X-90 V3-AUX Solar Charger

User Manual

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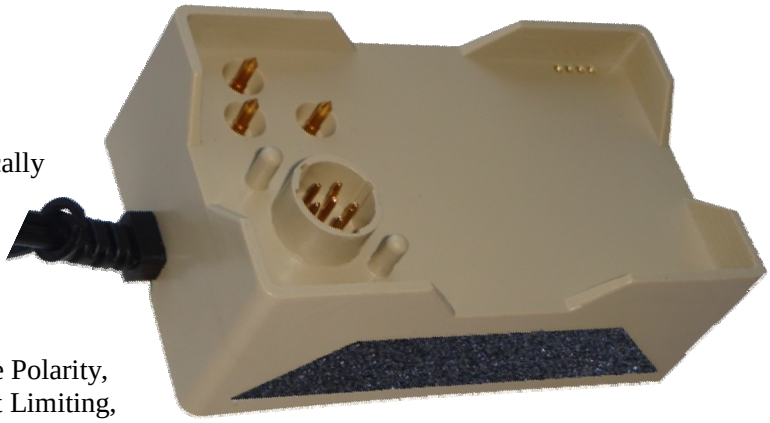
General Information

Introduction

The X-90 V3 Aux Solar Charger is a portable solar battery charger capable of fast charging a wide array of typical portable rechargeable batteries, while also providing uninterruptable DC voltage for operating numerous devices. The charger features numerous advanced and proprietary digital control algorithms, which enables automatic battery detection, maximum power point tracking (MPPT) of the solar panel, value-added features and "X-90 Smart Adapters". 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 advanced charge controller minimizes charge time by charging two battery strings simultaneously, while monitoring critical parameters to ensure safety and reliability. 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 batteries have been completely charged, if there are any fault conditions, and an estimate of the amount of time remaining until the battery is fully charged or discharged (depending on operating conditions).

Features



- Maximum Power Point Tracking
  - Up to 30% more power
- Universal Charging Algorithm
  - Identifies chemistry automatically
- Fully protected 12V/8A auxiliary output
- No User Input Required
- Fully Ruggedized Design
- Field Replaceable Sense Pins
- Fully Protected, including Reverse Polarity, Over Temperature, Active Current Limiting, and MIL-810F Compliant
- Integrated "Time Until Charged/Discharged" Calculator
  - An LED bar will indicate the time until charged or discharged based on the energy source, auxiliary load, and battery state of charge
- 12V or 24V Solar Panel Input - No Minimum/Maximum Solar Panel Wattage
- Polarized SAE plug to connect to solar panel or source
- Available extension input cable for use with other solar panels or DC sources
- Available “Y” adapter, to parallel multiple solar panels for maximum charge speed
- Compatible with "Smart X-90" adapters, allowing expanded operation with numerous batteries and adapters
- Emergency regulated 14.4V Aux output when there is no battery connected
- Auto dimming LED indicators reduce the LED brightness when there is no input power

Supported batteries	Chemistry
BB/UBI-2590/U	Li-Ion
BB-590/U	NiCd
BB-390B/U	NiMH
UBBL09	Li-Ion
UBBL36	Li-Ion
X-90 Smart Adapter	Numerous

Specification Summary

Maximum Input Voltage *	60V
Minimum Input Voltage	20V
Rated Charge Current	8A (total), 4A per battery string
Rated Auxiliary Output Current	8A
Auxiliary Output Voltage	10.5V - 16.5V
Maximum Ambient Temperature	60°C
Converter Efficiency	96%+

* *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 X-90 Solar Battery Charger. Read all the instructions and cautions of this manual and on the label of the X-90 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:

- **Observe polarity according to the label when connecting to the input or auxiliary port.**
- **Do not apply voltages higher than 60V on the input and higher than 20V on the auxiliary output port.**
- **ONLY connect suggested batteries or X-90 smart adapters to the bottom of the X-90.**
- **NEVER apply any other power sources or loads to the bottom connections of the X-90.**
- Only use recommended accessories with the X-90.
- Only charge recommended batteries; not doing so may result in fire, electrical shock, or injury.
- Do not charge a battery if the ambient temperature is outside of the recommended battery temperature limits.
- Disconnect the X-90 cables by pulling on the plug, not the cord.
- Do not use the X-90 with damaged cables or connector pins.
- Check for proper electrical connections to the cables and battery to avoid excessive heating and power loss from a loose or dirty connection.
- Do not try to operate the X-90 if there is any visible damage.
- Do not operate multiple X-90 units from a single solar source, when using solar power the panels should be separate for each X-90. It is permissible to use a single DC source, as long as the power rating is great enough to supply all connected X-90 units.

- Under certain high auxiliary load conditions, the X-90 may become very hot. While the X-90 is designed to not allow thermal damage to the unit, the top may become hot enough to hurt skin with extended exposure. Use caution when handling a hot X-90 or battery!
- Only use the auxiliary output port to power electrical devices
- In emergency situations the X-90 in stand-alone mode **(no BB-2590 connected)** can top off lead-acid batteries as long as their rated charge current is greater than 8A.
- **Do not attempt to charge other batteries with the auxiliary output port when at the same time a BB-2590 battery is connected. The auxiliary output is primarily intended for powering electrical loads.**
- Auxiliary output ports of multiple X-90s can be paralleled in order to increase total available capacity to the sum of the capacity of all connected batteries, and as long as all batteries have a **similar state-of-charge**, the total output current achievable is 8A multiplied by the number of paralleled units (the auxiliary LED of each X-90 should be **solid** in this case, **blinking indicates auxiliary overload**).
- Auxiliary output ports of multiple X-90s can also be paralleled when **every single connected X-90 is in stand-alone mode (not connected to a battery);** the total achievable auxiliary current in this case depends on the sum of available input power to each X-90, but is limited to a maximum of 8A per X-90.
- **Do not remove the X-90 unit from a charging battery to "check the progress" by looking at the state of charge indicator of the battery. This will reset the charge algorithm and increase the charge time. The X-90 unit will inform the user when the battery is fully charged.**

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 X-90 will use up to ~140W to charge a BB-2590 with its maximum rated charge current or ~65W for a BB-390 / BB-590. The available SAE Y cable can be used to parallel two solar panels in order to increase charge speed. There is no minimum input power requirement, but charge speed will decrease when used with lower power solar panels. A list of recommended panels is shown in Table 1 below.

Company	Part #	Max. Power @ 25°C	Nominal System Voltage
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 30W 12V	30W	12V
	P3 30W 24V	30W	24V

Table 1: Recommended Solar Panels

Battery Selection and Typical Operating Temperatures during Charging

Table 2 shows a list of BB-XX90 type batteries that can be charged with the X-90. Make sure that each 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 datasheets of most of the batteries list only the operating and storage temperature ranges which are more extended and not the same as the charging temperature range!

Company	Part #	Charge Current (per string)	Chemistry	Voltage
Mathews Associates, Inc.	BB-2590 SMBus	4A	Li-Ion	14.4/28.8
	BB-2590/U	3.2A *	Li-Ion	14.4/28.8
	BB-390A/U or BB-390/U	2A	NiMH	12.0/24.0
	BB-590/U	2A	NiCd	12.0/24.0
Bren-Tronics	BB-2590/U	4A	Li-Ion	14.4/28.8
	BB-390B/U	2A	NiMH	12.0/24.0
	BB-590/U	2A	NiCd	12.0/24.0
Patco Electronics Inc.	BB-2590/U	4A	Li-Ion	14.4/28.8
UltraLife Batteries	UBBL02 (UBI-2590)	3.2A *	Li-Ion	14.4/28.8
	UBBL10 (UBI-2590 SMBus)	3.2A *	Li-Ion	14.4/28.8
	UBBL09 (UBI-2590 12V/24V)	3.2A *	Li-Ion	12V/24V
	UBBL36 (1/2 UBI-2590)	3.2A *	Li-Ion	14.4V
	UBBL13 (UBI-2590 HC)	3.2A *	Li-Ion	14.4/28.8

Table 2: Recommended Batteries

**Due to design or protection limitations, certain Li-Ion batteries cannot be charge at the full 4A capability of the X-90 V3. These batteries are detected and charged at a safe 3.2A current level. This will increase the charge time for the affected batteries.

Available X-90 Smart Adapters

The X-90 V3 includes the capability to use adapter cables connected to the 6-pin XX90 barrel connector to allow the charging of numerous other batteries and accessories. The adapters communicate with the X-90 V3 to indicate the type of adapter connected, so as to allow the X-90 to implement the proper charge algorithm. ApECOR has the capability to provide specific charging solutions for nearly all battery types, please contact us at ask@apecor.com to request specific charging capability.

Operation

Connections and Configuration

There are basically two main methods to power the X-90 for charging the BB-XX90 type batteries: Solar panels (see Figure 16 and Figure 27) or a DC source such as other batteries (Figure 38 to Figure 510). 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 X-90 will use up to ~140W input power for BB-2590 batteries or up to ~65W for BB-390 and BB-590 batteries to charge them at their respective maximum charge currents. Other batteries can be used as power sources as long as they fulfill the input voltage and power requirements of the X-90. A 24V vehicle bus or two 12V lead-acid batteries in series could serve as a power source. Furthermore, if there is at least one partially discharged BB-XX90 battery available, it could potentially be used to recharge another BB-XX90, so that at least one battery is fully charged for a mission.

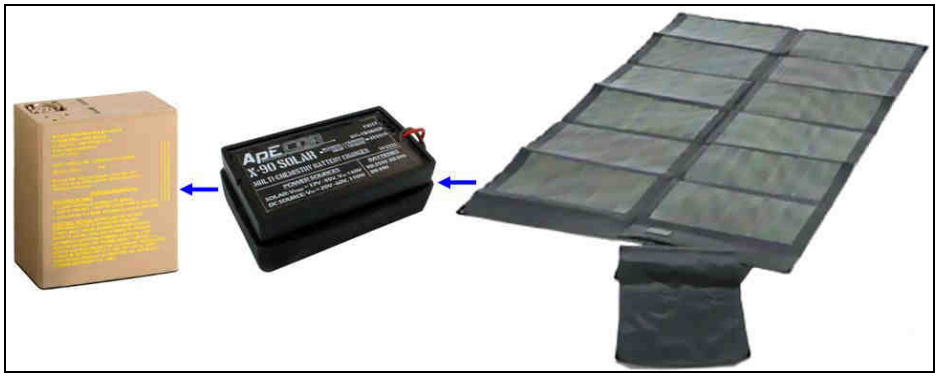


Figure 1: Charger Setup 1 with one Solar Panel as power source

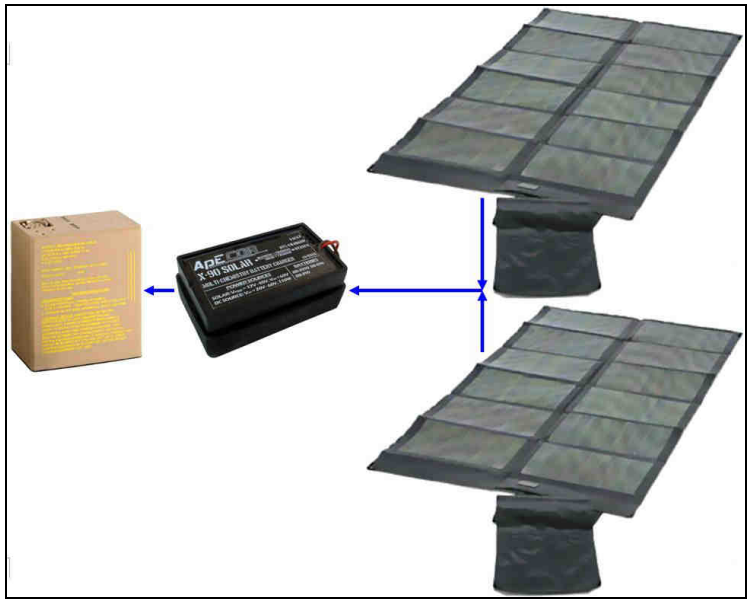


Figure 2: Charger Setup 2 with two Solar Panels in parallel as power source

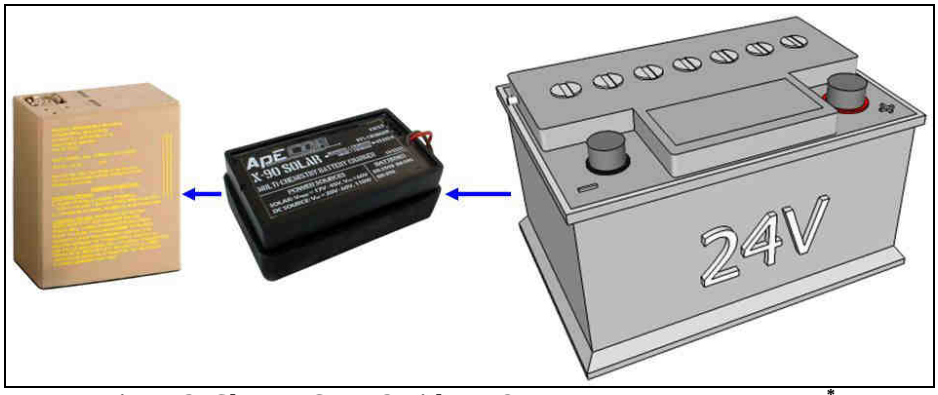


Figure 3: Charger Setup 3 with one 24V Battery as power source *

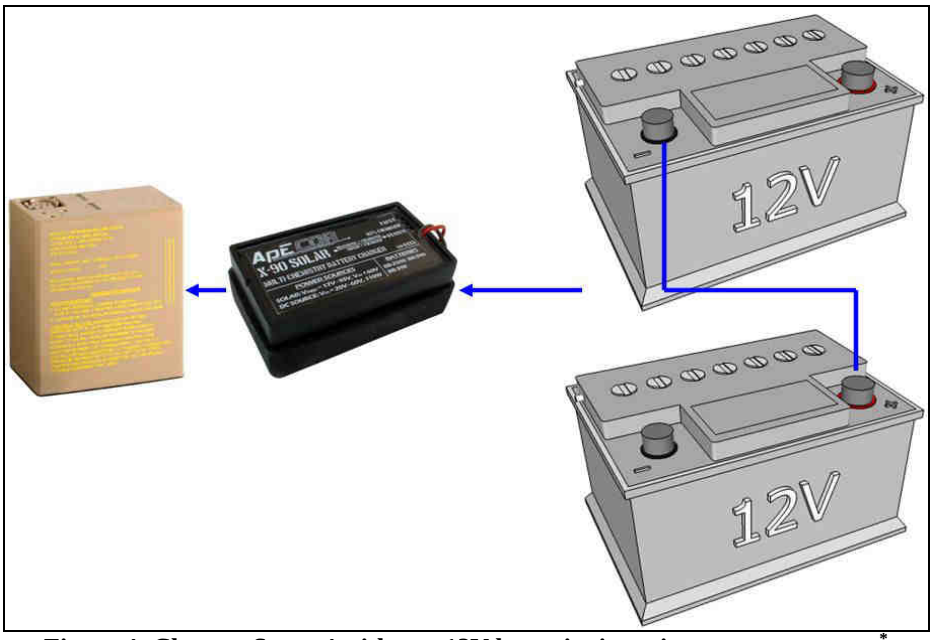


Figure 4: Charger Setup 4 with two 12V batteries in series as power source *

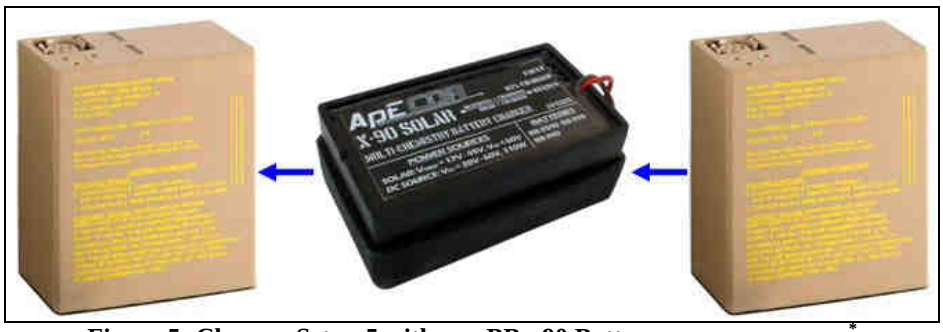


Figure 5: Charger Setup 5 with one BB-x90 Battery as power source *

* *using optional accessories*

Charging Procedures

Connect the X-90 to the power source to be used and the battery to be charged in any order. If the 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 LEDs will blink at different speeds meaning that the X-90 is analyzing the connected battery for about 2 - 5 seconds to determine its chemistry. If there was no fault, the "Status LED" will continue to blink, indicating that the battery is charging. The "85% Charged LED" only lights up when a BB-2590 (Li-Ion) is connected and its capacity reached about 85% of the total capacity. The charge is finished once the "Status" 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. **Place the X-90 with the battery in the shade wherever possible, especially at high ambient temperatures.** Even though the X-90 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). One simple method of shading the X-90 while charging is to place it underneath a rucksack.

Special Considerations for Charging BB-2590 Li-Ion Batteries

Besides the "Status LED" there is also a "85% Charged LED" for BB-2590 batteries. It will come on once approximately 85% of the battery's full capacity is reached. To charge the last 15% it will take about 30 to 40% of the total charge time! If there are more batteries to be charged, it makes sense to take off the current battery and to charge another fully depleted BB-2590 which could be charged to ~50% in the same time. This allows the user to have a higher overall state of charge for all the batteries instead of only having one battery completely charged.

Special Considerations for Charging BB-590 NiCd Batteries

The BB-590 battery is the hardest to accurately be charged to its full capacity using a variable power source such as a solar panel. In order to use the full potential of the charge algorithm implemented in the X-90, the following things have to be considered:

- Don't charge a battery if it is already known to be full. In some conditions a fully-charged battery might overheat if charged again. If possible, record the date of the last full charge of the battery and use it before recharging again.
- If possible, discharge the two battery strings inside the BB-590 equally. Don't repeatedly unplug the X-90 and connect it back to the battery. Those conditions might confuse the X-90 and it might terminate the charge too early.

Special Considerations for Charging BB-390 NiMH Batteries

The BB-390 has an internal temperature sensor which allows the X-90 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 X-90 from the battery and put it back on only to see the state-of-charge display. This is because once the battery's temperature during charge is above 40°C (104°F) the X-90 will not start charging the battery again unless its temperature has dropped below that point.

Auxiliary Output Operation

The X-90 V3 AUX incorporates a fully protected auxiliary output port, which can be extremely useful for powering numerous devices in both dismounted and wearable applications. The X-90 V3 AUX can operate the auxiliary output port independent of the power source, so the auxiliary output is still available even when there is no solar panel connected to the X-90. The voltage can range between 10.5 V and 16.5V when a Li-Ion battery is connected, which must be taken into consideration when choosing devices to be powered. This voltage range extends slightly higher than a typical 12V vehicle cigarette lighter plug, but most electronics intended for 12V operation will work well with this voltage range. In stand-alone mode (no battery connected) the auxiliary voltage is regulated to 14.4V. **NOTE: The auxiliary output port will only be operational when there is a Li-Ion battery connected or when the X-90 is in stand-alone mode.**

Auxiliary output ports of multiple X-90s can be paralleled in order to increase total available capacity to the sum of the capacity of all connected batteries, and as long as all batteries have a **similar state-of-charge**, the total output current achievable is 8A multiplied by the number of paralleled units. The "aux enabled" LED of each X-90 should be **solid** in this case to confirm that its output current is within its rated continuous current of 8A. Auxiliary output ports of multiple X-90s can also be paralleled when **every single connected X-90 is in stand-alone mode (no batteries connected);** the total achievable current in this case depends on the sum of available input power to each X-90, but is limited to a maximum of 8A per X-90.

An example of this case is if the user needed to deploy an ad-hoc uninterruptable power supply (UPS) to power a communications device or a water purification system. The user could deploy two X-90 systems, each with a BB-2590 and a solar panel, then parallel the outputs to create a power system that could support full time operation of a 30W device, with 400+ Wh reserve capacity for night time operation. Multiple Y cables can be used for further increased capacity.

Time Until Charged/Discharged Indicator

The X-90 Solar Charger has the capability to simultaneously harvest energy from a solar or DC source, charge the connected battery, and provide a protected auxiliary output. This in effect can allow the system to become an uninterruptable power supply (UPS), which can provide the auxiliary power until the battery is fully discharged. Depending on the balance of power, in some cases the battery will be generally charging, while in other cases the battery will be discharging. For example, if the auxiliary load is on average 50W, but the available solar energy is only 30W, there will be a 20W deficit, which must be supplied by the battery. The X-90 V3 AUX will estimate the current battery state of charge (SOC) and based on the current conditions calculate how much time it will take for the battery to become completely charged or discharged, depending on the balance of power. This is then indicated by the 10-segment LED bar below the label. This feature is only available with Li-Ion batteries.

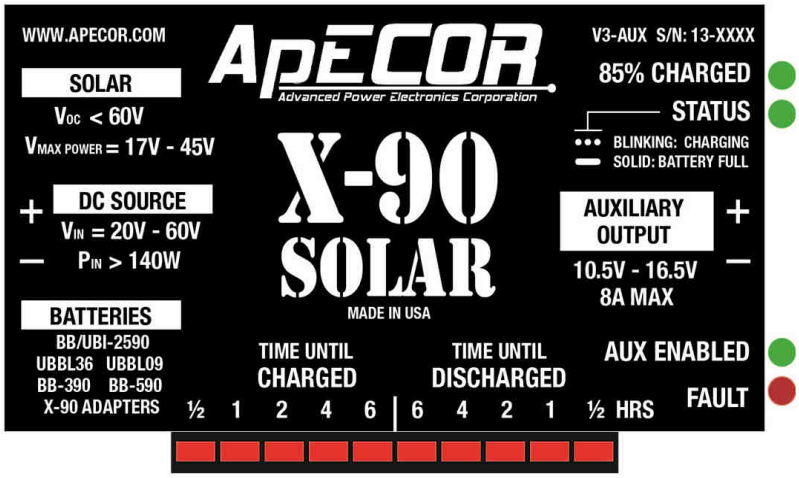
Typical Charging Times

Battery	Chemistry	Capacity (Ah)	Max Charge Current	Solar Panel (Watts)	Typical Full Charge Time (Hours)
BB-2590	Li-Ion	14.4	4A/String(1)	62	4.5 (3 hrs 85%)
				124	2.65 (1.75 hrs 85%)
				DC Source	2.5 (1.5 hrs 85%)
BB-390	NiMH	9.8	2A/String	62	3
BB-590	NiCd	4.8	2A/String	62	1.5
UBBL09	Li-Ion	18.4	4A/String	62	5.25
				124	3.25
				DC Source	3
UBBL36	Li-Ion	8.7	4A	62	2.75 (2 hrs 85%)

Table 3: Typical Charging Times

Notes:
(1) Only applies when charging certain BB-2590 type batteries. Depending on the design limitations imposed by various manufacturers, the X-90 will automatically charge some BB-2590 type batteries at 3.2A per string.

Label and LED Status Indicators



LED Status Information

Fault	Status	85% Charged	Aux Enabled	Meaning	Action to take
Red	**Green**	**Green**	**Green**		
Off	Off	Off	Off	Ready to connect	Connect battery
Off	Blinking (2)	Off	-	Charging	-
		On (1)		Charging, battery is 85% full (1)	**Optional:** Disconnect battery and connect a lower charged battery. In the time it takes to charge the last 15%, the first 50% of an empty battery could be charged. (1)
Off	On	On	-	Finished charging	Disconnect battery
On/ Blinking	-	-	-	Fault, converter not running	Check connections, make sure that operation of converter is within the maximum ratings
-	-	-	On	Aux output is enabled	An auxiliary load can be applied if desired
			Off	Aux output is disabled	The type of battery is not supported for auxiliary output or it has been disabled because of over-current or over-temperature
			Blinking	Aux output is close to maximum current or temperature rating	Reduce the load on the auxiliary port to keep it from turning off

Table 4: LED status information

Notes:
(1) Only applies when charging Li-Ion
(2) Blinking speed changes based on charging current: ~ (0.5 to 20) blinks/sec for a total charge current of (0 to 8) A

Troubleshooting

Condition	Possible Causes	Solutions
Fault light blinking for a long period of time	Input power may be low	Wait for more sunshine Orient panel perpendicular to sun

Table 5: General Trouble Shooting

Condition	Possible Causes	Solutions
X-90 finishes charge but state-of-charge display doesn't show all 5 bars	The X-90 might have stopped early because of changing input power	Unplug X-90 from the battery and plug back onto it to top off battery
	Internal battery SOC meter not accurate	A full discharge and charge cycle of the battery might recalibrate the gauges
85% light turning on and off	Available power changes a lot while battery is approximately 85% done	This is normal, no action needs to be taken

Table 6: Trouble Shooting for BB-2590 (Li-Ion)

Condition	Possible Causes	Solutions
There is no power available from battery after finished charging	Battery was charged at higher temperatures than recommended which triggered an internal safety switch	Let battery cool down, after it cools power will be available again. Make sure that battery is not being charged beyond recommended charging temperatures.

Table 7: Trouble Shooting for BB-590 (NiCd)

Condition	Possible Causes	Solutions
X-90 finishes charge but state-of-charge display doesn't show all 5 bars	The battery hasn't been discharged completely for a longer period of time which causes offsets	Discharge battery completely before charging again
	Battery temperature got too high because of ambient temperature being 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 X-90 to start charging again)
Fault light blinking	Temperature of battery is above 40°C (104°F)	Let battery cool down, X-90 will start charging battery once temperature is good

Table 8: Trouble Shooting for BB-390 (NiMH)

Maintenance

The X-90 has no user serviceable parts except for the spring sense pins. Check for broken, corroded, or otherwise damaged cable or battery contacts. Make sure that all battery contacts are straight and that the three spring pins can be pushed in and come out again if released. If a defect has been found, discontinue use of the X-90 and contact ApECOR. The input cable may be repaired if necessary; 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 on a cloth to clean the contacts, then rinse the contacts with water.

If a spring sense pin is damaged, contact ApECOR to purchase a spring pin replacement kit. This can allow the user to make the repair without returning the X-90 unit.

Features

The X-90 has many features that enhance its core functions, make it safer to operate and increase its reliability and performance.

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 611 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).

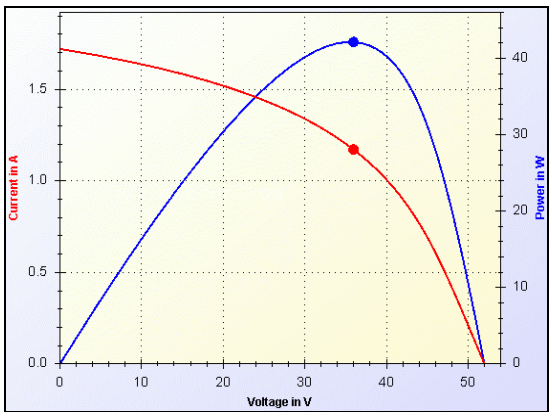


Figure 6: IV and PV curves for a typical solar panel

The X-90 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 X-90 superior to other MPPT battery chargers that look for the MPP every once in a while. This is because the X-90 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 X-90 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 respective battery, then the X-90 will drop out of MPPT mode. This can happen for all batteries if there is a higher power solar panel connected or it could mean that the battery (only for BB-2590 batteries) is nearly full.

Reverse Polarity Protection (Electrically and Mechanically)

In order to protect the entire system the X-90 has a reverse polarity protection (RPP) on the input and output connections. If there is no positive voltage seen on the terminals of the X-90, 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. Even though the input and output ports have reverse polarity protection, care should be taken to observe the indicated polarity on the wires to assure a proper connection.

Temperature Protection

The X-90 provides the full charge current up to a certain internal temperature. Above that temperature it will linearly de-rate the charge current up to a maximum allowable internal temperature in order to protect its circuitry to safe limits. The auxiliary output circuit also features temperature protection independent of the battery charging protection functions. If the auxiliary output is overloaded, and the temperature protection trips, the battery will still continue to charge. After the temperature has fallen to an acceptable level, the functionality will resume.

Over Current Protection

The X-90 is protected against over-current and short circuit conditions. Normally, it will limit the maximum charge current to 4A for a BB-2590 battery or to 2A for a BB-390 / BB-590 battery. If under some condition the current exceeds that value a fault may be triggered. After a fault, the software of the X-90 can successfully reset the fault in case it was only a temporary condition. If in the case of a failure where the high current could not be stopped because the circuitry of the X-90 is damaged, an internal fuse will break and disconnect from the battery. In that case the X-90 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.

The protection features of the auxiliary output port are designed for maximum reliability in tactical environments. As such there are multiple layers of protection, designed to allow the auxiliary output to stay operational as long as possible under non-ideal circumstances. To protect against very short current pulses which might ordinarily trip a current limit fault, the X-90 V3 Aux has the ability to operate the output port in a current limiting fashion for "ride through" capability until the port must be disabled for thermal reasons. Additionally, the controller will disable the output port if the current exceeds the maximum amount for an extended period. If the auxiliary output is disabled due to over current, it will quickly attempt to reconnect in order to continue operation. Also, in the case of a battery failure, where one of the two internal strings are disabled, the auxiliary output would still be available.

Automatically Dimming LED Indicators

The X-90 will automatically reduce the brightness of the LED indicators to approximately 30% of the maximum brightness when there is no incoming power. This would be in a case where the X-90 AUX is being used to power devices, without any solar or DC charging. When charging from a solar source, the LEDs are at full brightness, so as to be visible in the sun. In other cases the X-90 will save power by reducing the LED brightness, which can also serve to reduce excess light emission in dark environments. NOTE: In tactical environments, the soldier worn X-90 AUX should be securely strapped into a pouch which will completely cover the indicator LEDs.

Regulated 14.4V Output With No Battery Connected

Most solar battery chargers cannot operate without a battery to charge, this is not the case for the X-90 V3 AUX. If the X-90 V3 AUX is connected to input power, but there is no battery connected, the auxiliary output will be a regulated 14.4V with a regulated 8A current limit. This can serve two functions. The first function is in the case where a battery is damaged or unavailable, and the user would still like to use the X-90 to power a 12V device. Another case is where the X-90 can be used to recharge a 12V lead acid battery by connecting the auxiliary output to the terminals of the lead acid battery with the supplied adapter. When recharging a lead acid battery, be sure that the battery is capable of being charged with the amount of power provided by the solar panel or 8A if there is more than 120W of solar energy available.

Because the X-90 has no internal energy storage, the successful use of the auxiliary output to power a device will critically depend on the availability of sufficient solar energy to power the intended device. Insufficient solar energy or excessive load will cause the unit to reduce the output voltage, which will likely result in the powered device to cycle on and off. It is important to understand that this is unavoidable, and the ability for the X-90 to provide "emergency" power without a battery connected is a useful feature, but not an ideal configuration. In this case try to utilize as many solar panels as possible, and reduce the load as much as possible. Keep in mind that simple shadows and passing clouds can easily disrupt the energy flow, and cause the device to reset.

Warranty Statement

The X-90 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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