SOLAR STIK®

OPERATOR MANUAL FOR MKM BMS READER

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Revision History

Section	Page(s)	Description	Date
	6, 7	Added: **Recovering an Expander Pak with Red-flash Battery Status LED**	18 Dec 2017
	6	Clarified/highlighted observed behavior of BMS Reader when Battery Status LED does not emit light when the momentary switch is depressed.	14 Feb 2018
	3 4 6 8	Updated Introduction for clarity, accuracy and recommendation that only FSR-level personnel should use the BMS reader Added Battery Status LED information. Updated for clarity, accuracy and information regarding warranty. Added Technical Notes #5 and #6	25 Sep 2019
	6	Fixed typos in BMS Reader Screenshots	24 Oct 2019

MKM BMS READER

Introduction

Lithium batteries operate in a much more confined spectrum of voltage and current than lead-acid batteries. The Ultralife Multi-Kilowatt Module (MKM) installed in the 24VDC Li Expander Pak 2400s consist of eight (8) $LiFePO_4$ “supercells”. These cells require a complex battery management system (BMS), which manages the supercells and their protection circuits. The BMS is solely responsible for enabling or disabling the battery “terminals” where any external circuit is connected and through which all current flows.

Under/overvoltage conditions are tightly regulated by an internal protection circuit, or BMS. However, just as with lead-acid, irreversible damage can occur to a lithium cell when it is discharged below a certain voltage (Li Expander Pak 2400 is 2.5 V/cell) for an extended period of time.

The BMS is powered by energy stored in the MKM. When the voltage of the MKM falls below 13.6 V, (or 1.7 V/cell) the BMS enters an extended “hibernation mode” and disables the battery terminals. It does this to preserve what little energy remains in the MKM. The BMS must be powered and active to recognize the presence of a charging voltage.

While in hibernation, the BMS will occasionally “wake up” and search for voltage present at the terminals. The frequency of this check is dependent on the MKM voltage—the lower the voltage, the less frequently it will check for the presence of a charge voltage.

The battery’s internal BMS monitors, regulates, and records the activity of the MKM internal circuits. Performance, status and historical data points are available from the battery BMS using the Solar Stik MKM BMS Reader.

Data are most accurate when the MKM is in service and has been cycled several times, and it can be used to assess the general health of the MKM.

This Manual provides instructions on how to use the MKM BMS Reader during normal operations and also how to monitor recovery of an Expander Pak that has a red-flashing Battery Status LED.

It is strongly recommended that only FSR and technical support personnel use the BMS Reader when troubleshooting an MKM. It is a complex tool that if used improperly, can provide incorrect or incomplete information.

Note: Only the BATTERY STATUS LED on the case should be used by field operators to determine if the battery is functional. If a red-flash condition exists and cannot be rectified by charging the battery, the BMS Reader can be used as a tool to determine possible causes of the condition and potential recovery methods.

The Expander Pak 2400 Battery Status LED

The Li Expander Pak Battery Status LED is activated by depressing the momentary switch (Figure 1). The LED will either flash (green or red) or emit no light. The table below explains the meaning of the Battery Status LED report.

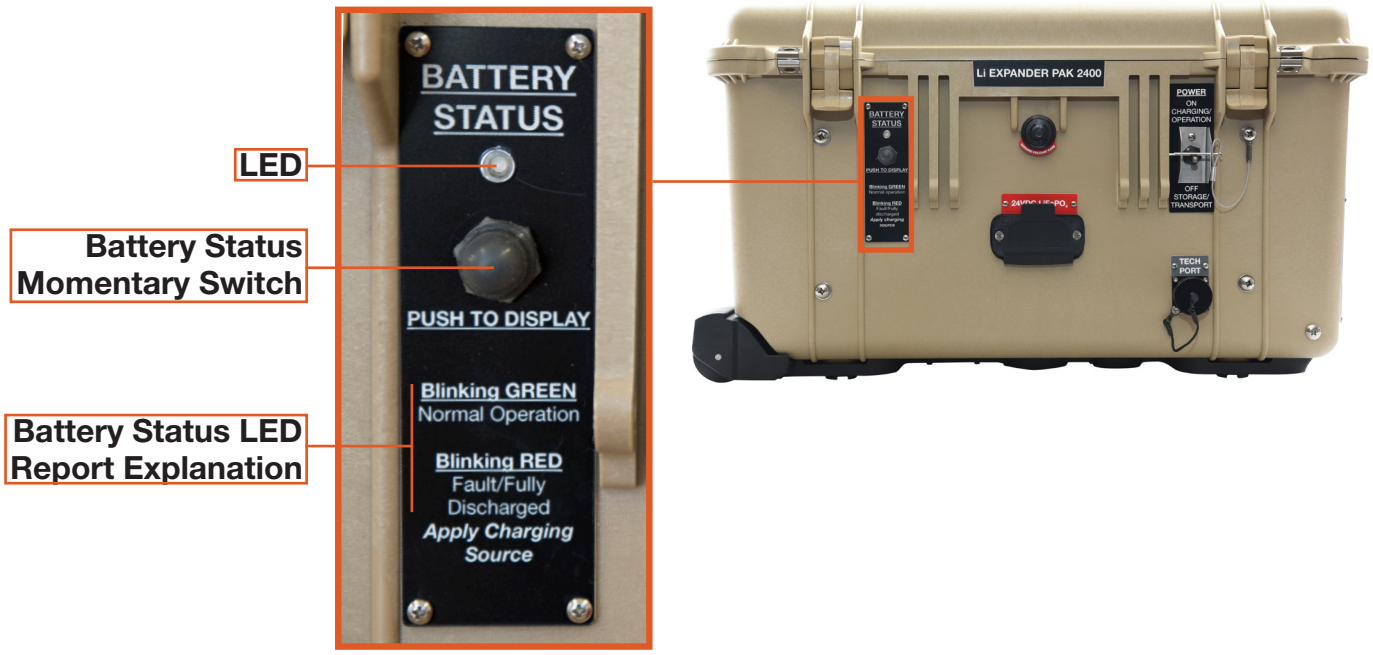


Figure 1. The Battery Status LED

Color	Frequency	Condition
Green	Flashing	**Normal operation**
Red	Flashing	**Protection circuits engaged:** 1. Cell overvoltage 2. Cell undervoltage 3. Overcurrent (charge or discharge) 4. Overtemperature (> 160 °F/71 °C) 5. An internal battery fault (such as a broken wire, etc.)
None	N/A	Expander Pak power switch off or Expander Pak inoperative

Features

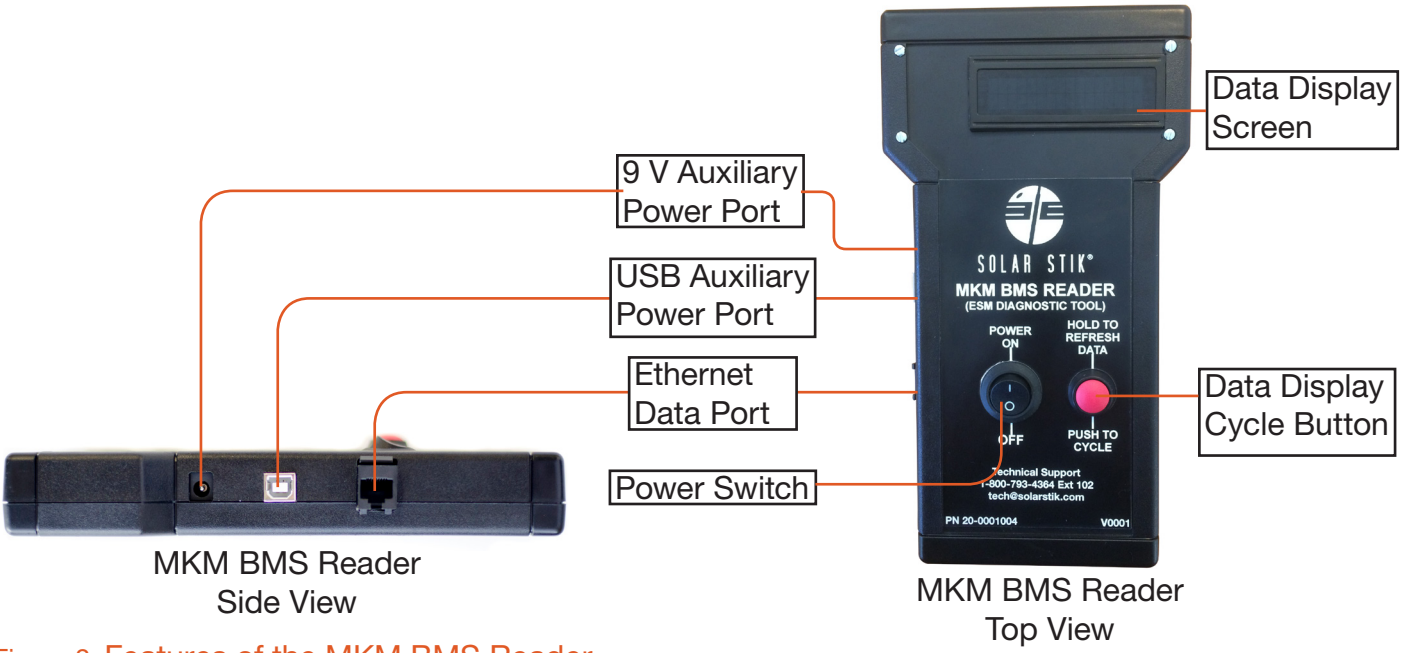


Figure 2. Features of the MKM BMS Reader

Connection

Figure 3. Connecting the BMS Reader to the MKM

OPERATOR INSTRUCTIONS

Activating the MKM BMS Reader

The MKM BMS Reader can be powered by either a 9 V battery or the 5 V USB auxiliary power ports.

1. Connect the MKM BMS Reader to the 24VDC Li Expander Pak 2400 Tech Port using the Ethernet cable.

2. Toggle the power switch to activate the Reader. **Note:** If the MKM BMS is updating the data from the cells, there may be a delay before the data are displayed on the screen.

3. Use the Data Display Cycle button to cycle through the parameters. Two parameters are displayed simultaneously on each screen. Press and hold the Cycle button to monitor one pair of parameters in real time as it is updated and uploaded from the MKM BMS.

Parameters Reported

(In the order that they are displayed on the screen)

- Voltage of 24VDC Li Expander Pak/MKM
- Current flowing in/out of MKM
- Temperature in degrees C of MKM
- SOC = state of charge
- Remaining capacity of MKM
- TTE = runtime remaining at current discharge rate
- Full charge capacity of MKM
- Cycle count
- Blank screen

*The top window depicts what may occur as the BMS is updating. Pressing the Cycle button once moves one parameter down the list.

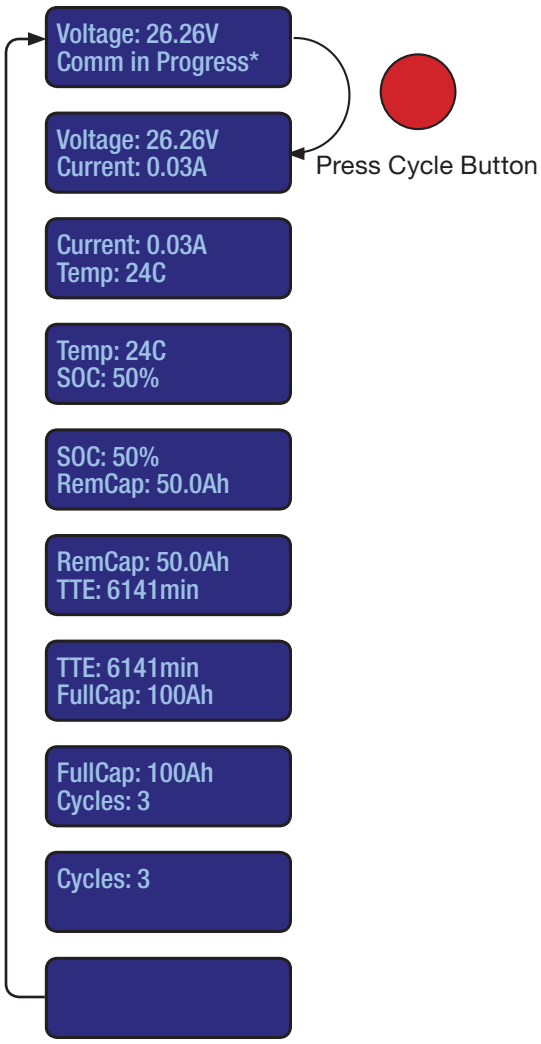


Figure 4. Parameters reported on data display screen

Recovering an Expander Pak with Red-flash Battery Status LED

It is most important to maintain Expander Paks in such a way that they do not reach a red-flash (inoperable) condition. If one or more Expander Pak Battery Status LEDs chronically flash red when in service, while other Expander Paks in the battery bank flash green, the MKM(s) may have one or more inoperable supercells. The MKM BMS Reader can be used to determine if an MKM is damaged and, if so, provide an estimate of the number of inoperable supercells within the MKM and whether the Expander Pak can be replaced under warranty.

Note: If the Battery Status LED emits no light when the button is depressed, the MKM BMS Reader will not report stored data unless the the LED is inoperable for reasons other than low MKM voltage If the MKM BMS reader reports data from an Expander Pak in a no-light LED status, the LED is either disconnected from the MKM or broken. If the BATTERY STATUS LED is inoperative, the MKM voltage has likely fallen below 17 volts and more than two (2) of the eight (8) cells have failed. The Expander Pak is non-mission capable (NMC), or bricked.

Procedure for Recovering an Expander Pak with a Red-flashing Battery Status LED

1. Disconnect the inoperative Expander Pak from the battery bank/System. Use the BMS Reader to measure the Expander Pak cell voltage. Document the value as a reference point to understand the current state of the MKM and how subsequent charging steps affect the voltage.

2. Charge the Expander Pak using a lithium battery charger for up to 48 hours and press the Battery Status LED momentary switch. If the LED indicator is still red, place the Expander Pak back on charge for an additional 24 hours. If the MKM voltage has plateaued, the Expander PAK is NMC. (See notes below for maintained voltage ranges and the extent of damage.) If the Battery Status LED is green, let the Expander Pak rest for 8 hours before returning to service.

3. After 8 hours, press the Battery Status LED momentary switch. If the Battery Status LED is still green, use the BMS Reader to measure the Expander Pak voltage. Record this voltage as a reference. The voltage can be expected to drop slightly.

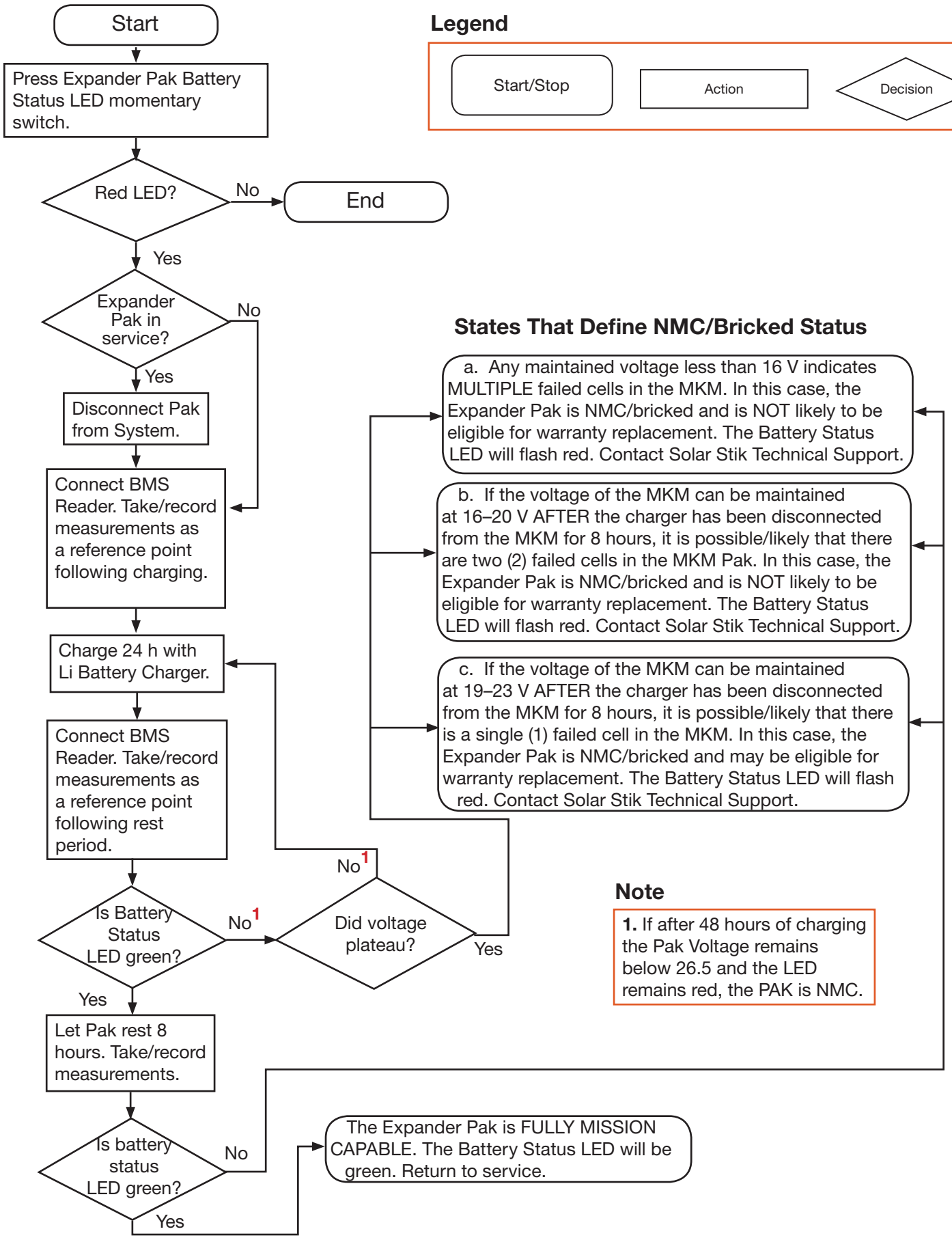
4. If the Battery Status remains green, return the Expander Pak to service and monitor the Battery Status LED and Expander Pak voltage regularly to ensure that it continues to perform to specifications.

Stable Voltage Ranges That Define NMC/Bricked Status of an Expander Pak

If the MKM maintains a voltage between 19 and 23 V after the 24 hours of charging but remains in a red-flash condition, it is possible that there is a single (1) failed cell. In this case, the Expander Pak is NMC/bricked and may be eligible for warranty replacement depending on age, cycles, and documented operating conditions. A full diagnostic analysis at Solar Stik Engineering facility is required before warranty claims will be honored.

If the voltage of the MKM can be maintained between 16 and 20 V after the charger has been disconnected from the MKM, it is possible that there are two (2) failed cells. In this case, the Expander Pak is NMC/Bricked and is NOT likely to be eligible for warranty replacement. The battery status LED will flash red as long as the voltage remains above 17.

Flowchart procedure for recovering a red-flash Expander Pak



MKM BMS Reader Technical Notes

1. If the display is blank, press the Cycle button to get to the next screen.

2. The BMS Reader may not respond while the MKM is doing its internal updates because the MKM turns off the communication interface during this process and may report a zero (0) value for all parameters during this time. When the battery has completed the internal updates, the communication interface turns back on automatically.

3. The DC voltage reading on the BMS Reader display is communicated from the “gas gauge” in the MKM. The gas gauge will “learn” a fully charged state when certain parameters are met during charging. This is known as a “charge termination detection”. When a charge termination is detected, the gas gauge sets the SOC to 100% because normally these events indicate the battery is charged fully. If the current and average current register within their respective designated ranges, and if the SOC calculated based on the voltage alone registers above a certain point, the gauge will learn a new capacity and set the SOC to 100%.

4. If the MKM BMS reader reports data from an Expander Pak in a no-light LED status, the LED is either disconnected from the MKM or broken.

5. The BMS Reader does NOT account for internal cell discharge during periods of storage. DO NOT USE the BMS Reader to determine SOC during periods of storage or inactivity.

6. If the 9 V battery that powers the BMS Reader is discharged, the LCD may operate, but it may report a zero (0) value for all parameters. Always use a fully charged 9 V battery.

ABOUT SOLAR STIK, INC.

SOLAR STIK®

Mission Statement
Using American-made components and constant innovation, Solar Stik creates portable power solutions that enable self-sufficiency for the soldier, the sailor, and beyond. In doing so, we save lives, change lives, and help revive American manufacturing.

Stikopedia
This document is a compilation of everything you would ever want to know about portable Hybrid Power Systems, including the philosophy and mechanics of high-efficiency circuits, and the individual technologies used to create them.

Solar Stik Training and Education

- **Solar School (St. Augustine, FL)** provides an introduction to the design and support of small-scale, renewable-energy, power generation systems, with detailed explanation of system components. Advanced configuration options with hands-on deployment of actual systems will enhance student understanding.
- **Solar Stik New Equipment Training (on site)** teaches Hybrid System configuration options with hands-on deployment of actual systems to enhance student understanding.

Solar Stik Training Courses are tailored to the specific needs of the students. To schedule Solar Stik Training or to learn more about the curriculum, please contact us.

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