

P2110-EVAL-02



Lifetime Power® Energy Harvesting Development Kit for Battery Charging User's Manual

- featuring THINERGY® Micro-Energy Cell

Overview

The Lifetime Power® Energy Harvesting Development Kit for Battery Charging is a complete demonstration and development platform for wireless battery-charging over distance powered by RF energy (radio waves). This kit features a THINERGY® Micro-Energy Cell (MEC) from Infinite Power Solutions (IPS) which has an ultra-thin form factor and extremely low leakage.

Batteries are charged by the P2110CSR Powerharvester® Chipset Reference Design, which converts RF energy, stores it into an intermediate capacitor, and then provides a pulsed, regulated voltage output which provides charge current to the attached storage. In this kit, the TX91501 transmitter is the source of RF energy at 915MHz, but other sources from 850-950 MHz can also be used for power.

A regulated load voltage is provided to power an application device, and the Texas Instruments eZ430-RF2500 wireless development tool is included for demonstration purposes.

Note:

This kit is based on the P2110CSR Powerharvester. Powercast's P1110 Powerharvester component also charges batteries and the main differences are as follows:

Parameter	P1110	P2110CSR
Charging Method	Continuous	Pulsed / Intermittent
Output Voltage Range	1.8V - 4.2V	2V – 5.5V
Output Voltage	Output voltage floats with the battery voltage until the configured maximum output voltage is reached	Fixed, regulated output voltage
Usage	Direct power OR Battery-charging (direct connection to typical battery)*	Pulsed power OR Battery-charging (additional circuitry typically required)
Operating / Charging Range (with identical antennas)	Shorter – roughly half as far as the P2110.	Longer – roughly twice as far as the P1110.

* P1110 is NOT to be used with thin-film batteries like THINERGY that require a fixed charging voltage.

The P1110 Evaluation Board kit (P1110-EVB) is also available to charge batteries using the P1110. The P1110-EVB will receive power from the transmitter included with the P2110-EVAL-01 or P2110-EVAL-02 development kits.

Contents

The contents of the kit are shown in the image and table below.



Qty	Item	Description
1	Power and Data Transmitter (TX91501-3W-ID)	3-watt, 915 MHz transmitter for power and data with integrated 8dBi antenna and two power jacks. Sends a pre-programmed transmitter ID that is received by the P2110CSR Powerharvester and can be decoded with additional components.
1	P2110CSR Evaluation Board (P2110CSR-EVB)	Evaluation board for P2110CSR Powerharvester. This board has an SMA connector to connect the antennas and a 10-pin connector for the Charging Board
1	Patch antenna	915MHz directional antenna with 120-degree reception pattern (included with the P2110CSR evaluation board)
1	Dipole antenna	915MHz omni-directional antenna with 360-degree reception (included with the P2110CSR evaluation board)
1	Charging Board (BAT-EVAL-01)	Charging Board for voltage selection, test points, and interfaces to other devices.
1	THINERGY MEC Evaluation Card	THINERGY MEC101 Micro-Energy Cell Evaluation Card (1mAH) from Infinite Power Solutions
1	CABLE-ADP-08	8-wire cable for connecting the Charging Board to the IPS Application Development Platform (ADP).
1	eZ430-RF2500	Texas Instruments eZ430-RF2500 Development Tool – used to demonstrate a low-power wireless application.

Set-up and Operation

Installation Overview

The following basic steps are required to operate the kit and are provided as an overview. Detailed installation instructions are provided immediately after this summary.

1. Connect an Antenna to the P2110CSR Evaluation Board (receiving unit)
2. Configure the P2110CSR Evaluation Board
3. Configure the Charging Board
4. Plug in the transmitter and point toward the receiving unit

Step-by-Step Installation

1. Connect an antenna to the P2110CSR evaluation board (receiving unit)

This kit includes two receiving antennas matched to receive maximum energy at 915MHz – a dipole for omni-direction charging and a patch for directional charging. The patch will work at further distance than the dipole, or provide a faster charge rate when used at the same distance from the transmitter as the dipole. Both antennas include an SMA connector for easy attachment to the P2110CSR evaluation board.

The estimated operating distance with the included transmitter and receiving antennas is:

Dipole antenna:	20-25 feet
Patch antenna:	40-45 feet

Other 915MHz antennas can be used, or if using an RF source other than the one included an antenna with proper frequency matching should be used for best performance.

Note:

A DC block must be used when the antenna is a DC short. Below is a link to a coaxial inline DC block that can be used. For actual deployment, a series capacitor on the input to the harvester is the best and lowest cost solution. The cap should be rated for the desired frequency to avoid unwanted insertion loss. <http://www.minicircuits.com/pdfs/BLK-89+.pdf>

Note: Optional testing of P2110CSR Evaluation Board only (also requires Step 5).

To test the proper function of the P2110CSR Evaluation Board use the following settings or see the instructions for the P2110CSR-EVB at <http://www.powercastco.com/PDF/P2110CSR-EVB.pdf>

J1:	Antenna connected
JP1:	C6 connected
S2:	LED

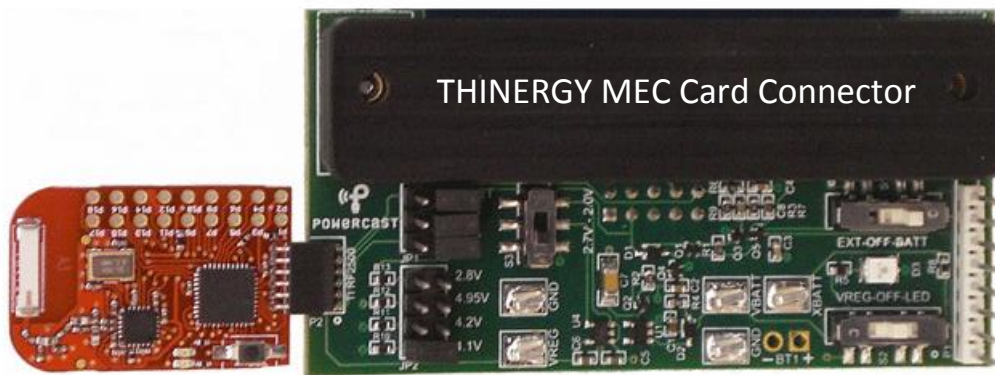
The LED will blink when sufficient power is available. The blinking rate is faster when closer to the transmitter and slower when further from the transmitter.

2. Configure the P2110CSR Evaluation Board

The P2110CSR Evaluation Board should be configured as follows when using the Charging Board:

- JP1: C8 connected – C6 for shorter charge pulses, C8 for longer charge pulses
- S1: Sets the charging voltage, VOUT
 - Default – 3.3V used for charging 2 rechargeable alkaline cells in series
 - 4.1 – Use this setting to charge the onboard THINERGY MEC
 - 4.2 – Use this to charge external lithium ion batteries
- S2: MEAS – this assures all power goes to charging board
- S3: not applicable
- S4: not applicable

3. Configure the Charging Board



BAT-EVAL-01 Charging Board (shown with attached eZ430-RF2500 wireless board)

3.1 Insert the THINERGY MEC into the Charging Board Card Connector

Slide the MEC Evaluation Card into the large black connector on the Charging Board. The exposed metal leads should be facing downward and slide into the connector. The connector and MEC card are keyed for proper insertion.

To charge a different battery than the included MEC card, set S1 switch to EXT and connect the external battery across XBATT and GND, or use the through-hole solder connection, BT1.

3.2 Configure the Charging Board for your desired application.

The following explains the functions of the jumpers and switches on the Charging Board:

JP1: Allows harvester signals (INT, RESET) to be sent to eZ430-RF2500 kit (explained below)

JP2: P2110CSR-EVB: Not used, do not connect a jumper. Output voltage is set on the EVB.

P2110-EVB rev B (lidded harvester): used to set the charging voltage. Place a shunt over the jumper with the required voltage.

4.1V – used for charging the IPS MEC

4.2V – used for charging Li-ION or Li-Polymer cells

4.95V – used for charging 3 rechargeable alkaline cells in series

2.8V – used for charging 2 NiMH cells in series

3.3V – used for charging 2 rechargeable alkaline cells in series.

Default voltage, selected by leaving all jumpers open

Warning – do not connect more than one jumper at a time.

S1: Selects storage device

BATT – charges IPS MEC

OFF – disconnects battery from charger to eliminate leakage

EXT – charge external batteries (BT1 or XBATT)

– use IPS ADP to charge IPS MEC (P1 – see instructions below)

S2: Selects battery output

VREG – regulated output, voltage controlled by S3

OFF – no output, used for charging only

LED – rapid battery discharge

S3: Selects desired output voltage regulation, 2.7V or 2.0V (2.7V for eZ430-RF2500 kit)

3.3 Plug the Charging Board (BAT-EVAL-01) onto the P2110CSR Evaluation Board using the keyed connector (J2) in the test area.

4. Plug in the transmitter and point toward the receiving unit.

Plug in the TX91501 Powercaster Transmitter and point it toward the receiving unit. The front of the transmitter has the Powercast logo and status LED. Please see the TX91501 User's Manual for detailed operating instructions.

<http://www.powercastco.com/PDF/TX91501-manual.pdf>

The transmitter should be used in the upright (vertical) position and the receiving antennas should also be positioned vertically.

Note:

As a precaution, do not operate the transmitter within 12 inches of the evaluation board when the patch antennas are attached.

Charging Range

The line-of-sight range using the included transmitter and antennas is as follows:

Dipole antenna:	20-25 feet
Patch antenna:	40-45 feet

Charge Current Calculation for THINERGY MEC

Direct measurement of the THINERGY MEC is not available as access to the THINERGY battery terminals was not provided to avoid possible damage to the cells. However, the charging current can be calculated with the use of an oscilloscope with a voltage probe. Set the charging board to charge the THINERGY MEC (JP2 to 4.1V, S1 to BATT, S2 to OFF). Attach a scope probe between the VBATT and GND test points. Monitor the voltage on the scope, and you'll notice two voltages over time, the open circuit battery voltage, V_{OC} , and the charging voltage, V_{charge} which is set by JP2. Subtract V_{OC} from V_{charge} and divide the result by the internal resistance of the battery and you will get the charging current for the amount of time that the pulse-charger is on. The THINERGY MEC provided has an internal resistance of approximately 35Ω .

Alternatively, charge current to the THINERGY MEC can be measured directly with the THINERGY ADP (not provided) using the 8-pin header P1 and the included cable (see below).

Charge Current Measurement

The charging current will only be shown for a small amount of time. To measure the current of an external battery, set the Charging Board to charge the desired battery (JP2 to correct voltage, S1 to BATT, S2 to OFF). The preferred method of measurement is to use an oscilloscope with a current probe attached to battery terminal connection, XBATT or BT1. You can also place an ammeter in series with the connection to XBATT or BT1, but depending on charging time, this method may not give accurate results.

Wireless Sensor Demonstration

The Texas Instruments eZ430-RF2500 wireless development tool is included in the kit as a simple and easy to use application demonstration. Please see the documentation from Texas Instruments for software installation and operation. TI provides a free sensor demo PC application and the source code. Powercast does not provide support for the eZ430-RF2500 kit.

To use the eZ430-RF2500 with the charging board:

- Install the Sensor Monitor software that comes with the eZ430-RF2500 kit
- Plug the eZ430-RF into a USB port, let windows search for drivers
- Launch the Sensor Monitor software. The access point node is shown middle of the window.
- Plug the THINERGY MEC into the Charging Board
- BAT-EVAL-01: S1 to BATT, S2 to VREG, S3 to 2.7V; P2110CSR-EVB: S1 to 4.1V
- Plug the eZ430-RF2500T target board into P2 on the Charging Board. A new node appear in the Sensor Monitor window
- With the transmitter running, the THINERGY MEC will continue to pulse charge while the eZ430-RF2500 continues to operate.

WARNING: DO NOT ATTEMPT TO RECHARGE THE BATTERIES INCLUDED WITH THE EZ430-RF2500 KIT AS THEY ARE NOT RECHARGEABLE!

JP1 allows for two P2110CSR Powerharvester pin signals to be tied to the eZ430-RF2500 through P2. INT is an output that goes high when the capacitor (C3-C5 on the P2110 Evaluation Board) reaches a charge threshold and the DC regulated output (3.3V default) is available. RESET is an input that turns the DC regulator off. These pins allow you to monitor the capacitor charging and control the output voltage, respectively. Through JP1, INT can be tied either to pin 1 or pin 4 of P2, and RESET can be tied to pin 6. These signals require code changes to the eZ430-RF2500, and are not implemented for the purpose of this evaluation kit.

THINERGY MEC Low-Voltage Shut-off

The Charging Board provides low-voltage shut-off at 2.1V to protect the THINERGY MEC.

It is recommended to remove the THINERGY MEC Evaluation Card from the connector slot when not in use to avoid unnecessary energy leakage.

THINERGY Application Development Platform (ADP)

The Charging Board has a header, P1, for connecting to the THINERGY ADP and charging an MEC in the ADP. A cable is provided for easy connection. With the cable, connect pin 1 of P1 on the Charging Board with pin 1 on the THINERGY ADP header, J5. The ADP can be configured in either “Pass-Thru” or “Gated” mode for MEC charging. Gated mode is recommended to see the pulsed charging voltage and current.

The J5 header pins on the ADP pins are used as follows:

- | | |
|-----------|--|
| 1. VIN-H | not used |
| 2. VIN-L | charge from Powercast Charging Board |
| 3. I/O-1 | not used |
| 4. I/O-2 | not used |
| 5. ENABLE | tied to ground for enabling the ADP EH interface |
| 6. +5.0V | not used |
| 7. GATE | inverted and delayed INT signal from P2110 (for measurement timing by ADP) |
| 8. A-GND | ground |

Documentation and Software

Powercast

Powercast documentation, including datasheets and user manuals:

<http://www.powercastco.com/documentation/>

P2110-EVAL-02 Development Kit – overview

<http://www.powercastco.com/PDF/P2110-EVAL-02-overview.pdf>

P2110-EVAL-02 Development Kit – user’s manual

<http://www.powercastco.com/PDF/P2110-EVAL-02-manual.pdf>

P2110CSR Powerharvester Chipset reference Design – datasheet

<http://www.powercastco.com/PDF/P2110CSR-datasheet.pdf>

P2110CSR Evaluation Board – instructions

<http://www.powercastco.com/PDF/P2110CSR-EVB.pdf>

TX91501 Powercaster Transmitter – user’s manual

<http://www.powercastco.com/PDF/TX91501-manual.pdf>

The P2110-EVAL-02 is subject to Powercast’s Limited Warranty for Development Systems

Infinite Power Solutions

THINERGY Micro-Energy Cells

<http://www.infinitepowersolutions.com/product/thinergy>

THINERGY Application Development Platform

<http://www.infinitepowersolutions.com/product/thinergyadp>

Technical support for THINERGY products is provided by Infinite Power Solutions.

Texas Instruments

eZ430-RF2500 Wireless Development Tool

<http://focus.ti.com/docs/toolsw/folders/print/ez430-rf2500.html>

Technical support for the eZ430-RF2500 wireless development tool is provided by Texas Instruments.

APPENDIX A – Charging Board Component Description

BAT-EVAL-01 Charging Board

Component	Description
J1	Keyed connector on the bottom to attach to the P2110 Evaluation Board
CONN1	THINERGY MEC Evaluation Card connector – Large, black connector for the THINERGY MEC Evaluation Card. Insert the Card with metal leads facing downward.
JP1	P2110 I/O interface to P2 RESET P2110 input - turns off regulated output from P2110 INT P2110 output – high when Vout is active INT P2110 output – high when Vout is active
JP2	Regulated charging voltage selection – ONLY CONNECT ONE AT A TIME 4.1V THINERGY Micro-Energy Cell 4.2V Li-ION or Li-Polymer cells 4.95V 3 Alkaline cells in series 2.8V 2 Ni-MH cells in series 3.3V 2 Alkaline cells in series (default setting with no jumper connection)
P1	Connector for IPS Application Development Platform. Pin 1 is marked with “^”.
P2	Connector for output load (e.g. for included eZ430-RF2500 kit or any low-power device with compatible connector)
S1	Switch for charge selection BATT (Charge is directed to the MEC) OFF (no charging) EXT (Charge is directed to XBATT, BT1, or the ADP header P1)
S2	Switch for output load VREG (regulated output to S3) OFF (output power from IPS MEC or external battery is OFF) LED (power to LED for rapid drain of MEC, or other battery at BT1)
S3	Selection for regulator output voltage – 2.0 or 2.7V (2.7V is required for the included eZ430-RF2500 kit with the pre-loaded TI firmware)

Note:

It is recommended to remove the THINERGY MEC Evaluation Card from the connector slot when not in use to avoid unnecessary energy leakage.