

## EVAL-08 Frequently Asked Questions & Troubleshooting Guide

### Features

The CBC-EVAL-08 is a demonstration kit combining a solar panel energy transducer with the EnerChip EH CBC5300 Energy Harvesting module that has two 50  $\mu$ Ah EnerChip Batteries. The EnerChips provide storage and starting power for the energy harvesting module. The purpose of this demonstration platform is to enable designers to quickly develop Energy Harvesting applications. A block diagram of the EVAL-08 is shown in Figure 1.

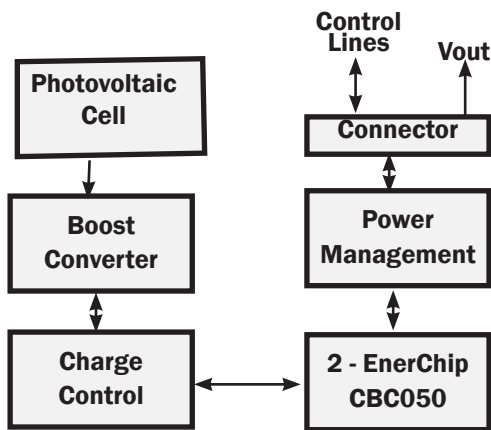


Figure 1: EnerChip EVAL-08 Demo Kit Block Diagram

### System Description

The photovoltaic cells convert ambient light energy into electrical energy. The output voltage of the photovoltaic cells is too low to charge the EnerChips and power the rest of the system directly, so a boost converter is used to boost the photovoltaic cell voltage to the voltage needed to charge the EnerChips.

The charge control block continuously monitors the output of the boost converter. If the output of the boost converter falls below the voltage needed to charge the EnerChips, the charge controller will disconnect the boost converter from the EnerChips. This prevents the EnerChips from back powering the boost converter in low ambient light conditions.

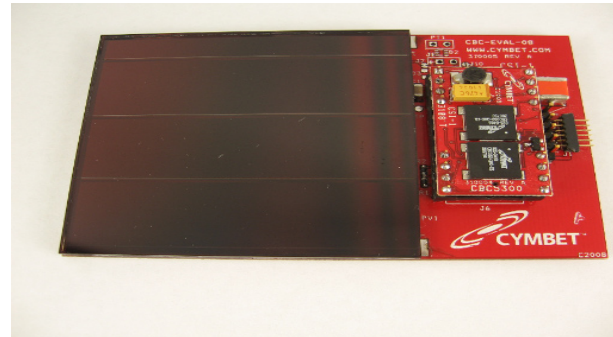


Figure 2: CBC-EVAL-08 EVAL Kit - 3.55 x 2 in.

The power management block is used to protect the EnerChips from discharging too deeply in low ambient light conditions, or abnormally high current load conditions. The power management block also ensures that the load is powered up with a smooth power on transition. The power management block has a control line ( $\overline{\text{CHARGE}}$ ) for indication to the system controller that the energy harvester is charging the EnerChips. A control line input ( $\text{BATOFF}$ ) is available for the controller to disconnect itself from the EnerChips when it is desired to conserve battery life for as long as possible in prolonged low ambient light conditions.

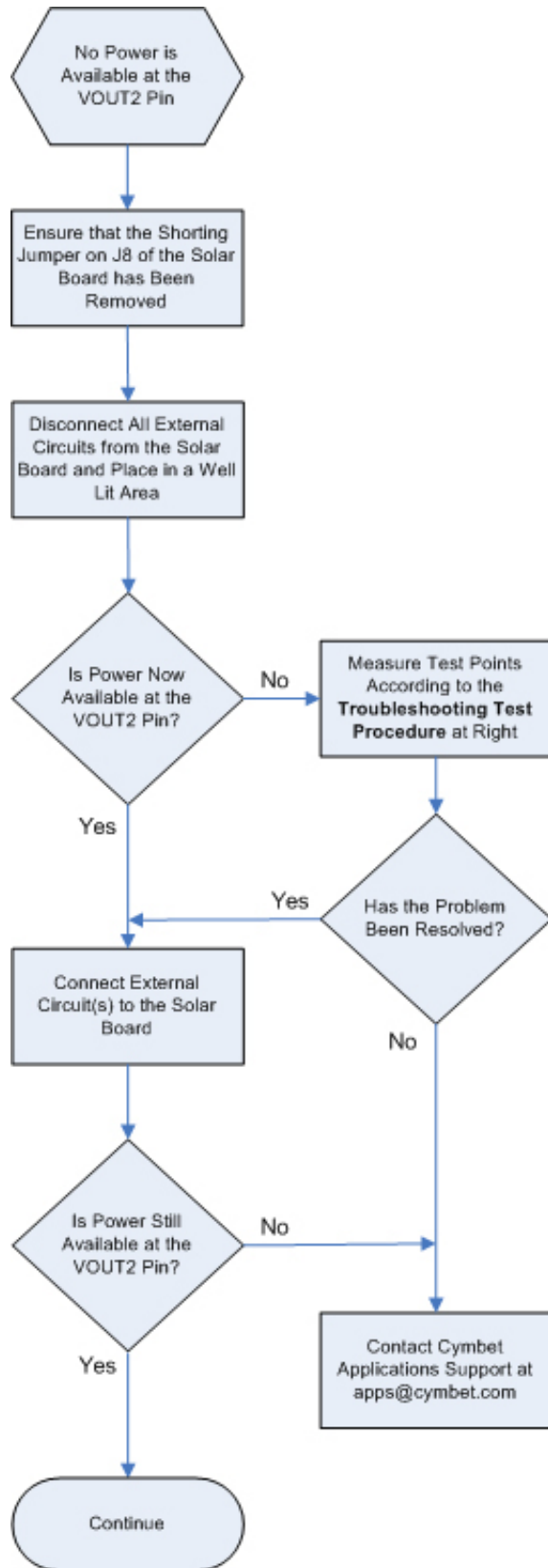
The EVAL-08 shown in Figure 2 with the EnerChip EH Module mounted on the Solar board with 100  $\mu$ Ah capacity.

There are two connectors on the EVAL-08 for connection to target devices to be powered. Either connector can be used for low power microcontroller based systems. In the case of a low-power wireless end device, the EVAL-08 has storage energy for up to 1000 transmissions - depending on protocol used - in no/low ambient light conditions.

Microcontroller systems that are powered by the EVAL-08 should contain firmware that is "Energy Harvesting Aware" and take advantage of the power management status and control signals in the CBC-EVAL-08.

# AN-1030: EVAL-08 FAQs & Troubleshooting Guide

## EVAL-08 Troubleshooting Guide



### Troubleshooting Test Procedure

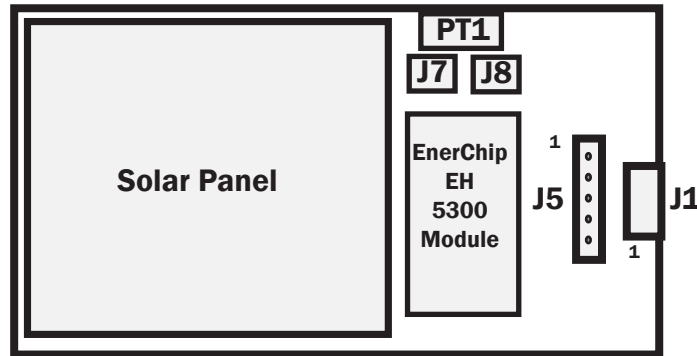
- 1) Using a voltmeter, put the ground lead on J5 pin 4 and probe J7 (left pin). Voltage should be 1.0V. This test verifies operation of the photovoltaic cell.
- 2) Probe right side of the tantalum capacitor (brown bar side) on the CBC5300 module. Voltage should be between 4.5V and 9V depending on ambient light and battery state-of-charge. This test verifies operation of the boost converter.
- 3) Probe the positive (bottom side) terminal of capacitor C2 on the CBC-EVAL-08. Voltage should be 4.06V, or steadily increasing if there is no output voltage. When the capacitor voltage reaches 3.8V, the output will turn on from zero volts to the voltage across capacitor C2. Note C2 will not be charging if the EnerChips are depleted. When the CBC-EVAL-08 is first powered up, the CBC5300 will first charge the EnerChips, then charge the output capacitor C2, then switch on the output when C2 is charged.
- 4) Probe J5 Pin 3 (VBAT). This pin should be at 4.06V.
- 5) Probe J5 Pin 5 (VOUT). This pin should be at 3.5V.
- 6) Probe J5 Pin 1 (CHARGE/). This pin should be at zero volts if the EnerChips are charged and enough ambient energy is available to operate the CBC5300 module. Depending on the input impedance of the voltmeter, a high level on this pin would read between 1.0V and 3.5V.

If none of the above works, check pin 1 on one of the EnerChips on the CBC5300 module (with it plugged into the solar board), as indicated in the figure below. It should read approximately 3.9V. If the voltage is less than 3.0V, the EnerChips have been damaged.

In applications where a radio is being used - as in wireless sensor networks - there can sometimes be external electrical interference with the radio signal that causes the radio receiver to stay on longer than normal. If this happens, the CBC-EVAL-08 output capacitor C2 will become discharged and the low battery cutoff circuit will engage, isolating the EnerChips from the load. If this happens it can take from several minutes to an hour or more for the EnerChips and output capacitor to be recharged.

# AN-1030: EVAL-08 FAQs & Troubleshooting Guide

## EVAL-08 Module Connectors



J1 Connector for User	
Pin Number(s)	Designation
1	BATOFF
2	GND
3	Not Connected
4	Not Connected
5	$V_{OUT2}$
6	CHARGE
Connector Type: Rt. Angle SIP	

J5 Connector for User	
Pin Number(s)	Designation
1	CHARGE
2	BATOFF
3	$V_{BAT}$
4	GND
5	$V_{OUT2}$
Connector Type: Vertical SIP	

J7 Connector	
Pin Number(s)	Description
1	Cut Trace to use external source
Connector Type: Trace	

J8 Connector	
Pin Number(s)	Designation
1	Positive input
2	GND
Connector Type: Trace Vias	

PT1 Connector	
Pin Number(s)	Designation
1	Piezo input 1
2	Piezo input 2
Connector Type: Trace Vias	

Figure 3: EnerChip EVAL-08 Connections

### EVAL-08 Module Connector Explanations

**J1 Connector** - Power and handshaking signals for connection to a target board - e.g. wireless end-point module. (For reference, header connector J1 is Mill-Max p/n 850-10-006-20-001000; the socket it mates to is Mill-Max p/n 851-93-006-20-001000.)

**J5 Connector** - Power and handshaking signals for connection to a target board - e.g. wireless end-point module. (For reference, header connector J5 is a 5-pin section of Samtec 50-pin header p/n TSW-150-07-G-S.)

**J7 Connector** - This trace is to be cut if an alternate solar panel is to be connected to J8.

**J8 Jumper and Shunt** - This connector ships with the shunt installed to protect the EH module. The shunt is removed before the EVAL-08 is charged for the first time. This connector can also be used to connect an alternate solar panel to the EVAL-08.

**PT1 Connector** - An alternate piezoelectric (or other AC) energy harvesting transducer can be connected. It can be connected in parallel with the EVAL-08 solar panel by leaving J7 intact. Or, the piezoelectric transducer can be used stand-alone by cutting the J7 trace.

**Ribbon Cable** - A flat 5-conductor ribbon cable is provided with the EVAL-08 to facilitate connection between the J5 connector and a 5-pin header on the user's board.

# AN-1030: EVAL-08 FAQs & Troubleshooting Guide

## Connecting the EVAL-08 to the System

The EVAL-08 board has two control lines that can be connected to a microcontroller for the purpose of conserving available energy, using incoming power efficiently, and extending EnerChip battery life. The table below describes the functionality of the J1 and J5 connector pins.

J1 and J5 Pin Descriptions	
Pin	Designation
BATOFF	Input control line to the EVAL-08 for disconnecting the EnerChips from the EVAL-08 charging circuit
$\overline{\text{CHARGE}}$	Active low output from the EVAL-08 indicating that the EnerChips have been charged or are being charged
$V_{\text{BAT}}$ (not accessible from the J1 connector)	Connected indirectly to the EnerChips' positive terminals through an isolation FET. Voltage is one diode drop above the potential at $V_{\text{OUT2}}$
$V_{\text{OUT2}}$	System power
GND	System ground

- $V_{\text{OUT2}}$  is the DC output voltage from the EVAL-08 and is approximately 3.5V depending on load current. It provides power to the system according to the Operating Characteristics table shown below.
- GND is the ground connection of the EVAL-08. It is to be connected to the system ground line.
- $V_{\text{BAT}}$  is normally used for factory test purposes. It is indirectly connected to the on-board EnerChips through an isolation pass transistor. The voltage on  $V_{\text{BAT}}$  is connected to  $V_{\text{OUT2}}$  by a diode and thus the voltage at  $V_{\text{OUT2}}$  is one diode drop lower than the voltage on  $V_{\text{BAT}}$ . It is recommended that  $V_{\text{BAT}}$  remain disconnected from external circuits. In no event should  $V_{\text{BAT}}$  be used for any purpose other than to provide power to a load.
- BATOFF is typically controlled by a microcontroller I/O line. When driven high, the on-board EnerChips will be disconnected from the charging source of the EVAL-08. This feature allows all available power to be delivered to the load rather than to charging the EnerChips, a useful mode when limited transducer power is available or when higher operating current is required from the system. When BATOFF is driven low, the interaction between the charging source and the EVAL-08 behaves normally. In other words, when BATOFF is low the EnerChips will always be charging when sufficient input power is available.
- $\overline{\text{CHARGE}}$  is an output signal from the EVAL-08 that will be forced low under one of two conditions:
  - » When transducer output power is very low, a low level on  $\overline{\text{CHARGE}}$  indicates that the EnerChips have been charged.
  - »  $\overline{\text{CHARGE}}$  will also be driven low when transducer output power is more than sufficient to operate the boost converter and charge the EnerChips at peak rate, regardless of the state of charge of the EnerChips. Programming an MCU timer to allow enough charging time to elapse after the assertion of  $\overline{\text{CHARGE}}$  will ensure that the EnerChips are fully charged before using them to deliver power to the system. The advantage is that the system is then aware of the minimum reservoir of energy available in the event transducer power goes to zero.

# AN-1030: EVAL-08 FAQs & Troubleshooting Guide

---

## Frequently Asked Questions

- Q: The ez430-RF2500-SEH GUI does not flash the temperature? It is static and does not blink.
- A: Pull the USB access point out of the USP port and close the ez430-RF2500-SEH application. Re-insert the USB access point. Double click on the ez430-RF2500-SEH icon. The temperature should be blinking now.
- Q: When I plug in the end point the end point does not display on the ez430-RF2500-SEH GUI?
- A: Usually the user can just unplug the board, wait a few minutes and plug the board back in. If this does not work then the output cap C2 may not be charged up if the unit has been in a dark place for hours. Measure the voltage across C2. The voltage should be about 4.1 volts. If the voltage is less than 3.5 volts place the solar board module in a brightly lit area for an hour and re-measure.
- Q: The end point displayed in the GUI indicates that the power is from the Enerchip and not the solar cell even though the cell is in bright light.
- A: Clean off the solar cell. Unplug the end point and wait for 30 minutes in a bright light. Plug the end point back in.
- Q: I am not sure if I have enough light to charge the battery?
- A: Probe right side of the tantalum capacitor (brown bar side) on the CBC5300 module. Voltage should be between 4.5V and 9V depending on ambient light and battery state-of-charge. This test verifies operation of the boost converter.
- Q: What if I short-circuit the output?
- A: The disconnect circuit will disconnect the battery from the output after the capacitor is discharged below about 3.0 volts. This prevents the battery from being discharged too deeply. The battery will automatically reconnect after the capacitor is recharged.
- Q: What happens if I want to run a larger pulse current application?
- A: See application note AN-1025. The output capacitor can be sized to drive almost any load as long as the duration is not too long. AN-1025 describes how to calculate the capacitor size.
- Q: Are the batteries on the board safe and green?
- A: Yes; there are no safety issues with the Cymbet battery or solar energy harvesting board. All the components are green.
- Q: What happens if the cell is short-circuited? Will it explode or leak harmful chemicals?
- A: No. There are no harmful chemicals to leak and the battery will not explode.

## AN-1030: EVAL-08 FAQs & Troubleshooting Guide

---

- Q: I want to remove the EH5300 module from the solar board. May I do this?  
A: Yes; however, you MUST use a DIP chip-type extraction tool to pull the DIP module from the board or you might break the pins off of the EH5300 board.
- Q: The  $V_{BAT}$  line and the  $V_{OUT2}$  line are at different potentials. Why?  
A: The  $V_{BAT}$  line is the raw battery output. The  $V_{OUT2}$  line is down-regulated to provide a lower voltage for 3.3 volt +/- 10% applications.
- Q: How long will the SEH module run in the dark?  
A: This will depend on the duration between transmissions. Theoretically you can get about 1200 transmissions from the module but to lessen the depth of discharge the firmware is programmed to stop at 400 transmissions. The cutoff circuit will engage and disconnect the battery if you modified the code to not shut off at 400 transmissions.
- Q: How long will the SEH module last if I use it every day and it is in the light most of the time?  
A: The SEH module should last at least 10 years.
- Q: How long will the two cells on the SEH module hold a charge assuming no light?  
A: The self-discharge of the cell is a function of several parameters, including temperature. For the self-discharge specifications, see the product data sheets at <http://www.cymbet.com/content/products.asp> .
- Q: What happens if the cell is left in a discharged state for a long period of time?  
A: Leaving the cell in a discharged state is not detrimental to the cell performance.
- Q: What happens if the SEH module is exposed to light indefinitely?  
A: This is not harmful to it.
- Q: Can I use the SEH module as a permanent, stand-alone power supply?  
A: Yes; take the output from  $V_{BAT}$  or  $V_{OUT2}$  and ground.