# Using the EnerChip™ Energy Harvesters with the TI LaunchPad

## Overview

Cymbet EnerChip™ energy harvesting solutions are well suited to powering low power microcontrollers (MCUs) and radios used in wireless sensor networks, data logging, and RFID applications. Useful amounts of energy can be harvested from a variety of ambient power sources including light, vibration, temperature differentials, and electromagnetic generators activated by liquid or air flow. Cymbet has developed power management and energy storage solutions that can be used in all such environments, making routine replacement of conventional batteries unnecessary.

This application note describes how three of the Cymbet Energy harvesting EVAL kits can provide uninterrupted power to the Texas Instruments MSP430-based LaunchPad development kit. Figure 1 illustrates the Cymbet EVAL-10 EnerChip CC Solar Energy Harvesting Kit connected to the TI LaunchPad. The EVAL-10 evaluation kit from Cymbet captures ambient light (indoor or outdoor) from the solar cell, converts the power efficiently using the Enerchip power management circuit, and provides continuous regulated power to the LaunchPad.

## Cymbet Energy Harvesting Kits and the Texas Instruments MSP430 LaunchPad

Cymbet has developed a number of innovative energy harvesting power management solutions and embodied them in several development boards. Three of these EH EVAL Kits work with the LaunchPad:

- CBC-EVAL-09: EnerChip™ EP Universal Energy Harvester Evaluation Kit
- CBC-EVAL-10: EnerChip™ CC Energy Harvester Evaluation Kit (Figure 1)
- CBC-EVAL-11: EnerChip™ CC Inductive Charging Evaluation Kit



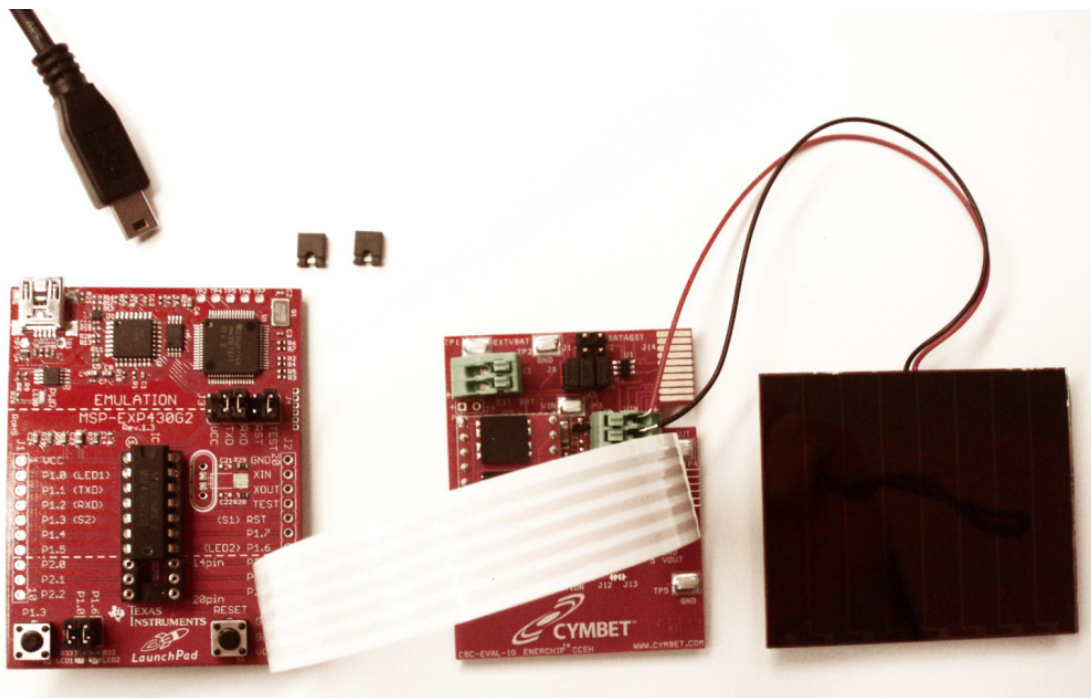*Figure 1: Cymbet CBC-EVAL-10 Energy Harvesting Evaluation Kit (right) Powering the TI LaunchPad (left).*

## CBC-EVAL-09 Universal Energy Harvester with Energy Processor

CBC-EVAL-09 is a universal energy harvesting (EH) evaluation kit that combines any one of multiple EH transducers with the EnerChip™ EP CBC915-ACA Energy Processor and the EnerChip CBC51100 100µAh solid state battery module that has two 50µAh EnerChip solid state batteries connected in parallel. The purpose of this evaluation platform is to enable designers to quickly develop Energy Harvesting applications. The CBC-EVAL-09 ships with a solar cell for initial evaluation kit testing. A photo of CBC-EVAL-09 board is shown in Figure 2. The CBC-EVAL-09 data sheet is located here: http://www.cymbet.com/content/products-resource-docs.asp. The EVAL-09 is available at Avnet, Digi-Key and Mouser.

## Connecting the CBC-EVAL-09 to the TI LaunchPad

After connecting the TI LaunchPad to a PC via the USB cable, it must be disconnected before connecting the EVAL-09. The white cable included in the EVAL-09 kit is used to connect the two kits together using VOUT and GND.

**Important Note**: There is a special orientation to the cable connection as shown in Figure 2. The cable is placed on pins 4 and 5 on J10 and the middle GND pin and VCC pin on the TI LaunchPad J6 connector. It is important not to connect the pin 3 VBAT connector on the EVAL-09 J10 connector to the top GND pin on the LaunchPad. This would result in improper operation of the EVAL-09.

Also, in order to avoid EH powering the entire TI LaunchPad board vs. just the MSP430 MCU, the LaunchPad J3 VCC and RST connector jumpers must be removed and set aside. These are to be restored for USB operation.
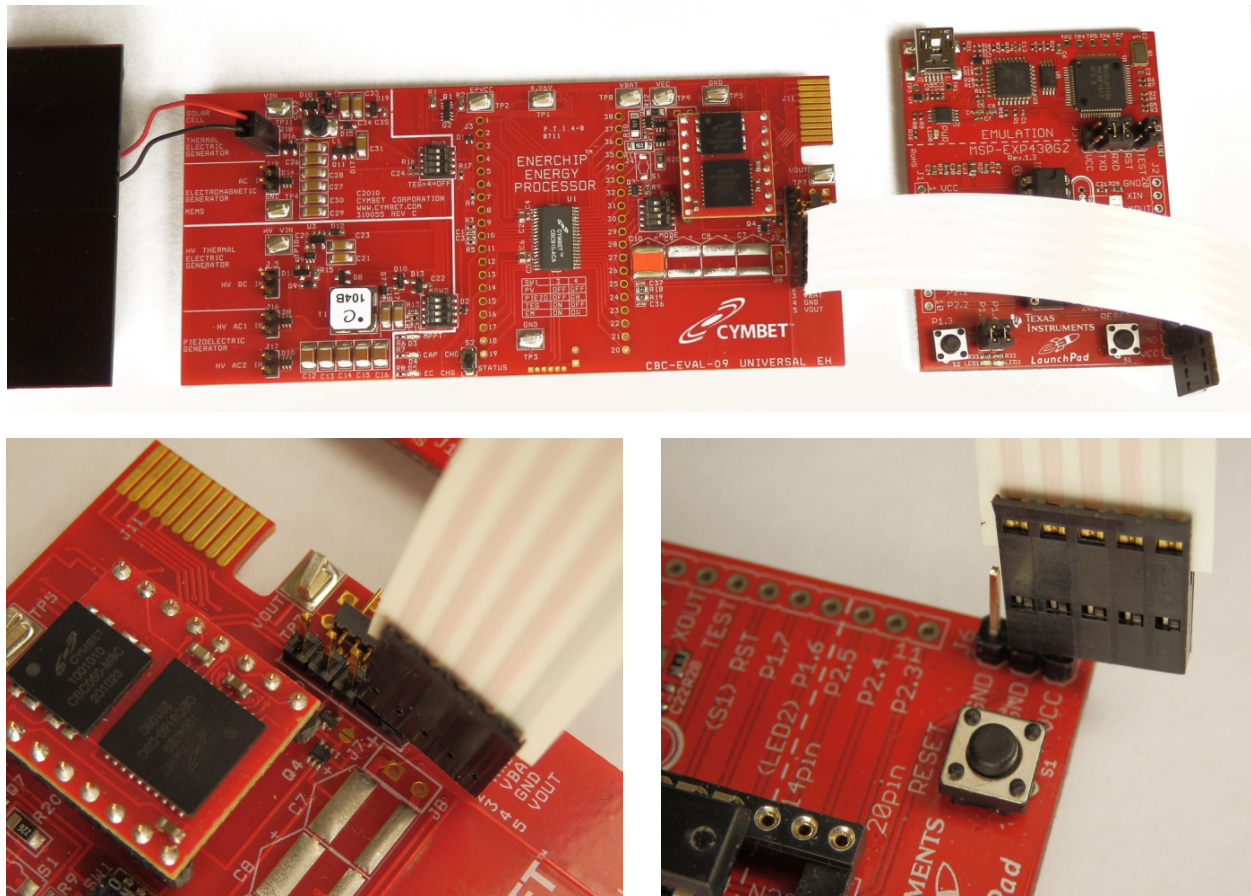


*Figure 2: CBC-EVAL-09 Universal Energy Harvester Connected to LaunchPad (top). Detail of Ribbon Cable Connection to CBC-EVAL-09 Board (bottom left) and LaunchPad (bottom right).*

## CBC-EVAL-10 EnerChip CC Solar Energy Harvester

CBC-EVAL-10 is a demonstration kit that provides designers a platform to easily develop Energy Harvesting (EH) solutions using the EnerChip CBC3150™ configured to operate in an energy harvesting mode. The kit (shown in Figure 4) combines a small solar panel, power management circuit, energy storage, regulated output voltage, and input/output pins for connection to commercially available microcontroller (MCU) and radio boards. A 16-pin CBC51100 module is included, providing the EH functions, battery management, and 100µAh solid state rechargeable energy storage. CBC-EVAL-10 is a practical, low cost realization of an EH-based power system that can provide many years of service without need of battery maintenance. Figure 3 illustrates the basic configuration of the EnerChip CC circuit as implemented on the CBC-EVAL-10 development module designed for evaluating the EnerChip CC devices in energy harvesting applications. The CBC-EVAL-10 data sheet is located here: http://www.cymbet.com/content/products-resource-docs.asp. The EVAL-10 is available at Avnet, Digi-Key and Mouser.
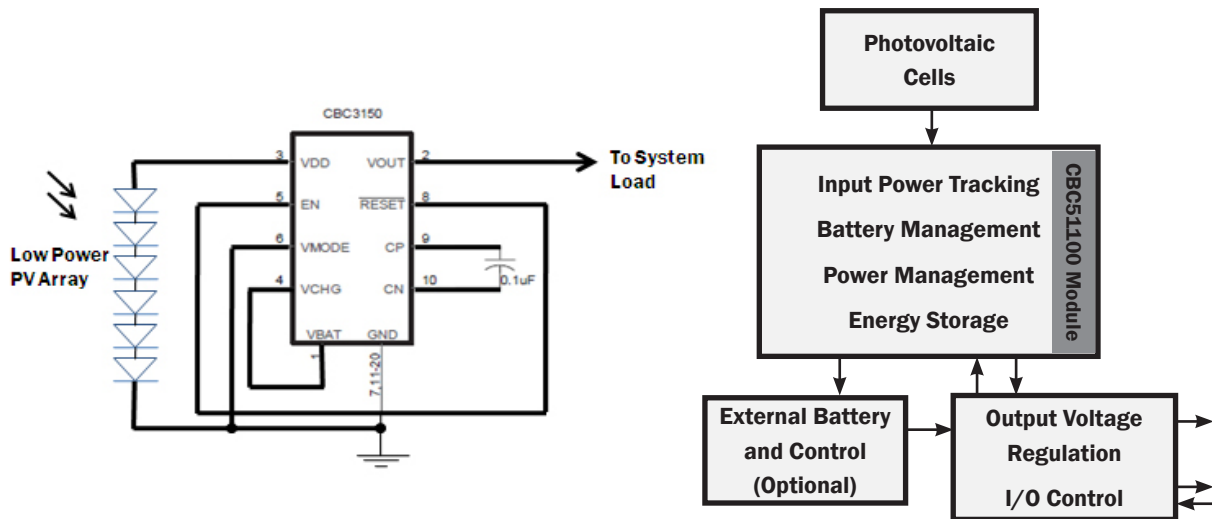
*Figure 3: Implementing Energy Harvesting with the EnerChip CC CBC3150 on the CBC-EVAL-10 Evaluation Kit.*

## Connecting the CBC-EVAL-10 to the TI LaunchPad

After connecting the TI LaunchPad to a PC via the USB cable, it must be disconnected before connecting the EVAL-10.

The white cable included in the EVAL-10 kit is used to connect the two kits together (see Figure 4). The cable is placed over all five pins on EVAL-10 J9 and all three pins on the TI LaunchPad J6 connector. Ensure that pin 5 on the EVAL-10 connector is connected to VCC on the LaunchPad.

Also, in order to avoid EH powering the entire TI LaunchPad board vs. just the MSP430 MCU, the LaunchPad J3 VCC and RST connector jumpers must be removed and set aside. These are to be restored for USB operation.
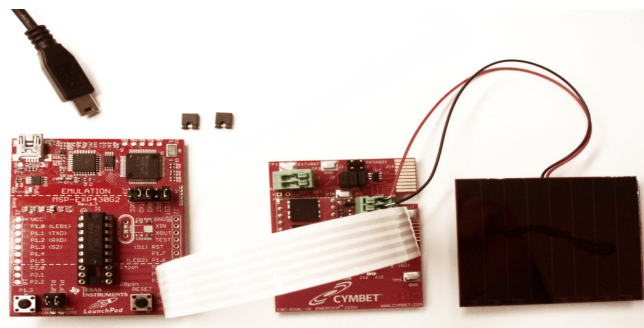
*Figure 4: CBC-EVAL-10 Demo Kit Connected to the LaunchPad.*

## CBC-EVAL-11 EnerChip CC Inductive Charger

CBC-EVAL-11 (shown in Figure 5) is a demonstration kit combining an RF inductive transmitter board with a receiver board containing an EnerChip CC CBC3150 solid state storage device with integrated power management. The transmitter board operates at 13.56 MHz and derives its power from a USB port. In addition to the EnerChip CC, the receiver board has a planar antenna for receiving power from the transmitter board, an output capacitor for delivering pulse current for radio transmissions, and a header connector for mating to a target board containing, for example, a microcontroller and/or radio board. The CBC-EVAL-11 data sheet can be found at: http://www.cymbet.com/content/products-resource-docs.asp. The EVAL-11 is available at Avnet, Digi-Key and Mouser.

## Connecting the CBC-EVAL-11 to the TI LaunchPad

After connecting the TI LaunchPad to a PC via the USB cable, it must be disconnected before connectiing the EVAL-11 to the LaunchPad.

The white cable included in the EVAL-11 kit is used to connect the two kits together. Note the orientation of the EVAL-11 to the TI LaunchPad. The cable is placed over all five pins on EVAL-11 J4 connector and all three pins on the TI LaunchPad J6 connector. Ensure that pin 5 on the EVAL-11 J4 connector is connected to VCC pin on the LaunchPad.

Also, in order to avoid EH powering the entire TI LaunchPad board vs. just the MSP430 MCU, the LaunchPad J3 VCC and RST connector jumpers must be removed and set aside. These are to be restored for USB operation.
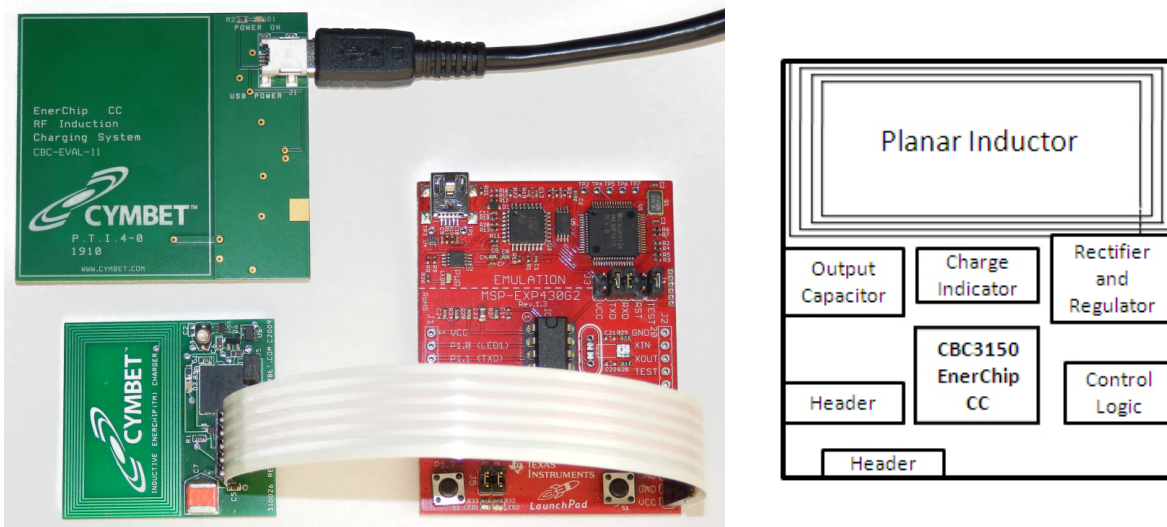


*Figure 5: CBC-EVAL-11 Connected to LaunchPad, Along with a Functional Diagram of the CBC-EVAL-11 Receiver Board.*

## Using Energy Harvesting Data Logging Firmware with the LaunchPad V1.1

To use the LaunchPad as an energy harvesting datalogger you must use the IAR or Code Composer development environment to build and load the datalogging firmware. The IAR and Code Composer project can be found on the CD-ROM included with the Cymbet EVAL kit or is also available at the Cymbet Corporation web site: http://www.cymbet.com/content/products-resource-docs.asp in the Software/Firmware table.

Install the MSP430G2231 chip into the LaunchPad board. Build and load the datalogger application to the LaunchPad board. The datalogger application is based on the original LaunchPad thermal demo code and the original LaunchPad code will be readily apparent from viewing the source. The datalogger code runs first and then defaults to the LaunchPad thermal demo application when plugged into the USB port.

### USB Powered Mode

In this mode the LaunchPad board gets its power from the USB cable. To configure for this mode make sure the flex cable from the Cymbet Energy Harvester is disconnected.  Install the original  5 jumpers in the J3 block. Power for the board now comes from the USB connection.

### Cymbet EVAL Kit Powered Mode

This configuration powers the LaunchPad board from one of Cymbet's energy harvesting EVAL kits. To operate in this mode,  you must first unplug the LaunchPad from the USB port and remove jumpers VCC and RST from the J3 jumper block. This keeps the energy harvester from powering the USB interface and only powers the actual MSP430 MCU chip.  Connect the 5-pin flat flex cable from the  energy harvesting board to J6 of the LaunchPad board as detailed in the appropriate previous section.

### Log Temperature Data

To log temperature data,  configure the LaunchPad board in CYMBET POWERED MODE. The LaunchPad will start blinking both of the LEDs at a 1 second rate.  A short press of the button starts logging. The green LED will blink with each temperature logged and will initially log one temperature per 2 seconds. After the 32 temperatures are logged, each with a corresponding blink of the green LED, the red LED will blink to indicate the logger registers are full. Go to the next Read Temperature Data  section  to configure the LaunchPad to send its logged data and clear itself for another run.

The 2-second logging interval is declared in a #define statement in the C source code and may be modified by recompiling and reloading the firmware.

### Read Temperature Data

To readout logged data, configure the LaunchPad board for USB POWERED MODE. When the LaunchPad board is plugged into the USB port a COM port driver will appear in the device manager of Windows that  is called MSP430 Application UART with an associated COM port number. Note this number. Start up a terminal emulator program like TeraTerm or Hyperterminal and configure to hook this COM port at 9600 baud with no flow control and 1 stop bit and 8 bits of data. The LaunchPad board will now blink the LEDs alternately at about a half-second rate.  A short press of the left button will cause any logged data to be sent to the terminal emulator as 8-bit ASCII HEX values that represent the upper 8 bits of the 10-bit A/D converter reading the temperature sensor. If there is no data logged, you will see a 00, on the terminal emulator to indicate no data present. If you don't see any data the terminal emulator is not configured correctly. If you see logged temperature data you may press the reset button followed by a 1 second press of the left button to again send the data. To erase data press the RESET button and then hold the left button down for over 3 seconds and the application will again send the data but erase it afterwards.  After readout the LaunchPad will revert to the original LaunchPad demo software.

The application may now be used to log new data.

## Terminal Emulator Quirks

In Windows the terminal emulator must be operating on a USB COM port emulation driver which instantiates as COMX where X could be any number based on the particular port and particular connection of the LaunchPad hardware when the LaunchPad is plugged into the USB port. Various terminal emulators can be quirky on "hooking" or connecting to a particular COM port. Use the device manager to make sure the COM port for the "MSP430 applications UART" appears under Ports (COM and LPT). If the "MSP430 applications UART" does not appear try unplugging the LaunchPad/USB cable from your PC and plugging it into a different USB port. Once you see the "MSP430 applications UART", note the COM port number and configure the terminal emulator to use that COM port. Remember that when you unplug the USB cable to the LaunchPad, the COM port will probably disappear and so will its connection to the terminal emulator. You may need to close the terminal emulator, unplug the LaunchPad cable, wait a few seconds, plug in the LaunchPad, restart the terminal emulator, and configure the terminal emulator.

To configure the desired COM port, set the port for 8 bits, 9600 baud, no parity, with one stop bit and no flow control.

## Code Description

The datalogger code is based on the original LaunchPad temperature demo code. This original code makes use of many timer modes and uses the watchdog timer as a switch debounce timer. The timer code and the function PreApplicationMode was modified to make the button detect a short or long button press. There are several routines that reconfigure the timers for the various modes of the LaunchPad demo and an additional mode was added for the Cymbet Datalogger demo. The Cymbet Datalogger demo code checks for the modem cable not present and then calls the CymbetLogData routine which reconfigures the timers, runs the Cymbet datalogger, and then blinks the red LED when full. If the modem cable is present the routine waits for a button press to dump any logged data, erases the logged data if the button press was long, and then returns to the original LaunchPad demo.

## Ordering Information

| EnerChip Part Number | Description | Notes |
| --- | --- | --- |
| CBC-EVAL-05 | EnerChip CC Evaluation Kit | A CBC3112 and a CBC3150 on 24-pin module for experimentation |
| CBC3150-D9C | EnerChip CC 50uAh with Integrated Power Management | Parts sold tube or tape-and-reel |
| CBC-EVAL-10 | EnerChip CC Energy Harvester Evaluation Kit | Contains Solar Cell Panel and CBC51100 Module |
| CBC-EVAL-09 | EnerChip Universal Energy Harvesting Demo Kit | Contains Solar Cell and CBC51100 Module |
| CBC-EVAL-11 | EnerChip CC Inductive Charging Evaluation Kit | Shipped in Box |