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# P2110-EVAL-01

## Lifetime Power® Energy Harvesting Development Kit for Wireless Sensors User's Manual
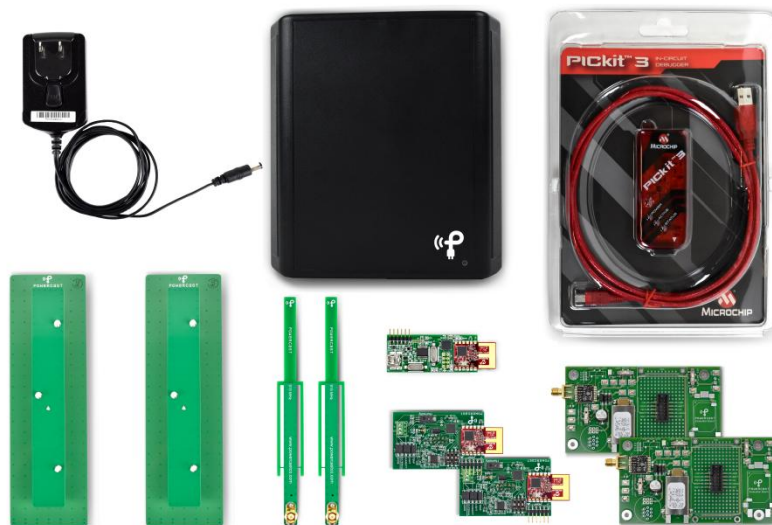## *- featuring PIC® MCU with eXtreme Low Power (XLP) Technology*

## Overview

The Lifetime Power® Energy Harvesting Development Kit for Wireless Sensors is a complete demonstration and development platform for creating battery-free wireless sensor applications powered by RF energy (radio waves). It is designed and configured for extremely low power operation, and the firmware is pre-installed for out-of-the-box operation.

The wireless sensor boards are powered by the P2110 Powerharvester Receiver, which converts RF energy into DC power. 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. The communications from the sensor boards to the access point is 2.4GHz using 802.15.4-compliant radios.

No batteries are needed to power the wireless sensor board. RF energy is converted into DC and stored in a capacitor. When sufficient charge is stored the regulated output of the P2110 provides power to the wireless sensor board until the operation is completed by the node or until the power is turned off at the low-voltage threshold on the capacitor. The included wireless sensors measure temperature, humidity and light, and have an interface for an external sensor.

## Contents

The contents of the kit are shown in the image and table below. The kit includes an RF transmitter, RF energy harvesting receiver boards and antennas, wireless sensor boards, a PIC® MCU-based development board and radio, and a programming tool.

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| Qty | Item | Description |
|-----|------|-------------|
| 1 | Power and Data Transmitter (TX91501-3W-ID) | FCC approved, 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 P2110 Powerharvester component and is decoded by the MCU on the Wireless Sensor Board |
| 2 | P2110 Evaluation Board (P2110-EVB) | Evaluation board (Rev. B) for P2110 Powerharvester Receiver.  This board has an SMA connector to connect the antennas and a 10-pin connector for the Wireless Sensor Board |
| 2 | Patch antenna | 915MHz directional antenna with 120-degree reception pattern (included with the P2110 evaluation board) |
| 2 | Dipole antenna | 915MHz omni-directional antenna with 360-degree reception (included with the P2110 evaluation board) |
| 2 | Wireless Sensor Board (WSN-EVAL-01) | Sensor for Temp/Humidity/Light and an external input.  Plugs into P2110 evaluation board, and sends data to the access point (Microchip 16-bit XLP Development Board) |
| 1 | Access Point (WSN-AP-01) | Custom receiver board featuring Microchip's PIC24F MCU that is pre-programmed to operate as an access point for receiving data from the Wireless Sensor Boards. |
| 1 | PICkit™ 3 programmer / debugger (PG164130) | Programming tool for updating code on the Wireless Sensor Boards and the 16-bit XLP Development Board.  USB cable included in package. |

## Set-up and Operation

### Installation Overview

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

1. Install HyperTerminal or equivalent terminal emulator program.
2. Connect Access Point board to a PC.
3. Configure terminal emulator program.
4. Connect antennas and sensor boards to P2110 evaluation board.
5. Turn on the transmitter and point toward receivers.

## Step-by-Step Installation

**1. Install a terminal emulator program on your PC.**
As of Windows 7, no terminal emulator program is included in Windows. Windows 7 and beyond users can download HyperTerminal from the following link: HyperTerminal.zip

The download file is also found on the following page:
http://www.powercastco.com/documentation/

There are only two files in this ZIP package:
hypertrm.dll
hypertrm.exe

Unzip the files to a location of your choice and click on **hypertrm.exe** when you are ready to operate the program (not yet).  Be sure to keep these files in the same directory.

**2. Connect the Access Point board (WSN-AP-01) to a PC using a USB cable**
For Windows 7, 8 and 10 users, installation of the USB device driver will happen automatically. For Windows XP users, a driver can be obtained at the documentation page linked above, or direct here.

**3. Configure terminal emulator program to see data on the PC**
The data can be displayed through a PC using any terminal emulator program.  This manual will show how to configure HyperTerminal, but the following settings are needed with any terminal emulator that is used:

| | |
|---|---|
| Baud rate: | 19200 bps |
| Data bits: | 8 bits |
| Parity: | None |
| Stop bits: | 1 bit |
| Emulation: | ANSI or Auto Detect |

3.1 First, you will be shown the following dialog box in which to enter a name for the connection.  You can choose any name, "Powercast" is used in this manual.  Enter "Powercast" into the dialog box and select "OK" to continue.



3.2 The following dialog box will appear.  Select the COM port which is being used for the access point and click "OK".  COM16 is used in this example.
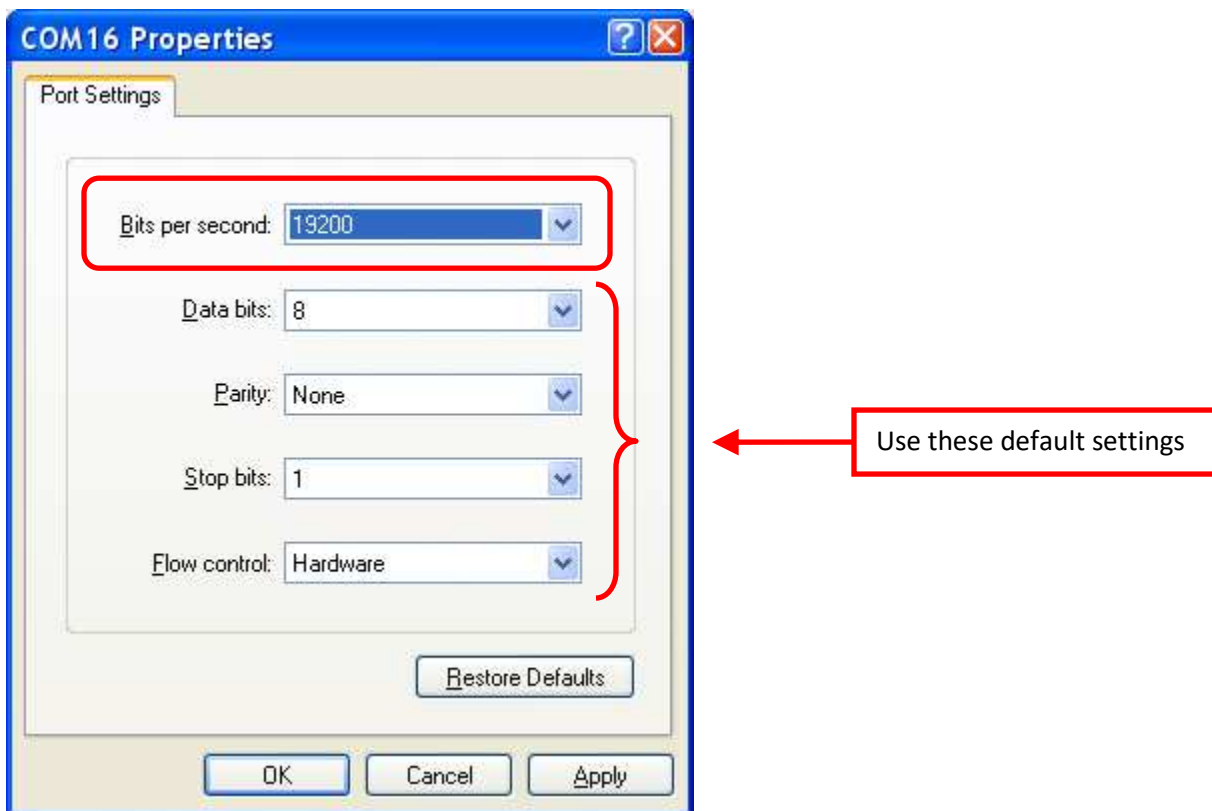
Note:
If more than one COM port is shown you may need to use System Properties through Windows Control Panel to determine which is the correct COM port.

3.3 Set the baud rate (Bits per second) to 19200 (19.2kbps) and click "OK".



Use these default settings

3.4 A blank screen will appear. Packets are displayed automatically when the TX91501 transmitter or other RF energy source is providing power to a P2110 evaluation board with the sensor board attached.

3.5 Press switch PB1 on the Access Point Board to reset the system software and validate proper installation.  If everything has been installed properly you will see the following message displayed on the screen:
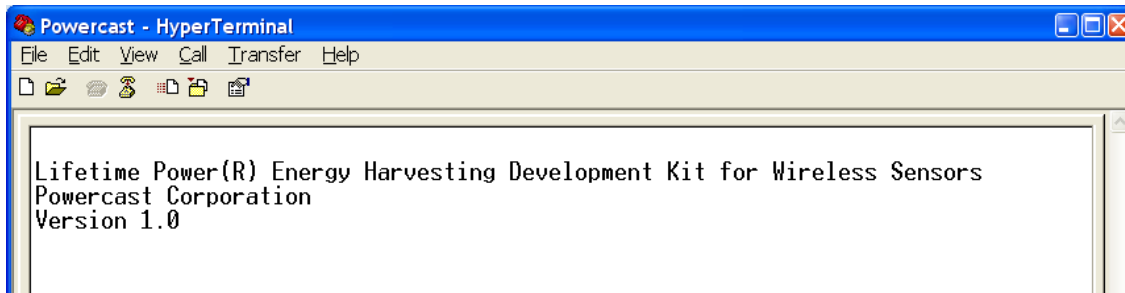


Switch PB1
Resets the system software and all data buffers, including time counter and dT counter.  Pressing  PB1  is not required to start receiving packets and displaying sensor data.

## 4. Configure the P2110 evaluation board

4.1 Attach an antenna to each P2110 evaluation board using SMA connector J1.  The line-of-sight range when using the included patch antennas is around 40 feet and around 20 for the dipole antenna.
Note:  Operating the evaluation board on a ground plane such as an anti-static protection mat on a lab bench may cause significant signal attenuation.

Note:  Optional testing of P2110 Evaluation Board only (also requires Step 6).
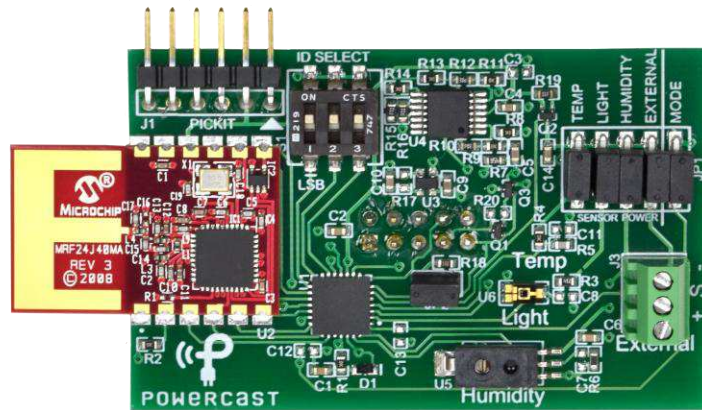To test the proper function of the P2110 Evaluation Board use the following settings or see the instructions for the P2110-EVB at http://www.powercastco.com/documentation/
      J1:      Antenna connected
      JP1:    C3 connected
      S2:     LED
      The LED will blink when sufficient power is available.  The blinking rate is faster when
      closer to the transmitter and slower when further from the transmitter.

4.2 Verify the configuration of the P2110 evaluation boards as follows:
      JP1:    C5 connected   (can also use C4 with a properly sized user-installed capacitor)
      S2:     doesn't matter
      S3 :    doesn't matter
      S4 :    doesn't matter

4.3 Attach the wireless sensor boards to the P2110 evaluation boards using the keyed connector and set the sensor board node IDs (values of 0-7) as desired using the 3 position DIP switch (S1).  Set the jumpers on JP1 as appropriate for TEMP, LIGHT, HUMIDITY, EXTERNAL, and MODE.  They should all be connected for the default mode of operation.

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**WSN-EVAL-01 wireless sensor board**

<u>Note:</u>  JP2 can be used to measure current being used by the sensor board.  It should be connected for normal operation.  This is explained in greater detail on page 14.

**5. Plug in the Transmitter**
Plug in the TX91501 Powercaster Transmitter and point it toward the P2110 evaluation boards with the wireless sensor nodes.  The line-of-sight range when using the included patch antennas is around 40-45 feet, and less for the dipole antenna.

Note –  As a precaution, do not operate the transmitter within 12 inches of the evaluation board when the patch antennas are attached.  Please see the transmitter user's manual for operating details.

**6. Verify Packet Reception**
The sensor modules will transmit data when Vout of the P2110 is activated.  Confirm packet reception on the Access Point by watching the LED D3.  This LED will flash every time a packet is received.  The received data will also display on the PC as shown below.
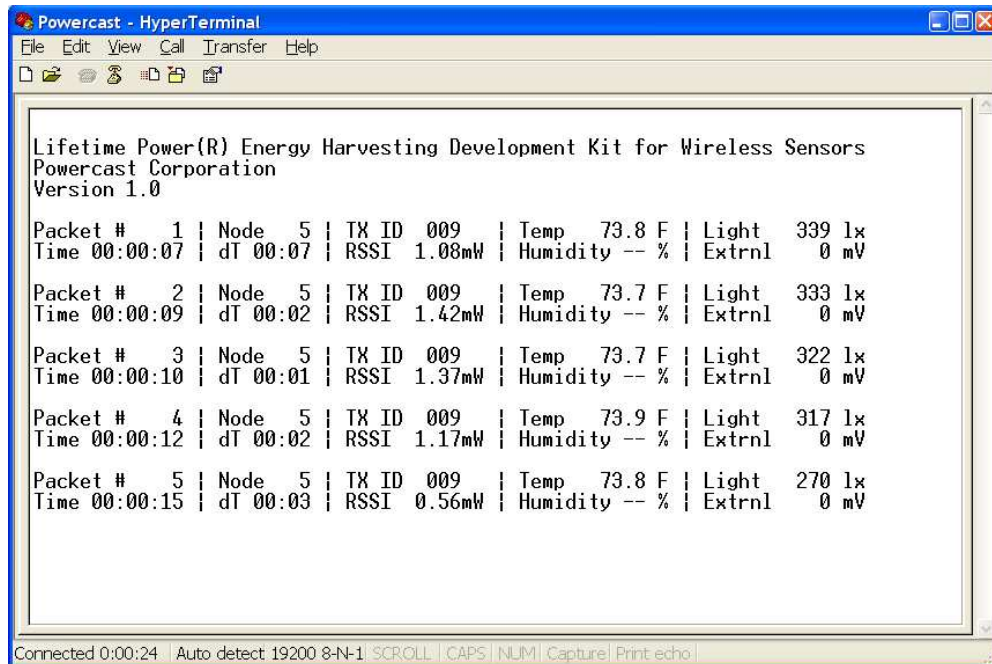
## Data Output Ranges

The following table explains each item displayed on the screen and the valid range of data.

| Parameter | Description | Range |
|---|---|---|
| Packet# | Packet counter (reset when S1 is pressed) | 1 to 99999 – number is incremented with each packet received |
| Time | Relative time counter (reset when S1 is pressed) | 00:00:00 (HH:MM:SS) up to 99:59:59 |
| dT | Time differential between received packets. A separate counter is used for each node | 00:00 (MM:SS) up to 99:59 |
| TX ID | The ID number broadcasted by the TX91501 transmitter (factory programmed). | 1 – 254<br>"---" otherwise (error) |
| Node | Wireless Sensor Board identifier* | 0 – 7 (configured by DIP switches) |
| RSSI | Received Signal Strength Indicator – the received signal strength from an RF power source | 0.04 – 50 mW<br>"---" otherwise |
| Temp | Temperature (Fahrenheit ) | 25 - 125°F<br>"---" otherwise |
| Humidity | Relative Humidity | 15 – 85 % rh<br>"---" otherwise |
| Light | Ambient luminance (Lux) | 10 – 99999 lux<br>"---" otherwise |
| Extrnl | External sensor reading | 0 – 3000mV |

* If both wireless sensor boards are set to the same ID then the Time and dT values will be based on packets received from either node. It is recommended that each wireless sensor board is assigned a unique ID.

### Wireless Sensor Board Voltage
The wireless sensor boards are regulated to operate at 3V. This voltage can't be adjusted.

### Transmitter Identification (TXID)
The TX91501 sends a unique identifier code along with the power that it outputs. This code can be used for wireless sensor location tracking if devices are mobile. The wireless sensor board contains a circuit for decoding this ID. If the wireless sensor board for some reason can't read the ID, or there is no ID, it sends an error code, and "---" is displayed on the terminal.

### Receiver Signal Strength Indicator (RSSI)
RSSI shows the actual power level that is being received at the antenna. This number is accurate from 0.04mW to 50mW. If the value is outside of the range, "---" is displayed, denoting an RSSI read error. Movement and reflections from various objects will affect the RSSI reading.

### Temperature Sensor
A Murata NCP18XH103F03RB thermistor is used to measure temperature in the range of 25°F to 125°F. A reading outside this range will constitute and error and "---" is displayed. Also, if power is removed from this sensor by removing the TEMP jumper on JP1, "---" is displayed.

### Humidity Sensor
A Honeywell HIH-5030 humidity sensor is used to measure humidity in the range of 15% to 85%, with 3% accuracy. A reading outside this range will constitute and error and "---" is displayed. Also, if power is removed from this sensor by removing the HUMIDITY jumper on JP1, "---" is displayed.

### Light Sensor
A Vishay TEMT6000X01 ambient light sensor is used to measure luminance in the range of 10 lux to 99999 lux. A reading outside this range will constitute and error and "---" is displayed. Also, if power is removed from this sensor by removing the LIGHT jumper on JP1, "---" is displayed.

### External Sensor Port
The wireless sensor board has a terminal block (J3) for using external sensors. This port can supply power to an external sensor, but the more power that the sensor uses, the longer the time period between packets transmitted.
1. Connect the sensor wires to J3 as follows: (+) power, (S) sensor output, (-) ground.
2. Enable reading of the sensor port by connecting the EXTERNAL jumper pins on JP1.
WARNING: this port can only supply 3V to external sensors; do not apply more than 3V to EXTERNAL port, as this will cause damage to the Wireless Sensor Board.

### Current Measuring
JP2 is provided to allow for current usage measurements of the Wireless Sensor Board. The running time of the board is too short (approx. 10ms) to allow for average current monitoring using a digital multi-meter. An oscilloscope is required to witness the current usage. To measure current using a current probe, remove JP2 and connect a test lead with hooks on either side from one pin to the other. Attach the current probe to the test lead. If a current probe is not available, R18 is provided as a current sensing resistor. R18 is a 10Ω resistor in parallel with JP2. With JP2 disconnected, the voltage across R18 can be witnessed on the oscilloscope by connecting a voltage probe across JP2. The current can then be calculated.

## Software

### Firmware source code
The source code for the Wireless Sensor Board and Access Point (Microchip XLP 16-bit Development Board) is available for download from the Powercast website
http://www.powercastco.com/documentation/

Software for Microchip's MiWi™ protocol is included as part of Powercast's code and is subject to accepting Microchip's MiWi™ Software License Agreement before download.

All software pre-loaded in the kit components or available for download is subject to Powercast's Limited Warranty for Development Systems.

### Modifying the firmware on the Wireless Sensor Boards or Access Point
The software on the Wireless Sensor Boards and the Access Point can be modified using Microchip's free MPLAB® Integrated Development Environment (IDE). Programming is done using the C programming language.

### Download MPLAB IDE from Microchip Technology Inc.
Use the link below and follow Microchip's instructions for installation and operation.
http://www.microchip.com/mplab

### PICkit 3 Programmer/Debugger
The PICkit 3 programming tool is included to re-program the wireless sensors boards and the access point.


## Documentation


### Microchip Technology

nanoWatt XLP Technology – eXtreme Low Power PIC® Microcontrollers
http://www.microchip.com/XLP

MPLAB IDE
http://www.microchip.com/mplab