. Voltage, PV – Power vs. Voltage) in Figure 6 show that at a certain voltage the available power has a maximum. Typical battery chargers use the battery's voltage to select where the solar panel is operating on the curve and this point of operation is mostly lower than the maximum power point (MPP).

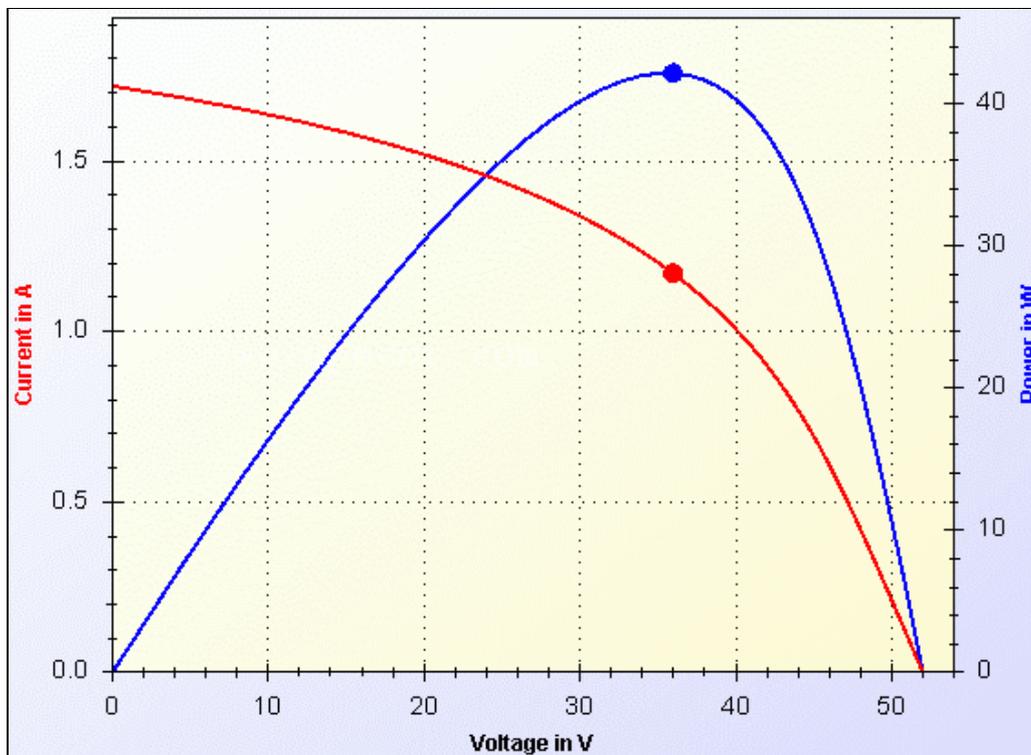


Figure 6: IV and PV curves for a typical solar panel



The MA-4025 Solar uses an advanced version of MPPT which is constantly running to make sure that it always operates at the MPP of the panel. This makes the MA-4025 Solar superior to other MPPT battery chargers that look for the MPP every once in a while. This is because the MA-4025 Solar finds the new MPP very quickly during changing conditions whereas other MPPT chargers don't operate at the new MPP until their next scan. This is especially important during days with lots of clouds and wind which lead to fast variations in available power. Since the MA-4025 Solar can operate longer at the maximum power than other chargers, it can charge the battery faster. The changes in available solar power reaching the panel is usually shading caused by objects blocking the sun such as clouds, people, or trees. If there is more power available from the solar panel than needed to charge the battery, then the MA-4025 Solar will drop out of MPPT mode. This can happen if there is a higher power solar panel connected or it could mean that the battery is nearly full.

### **Reverse Polarity Protection (Electrically and Mechanically)**

In order to protect the entire system the MA-4025 Solar has a reverse polarity protection (RPP) on the solar panel and battery side. If there is no positive voltage seen on the terminals of the MA-4025 Solar, it won't allow any current to flow, which is the electrical RPP. In addition, there is a mechanical RPP which means that the solar panel and battery cannot be plugged in the wrong way.

### **Temperature Protection**

The MA-4025 Solar provides the full charge current up to a certain internal temperature. After that it will linearly de-rate the charge current up to a maximum allowable internal temperature in order to protect its circuitry to safe limits. For the respective graph, refer to Figure 8 in paragraph Technical Specifications.

### **Over Current Protection**

The MA-4025 Solar is protected against over-current and short circuit conditions. Normally, it will limit the maximum charge current to ~4A. If under some condition the current still comes up higher, a fault may be triggered. After that, the software of the MA-4025 Solar can successfully reset the fault in case it was only temporarily. If the high current could not be stopped because the circuitry of the MA-4025 Solar is damaged, an internal fuse will break and disconnect from the battery. In that case the MA-4025 Solar would be permanently non-operational. This behavior is preferred, as the battery is protected from short circuit currents that could have led to a catastrophic failure of the battery.

## Technical Specifications

### Converter Efficiency

Figure 7 shows typical efficiency numbers of the MA-4025 Solar as a function of total output current with two different input voltages and with an output (battery) voltage of ~15V at 25°C (77°F) ambient temperature. The 20V input voltage case represents the maximum power voltage of a “12V” solar panel whereas 40V represents the maximum power voltage of a “24V” solar panel, both at 25°C (77°F) panel temperature.

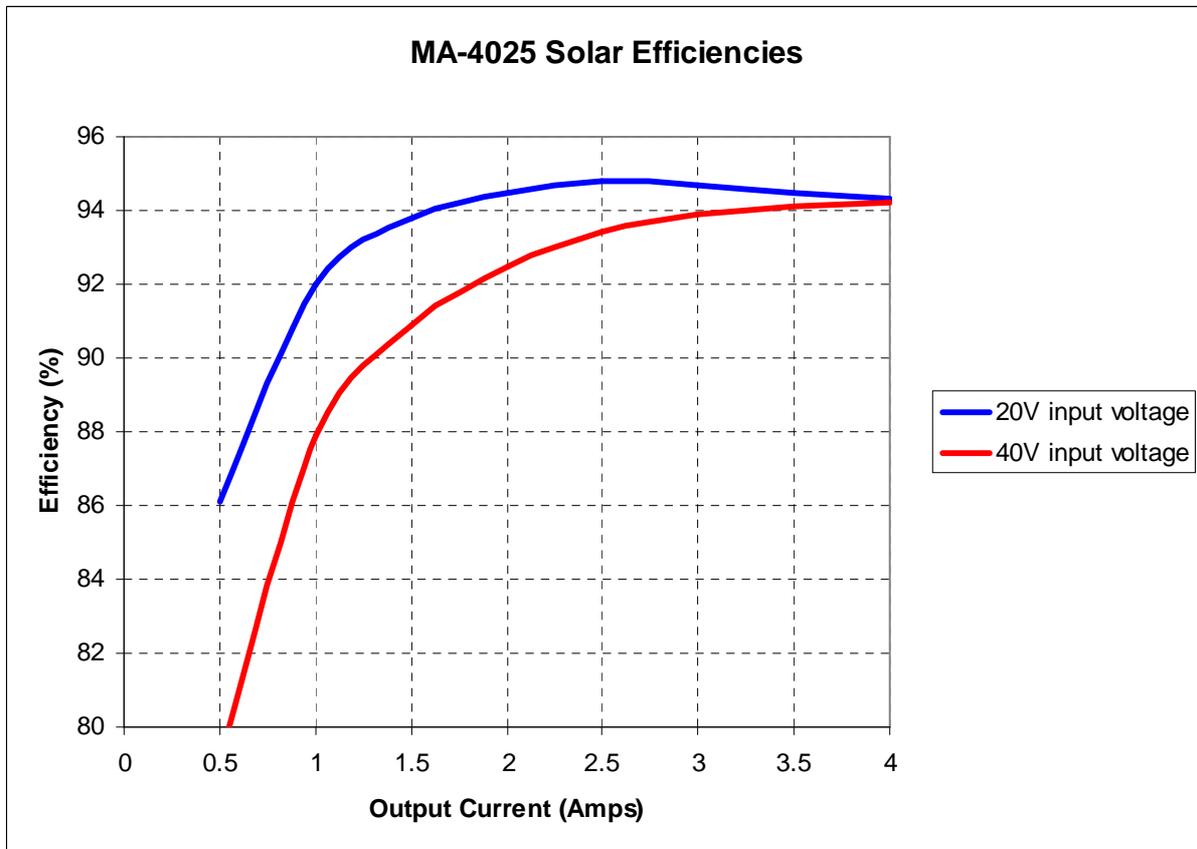


Figure 7: MA-4025 Efficiencies

When charging the MA-4025 battery with a certain solar panel and at a particular power level, the MA-4025 Solar operates at certain points on the efficiency curve. Some configuration examples can be seen in Table 6; the last column then shows the expected converter efficiency for each case.

<u>Panel System Voltage</u>	<u>Maximum Power Voltage of Panel</u>	<u>Charge Current Level</u>	<u>Current per Battery String</u>	<u>MA-4025 Solar Efficiency</u>
12V	20V	Full current	4A	94.3%
24V	40V	Full current	4A	94.2%
12V	20V	Half current	2A	94.5%
24V	40V	Half current	2A	92.5%

Table 6: Typical MA-4025 Solar Efficiencies while charging the MA-4025 battery

**Maximum Output Current vs. Heatsink Temperature**

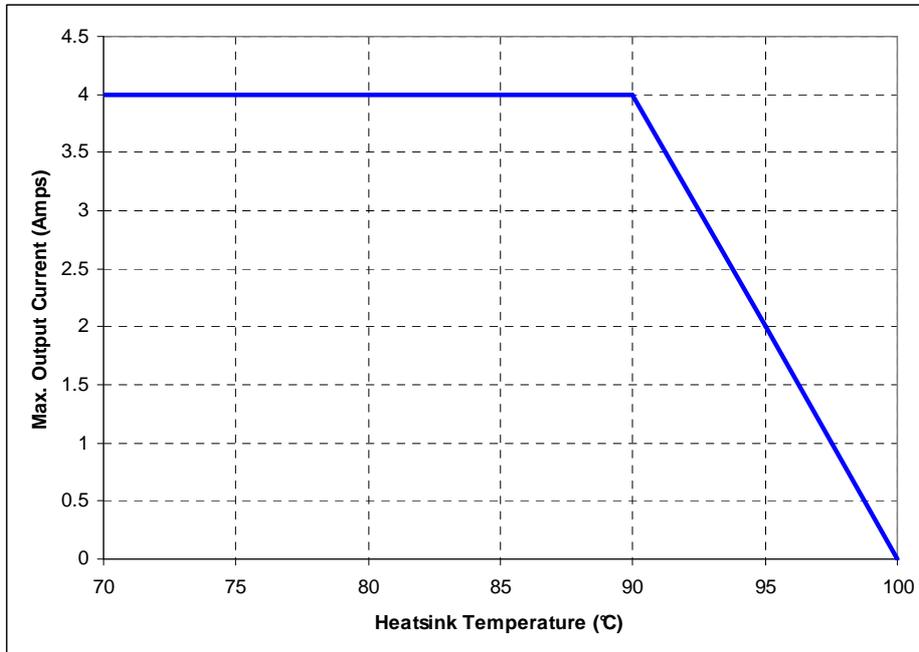


Figure 8: Max. Output Current vs. Internal Heatsink Temperature

**Maximum Output Current vs. Input Voltage**

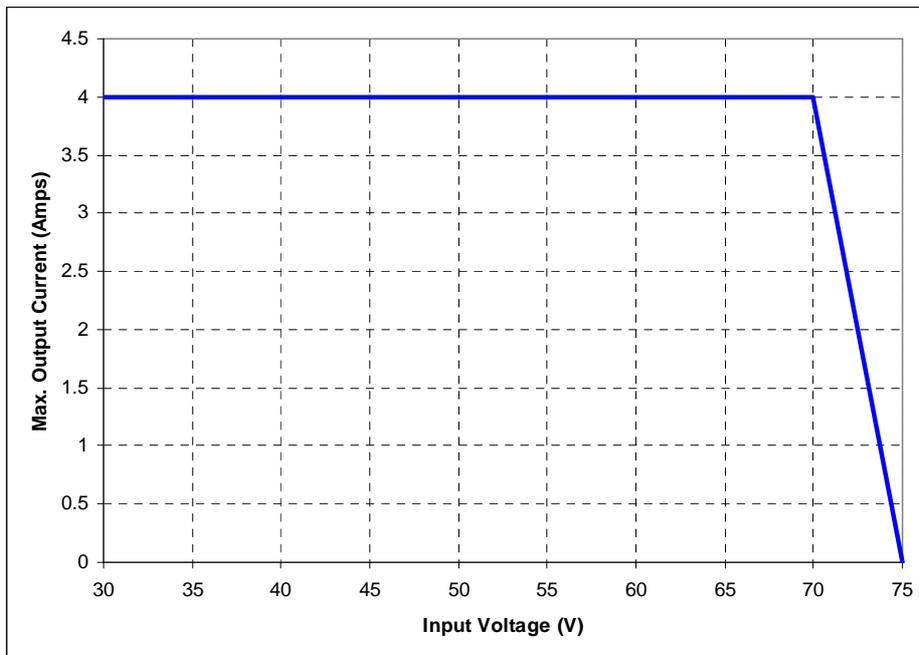
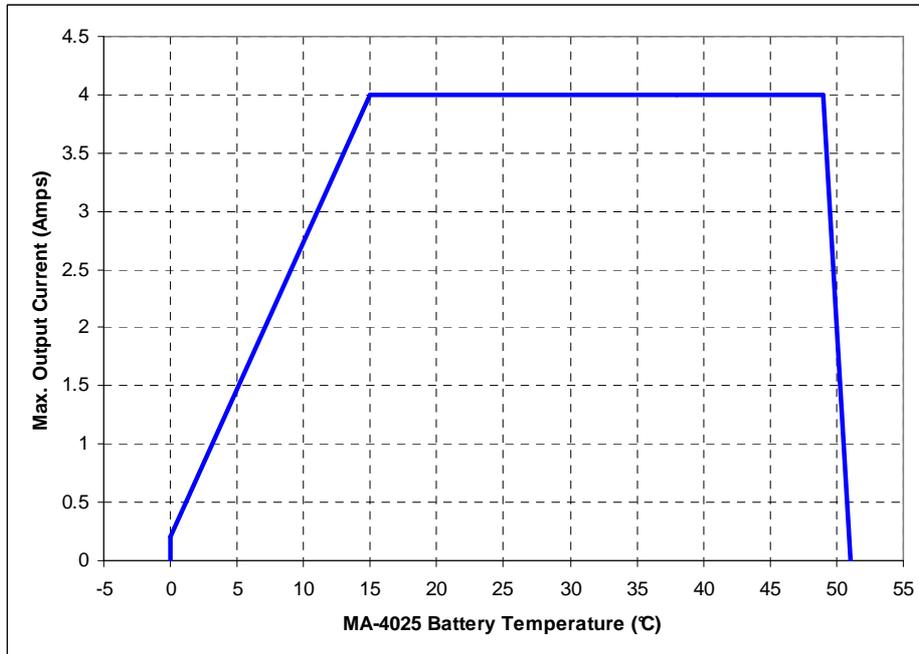


Figure 9: Max. Output Current vs. Input Voltage

## Maximum Output Current vs. Battery Temperature



**Figure 10: Max. Output Current vs. MA-4025 Battery Temperature**

For further technical information please consult the datasheet of the MA-4025 Solar Charger.



## Warranty Statement

The MA-4025 Solar Charger is warranted to be free from defects in material and workmanship for a period of TWO (2) years from the date of shipment to the original end user. ApECOR will, at its option, repair or replace any such defective products.

### **Claim Procedure**

- Before requesting warranty service, check the User Manual to be certain that there is a problem with the controller. Contact ApECOR to request Returned Material Authorization (RMA). Return the defective product to your authorized ApECOR distributor with shipping charges prepaid. Provide proof of date and place of purchase.
- To obtain service under this warranty, the returned products must include the model, serial number and detailed reason for the failure, the module type, solar panel size, type of batteries. This information is critical to a rapid disposition of your warranty claim.
- ApECOR will pay the return shipping charges if the repairs are covered by the warranty.

### **Warranty Exclusions and Limitations**

This warranty does not apply under the following conditions:

- Damage by accident, negligence, abuse or improper use.
- PV or load currents exceeding the ratings of the product.
- Unauthorized product modification or attempted repair.
- Damage occurring during shipment.

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