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TI Designs
Segment LCD Based Low End In-Home Display With Wireless RF Design Guide

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Design Resources

TIDM-LOWEND_IHD	Design Folder
CC2530EMK	Product Folder
MSP430FG461x	Product Folder

TI E2E™ Community

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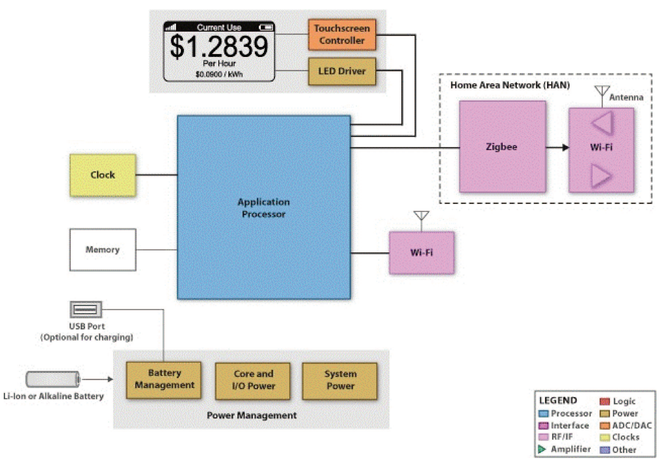
Design Features

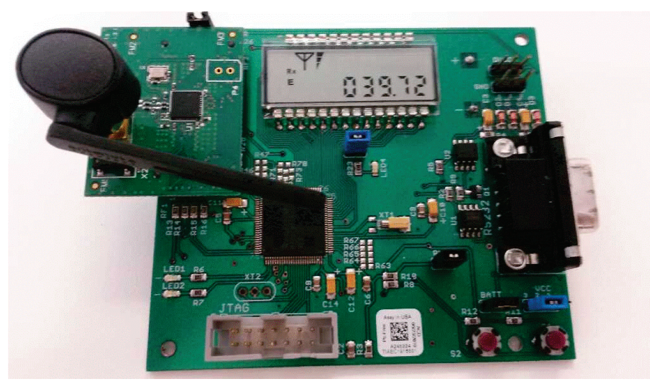
- Long Battery Life with Very Low Power MSP430
- Easy Interface with Communication Modules (UART or SPI)
- Segment LCD
- Support for low-power RF (Sub-1GHz and 2.4 GHz ZigBee) implementations
- Debug Interfaces (JTAG and Serial)

Featured Applications

- Home Automation
- ZigBee Networks
- Development Platform
- Automatic Meter Reading (AMI)

Block Diagram





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1 Overview

With the on-going deployment of smart electrical meters (Automatic Meter Infrastructure) a two way communication back and forth from the utility to the consumer will be established. New sources of information will be available to the consumers, either directly through the smart electrical meter or through some form of energy gateway. This information can be utilized and brought to the consumer in an informative way: an In Home Display (IHD).

An In Home Display allows utility customers to track their energy usage in chart or graph form based upon kilowatt hour used. It provides most types of energy awareness information that a customer may require: total energy consumption, real-time pricing, comparative analysis with typical energy usage and more.

An IHD is essentially a display, portable or in a wall (for new homes), that can communicate with utility meters (electric, gas, water) and others communication enabled in-home appliances (using ZigBee, Wireless MBus for instance). When ZigBee enabled, it can be set up to act as a coordinator or router. Thanks to these communication features, it can receive custom real-time messages from the utility companies regarding billing, energy prices and more.

The low end in-home display utilizes the MSP430 as the main processor. It allows the perfect combination of flash, processing power, and low power capability to create a device with long battery life.

1.1 Related Designs

This low end in-home display can be paired with TI's Smart Meter Board (SMB) System solution. The Smart Meter Board (SMB) from Texas Instruments is a comprehensive modular and scalable tool to demonstrate the capabilities of a Smart Meter along with the smart grid's most prolific communications protocols. The SMB is a unique modular and scalable environment that lets developers include multiple wired and wireless communication protocols including power line communication (PLC), near field communication (NFC), Wi-Fi, sub-1GHz and 2.4GHz ZigBee ® Smart Energy Profile (SEP) on e-metering applications. The SMB performs energy or electricity metering and has the capability of transferring key meter data via wired and wireless sensors to showcase Automatic Meter Reading (AMR) and Automatic Metering Infrastructure (AMI) systems. The SMB is pictured below.

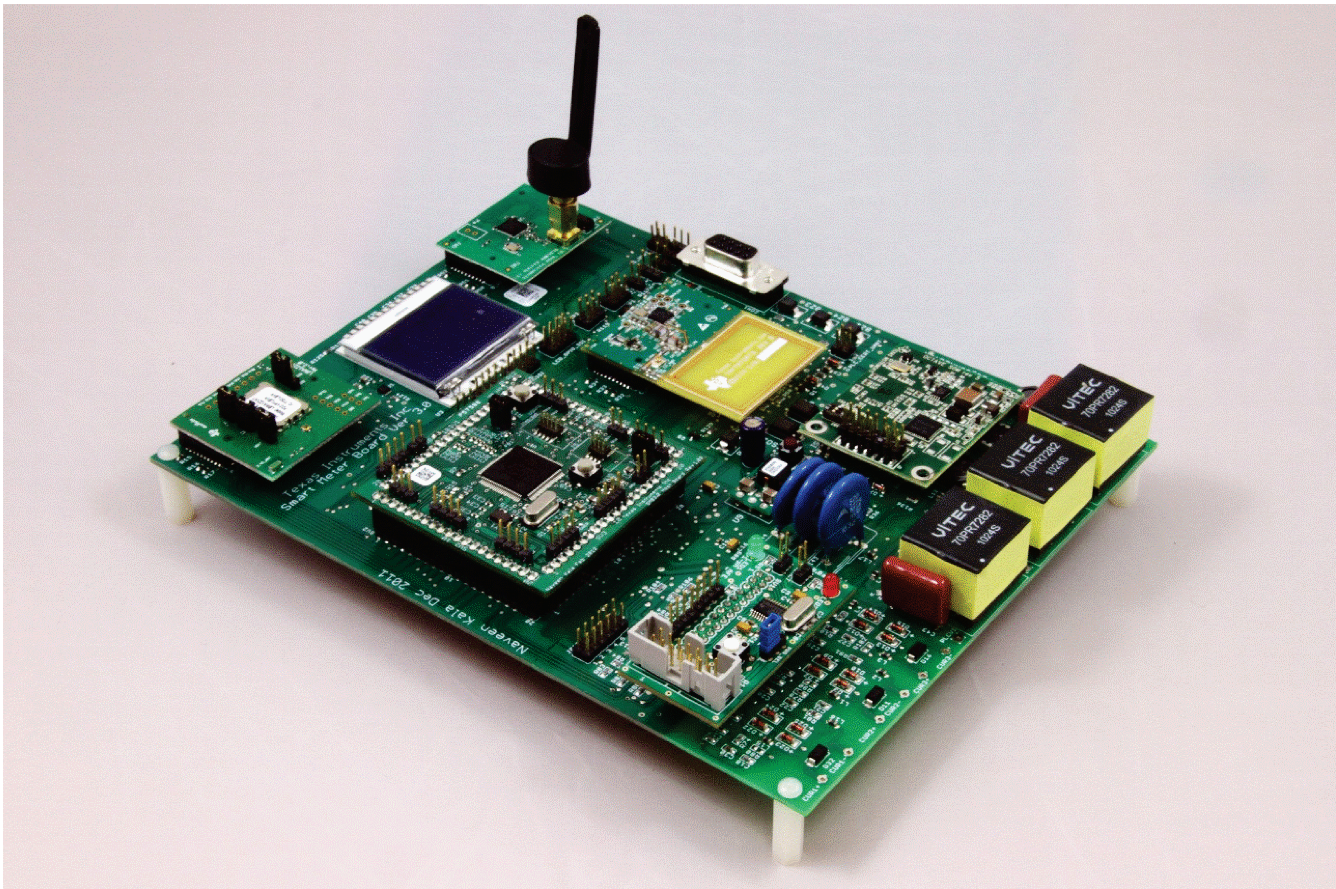

Figure 1. Smart Meter Board (SMB)

The metering data is sent from the SMB to the in-home display via a zigbee connection that is established between the ZigBee module on each of the devices. Please refer to the Smart Meter Board user guide for more information regarding pairing and ZigBee communication.

1.2 Capabilities

The MSP430F461x based In Home Display reference design (referred as IHD430 moving forward) design proposal is a low-cost display unit that is primarily used to display readings from the Smart Meter Board (SMB) 3.0. It also has the capability to communicate with a similar IHD430 or any communication interoperable end-point. The IHD430 comes with one IHD with connected CC2530 module, an antenna for the CC2530, and two AAA 1.5-V batteries.

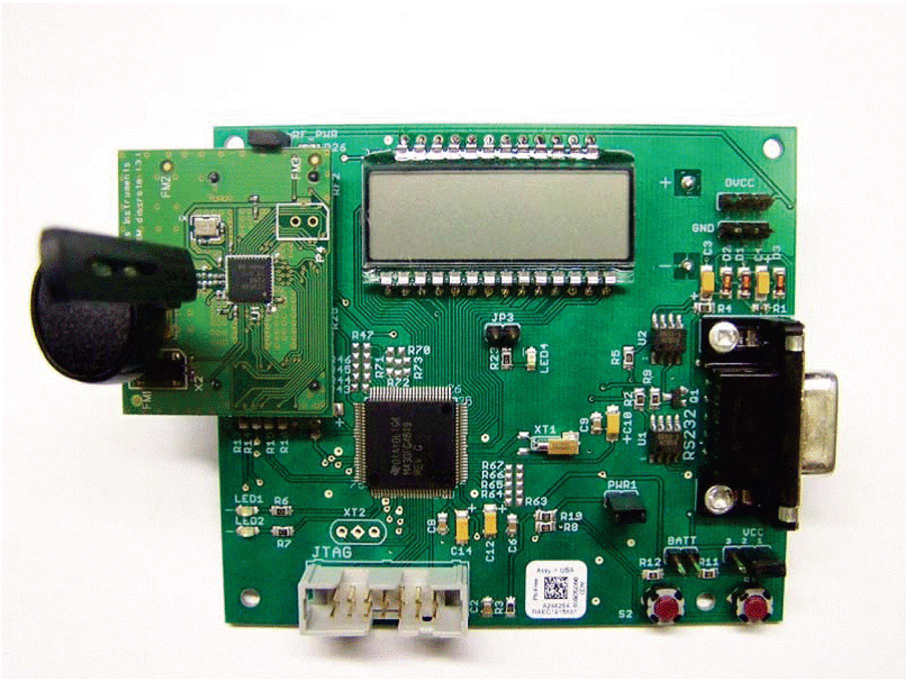

Figure 2. MSP430F461x IHD Board

1.3 Devices Supported

The IHD430 is based on the Texas Instruments ultra-low power MSP430 family of microcontrollers and Texas Instruments Chipcon wireless evaluation modules (EVM). The board contains a MSP430F461x microcontroller. It has support to connect any low-power wireless transceivers for ZigBee or sub-1-GHz communication from Texas Instruments.

1.4 Tools Requirement

The IHD430 shipped is pre-installed with code that configures the IHD430 to act as a receiver and display received values on the LCD. If it is desired to modify the pre-installed code, a MSP430 Flash emulation tool (MSP-FET430UIF) is required to download and debug code on the MSP430 and a SmartRF05 EB board is required to reprogram the on-board CC2530. The on-board MSP430 uses the standard 4-wire JTAG connection for JTAG communication.

1.5 Functional Overview

The IHD430 contains components that enable a wide range of applications. Figure 3 shows the components of the IHD430.

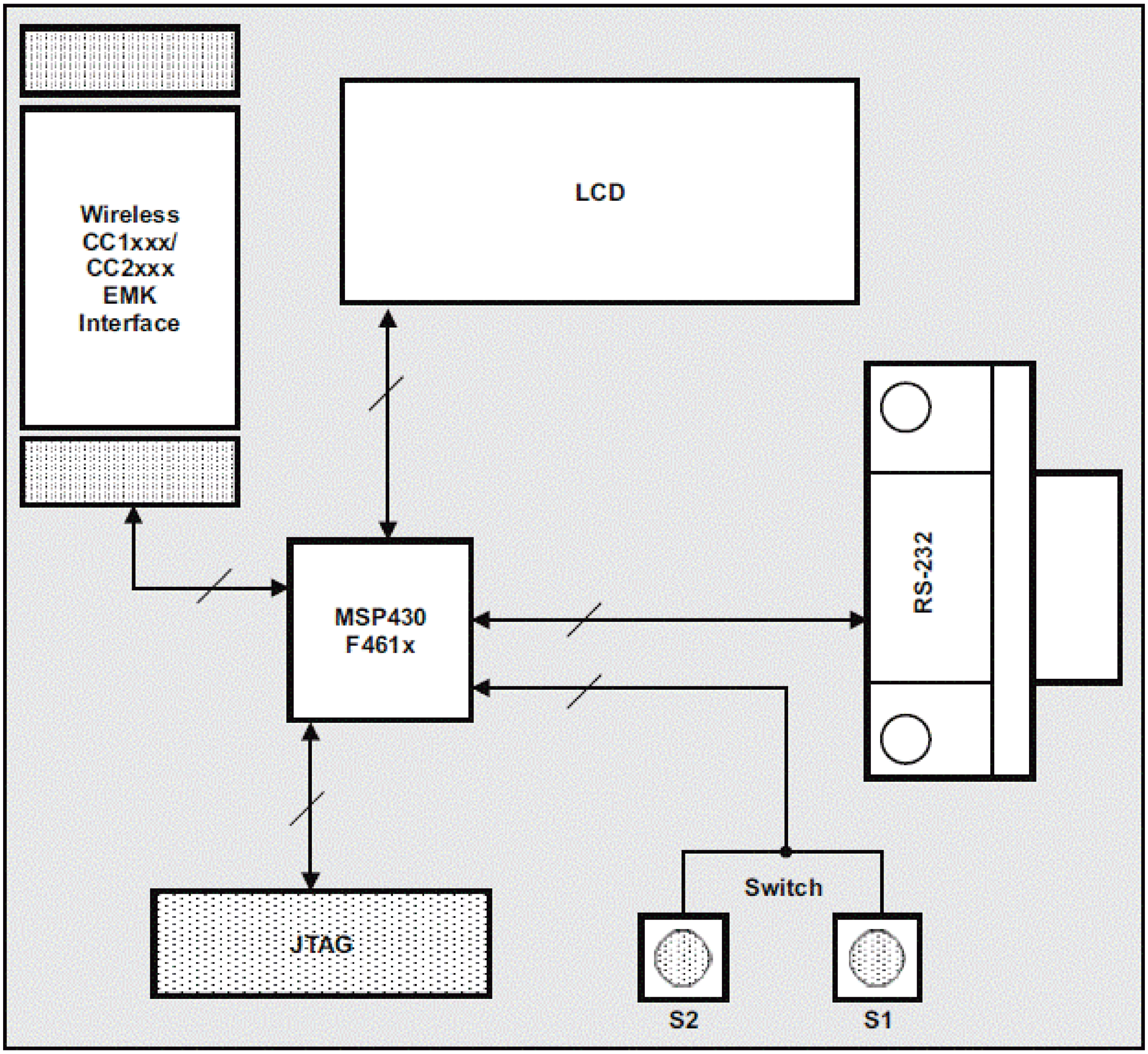

Figure 3. IHD430 Board Block Diagram

The IHD430 has a CC2530 that enables wireless ZigBee communication. The CC2530 is connected via an RF connector and, therefore, can be easily replaced with another pin-to-pin compatible EM module. In addition, it contains a JTAG connector that can used to program the MSP430 and power the entire board via FET debugger. Other components include two push-button switches and an RS-232 DB-9 header for PC communication via UART. Data is available on the on-board 4-mux LCD or via the RS-232 link.

2 Features

- Long Battery Life
- Easy Interface with Communication Modules (UART or SPI)
- Segment LCD
- Support for Low-Power RF (Sub-1GHz and 2.4GHz ZigBee) implementations connects a meter to a home area network (HAN) for short-range communication.
- Easy software integration with support for TI Smart Grid software libraries, including ZigBee SEP 1.x and 2.0, WMBUS
- Debug Interfaces (JTAG and Serial)

3 Set-Up Instructions

This section explains the various settings for running the low end in-home display reference design for different use cases.

3.1 Battery and Jumper Settings

Power may be provided locally from two on-board AAA batteries, externally from a Flash emulation tool (FET), or from an external supply. The power source is selected by configuring jumpers on VCC and BATT headers. By placing a jumper on the PWR1 header, power is supplied to the on-board MSP430. Figure 4 shows the jumper hierarchy and configuration options.

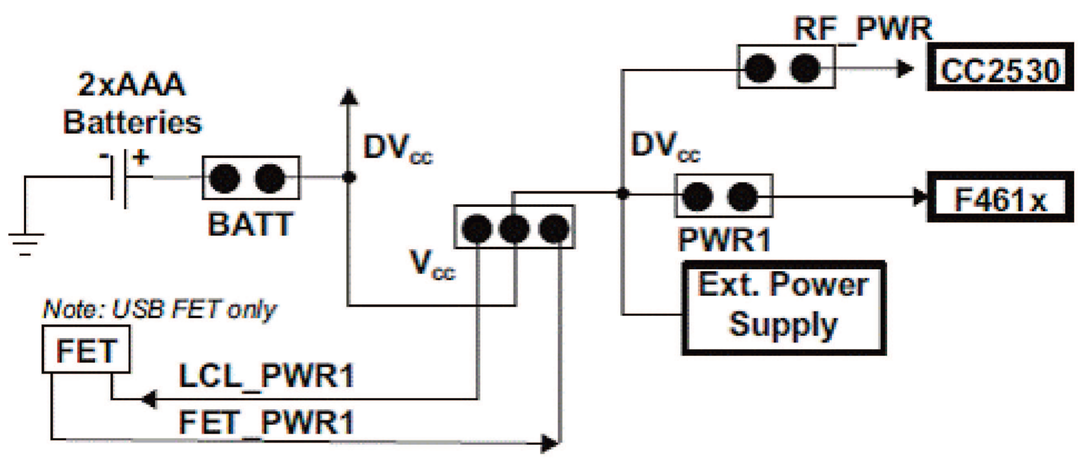

Figure 4. Power Selection Jumpers

The battery header BATT is used to select the on-board batteries to power the system independently from the FET. By placing a jumper on the BATT header, the entire board is powered (DVCC).

The power selection header VCC is a 3-pin header that is used to select the power connection between the board and the USB-FET interface only. A jumper on this header is needed only when JTAG communication is required. A jumper placed on the pins [1-2] selects the JTAG FET as the power source. A jumper placed on the pins [2-3] selects external or local power, either from the batteries or an external supply, to be applied to the FET for proper logic threshold level matching during program/debug.

Header PWR1 has been provided to enable/disable power to the on-board MSP430. A jumper placed on PWR1 provides power to the MSP430 device. MSP430 device current consumption can be measured via this header.

Header RF_PWR has been provided to enable/disable power to the CC2530. It should be noted that the power to the CC2530 is independent from the PWR1 jumper. Removing power from the on-board MSP430 via the PWR1 jumper does not remove power from the CC2530 and vice versa. A jumper on this header should be removed when CC2530 is not in use to save power.

Once the required power selections have been made via jumpers, the IHD430 is ready to be used.

After powering a SMB or powering another IHD430 configured as a transmitter, the IHD430 receiver should briefly display Ihd430 until data is received from the SMB transmitter or IHD transmitter. Once it receives this data, the IHD430 displays it on its LCD. Press S2 to enable or disable data transmission through the RS-232 UART. Press S1 to make the IHD430 enter a low-power sleep mode. Power consumption can be further reduced by removing the RF_PWR jumper.

3.2 Running MSP430IHD with Smart Meter Board Demo

Please refer to the Smart Meter Board 3.0 User Manual for more information on setting up communication between the two.

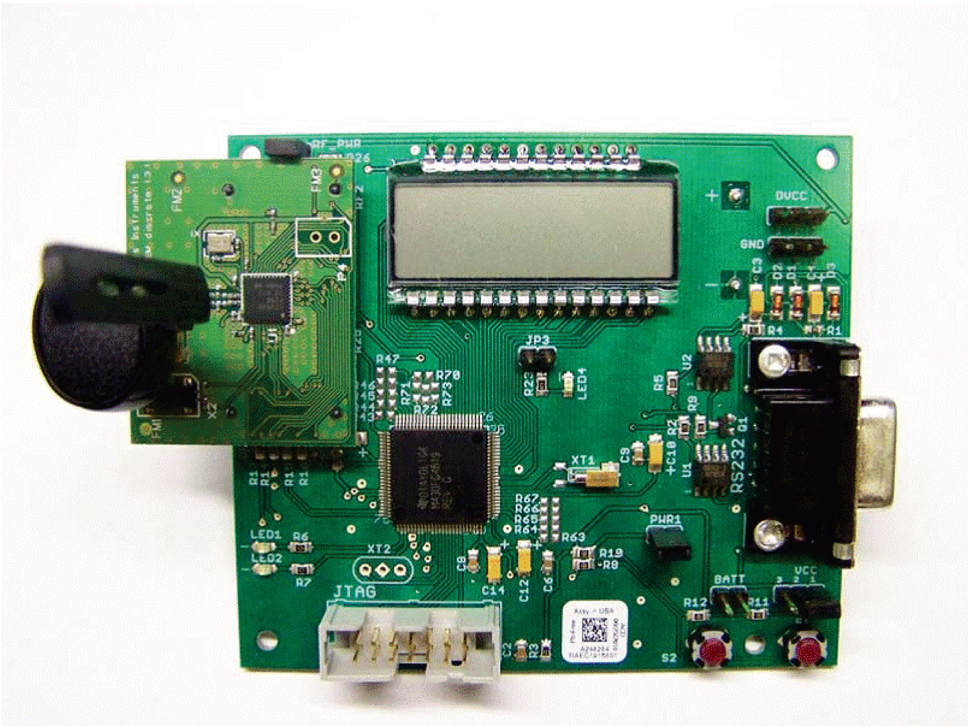

Figure 5. In-Home Display (IHD)

4 Daughter Card Description

The CC2530 Evaluation Module (EM) is an add-on/plug in daughter card. The CC2530EM is usable with a motherboard, typically SmartRF05EB. The CC2530 EM is a ZigBee/IEEE 802.5.4 RF Transceiver designed for RF Application in the 2.4GHz unlicensed ISM band and contains the RF IC and necessary external components and matching filters for getting the most out of the radio. The communication interface to the application processor is via UART. The module is used to perform the Smart energy/Automatic Meter Reading (AMR) portion of SMB. The instantaneous power consumption is sent periodically to the ZigBee module for wireless transmission. The EM can be used as reference design for antenna and RF layout.

SmartRF Studio is a PC application developed for configuration and evaluation of many of the RF-IC products from Texas Instruments, including the CC2530. The application is designed for use with an applicable SmartRF evaluation board, such as the SmartRF05EB, and runs on Microsoft Windows.

The latest version of SmartRF Studio can be downloaded from the Texas Instruments website (www.ti.com/smartrfstudio), where you will also find a complete user manual.

Software is available on TI Designs for the MSP430 IHD and the CC2530 RF modules on the SMB and IHD.

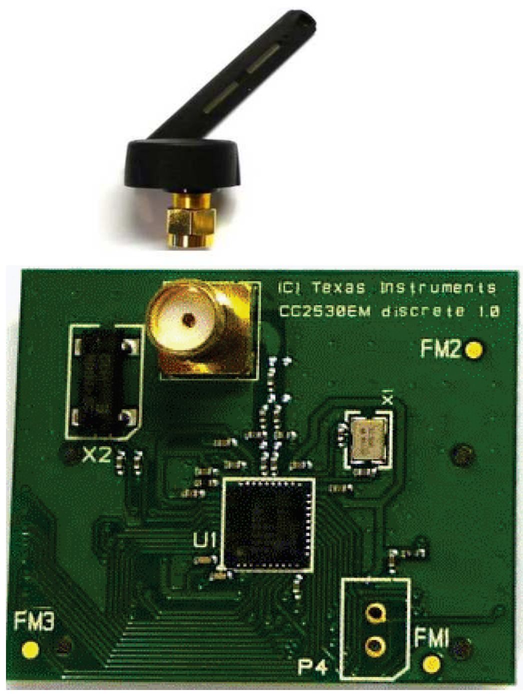

Figure 6. ZigBee Radio

5 Test Results

5.1 Test Set-Up

The test consists of powering up the SMB with the wifi, ZigBee, and the metrology module plugged into the motherboard. Once the SMB is connected to the wi-fi access point, the host processor starts calculating power usage of the electrical load connected to the exterior power outlet on the side of the system. To test accuracy and the communication modules we use a predefined load, in this case it is a 40 watt bulb in a desk lamp.

5.2 Results Summary

Once the smart meter board starts up and connects to the wi-fi access point, the metrology engine can calculate power usage. The consumption wattage can then be displayed on the LCD screen as shown below.

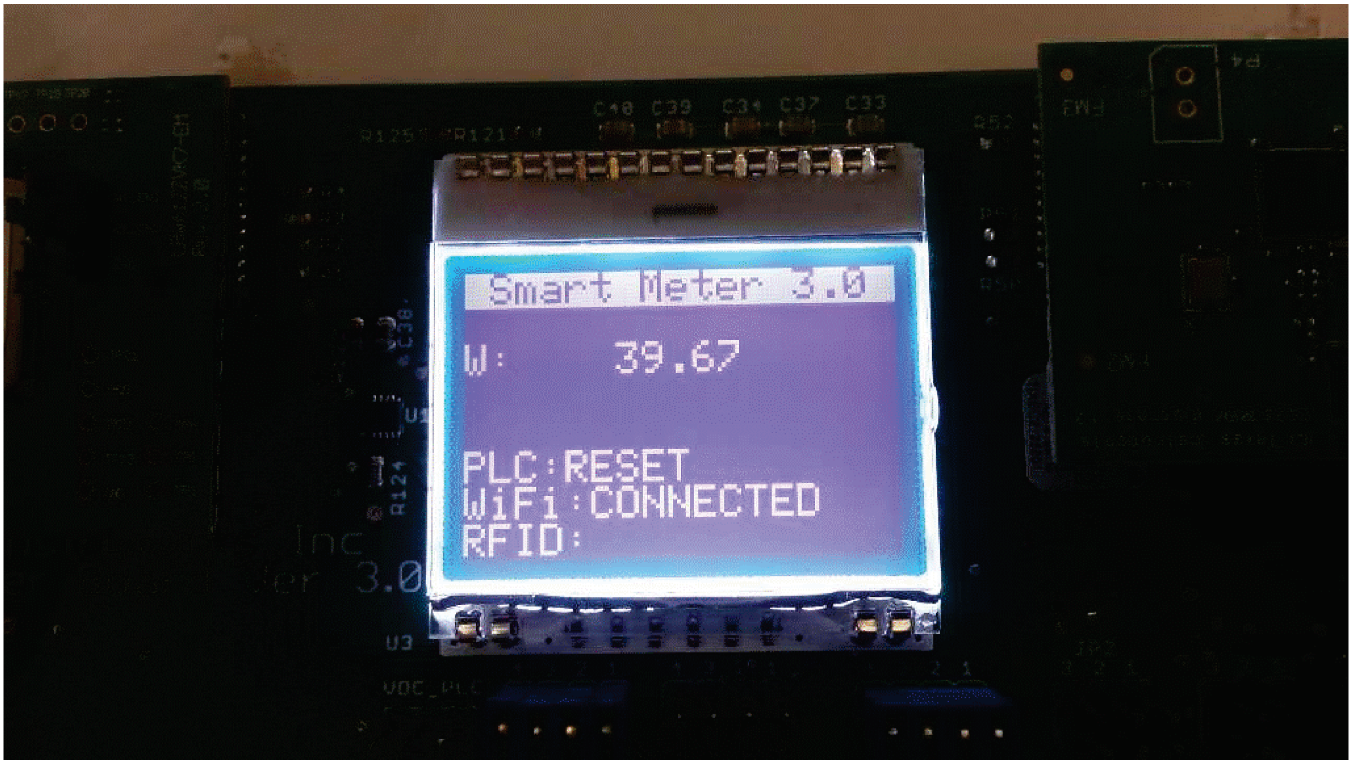

Figure 7. LCD Screen

The data is also transmitted out via the wireless and ZigBee modules. The host processor of the smart meter board handles the messages to each module. Theoretically, when the LCD screen is correctly displaying data, then the other modules will also transmit the correct data. The test results for the ZigBee module are next.

Before the in-home display starts receiving data from the SMB, the LCD screen will read “lhd430”. Once the IHD is receiving data the screen will show an antenna symbol with signal strength. The center of the display will present the current metering data.

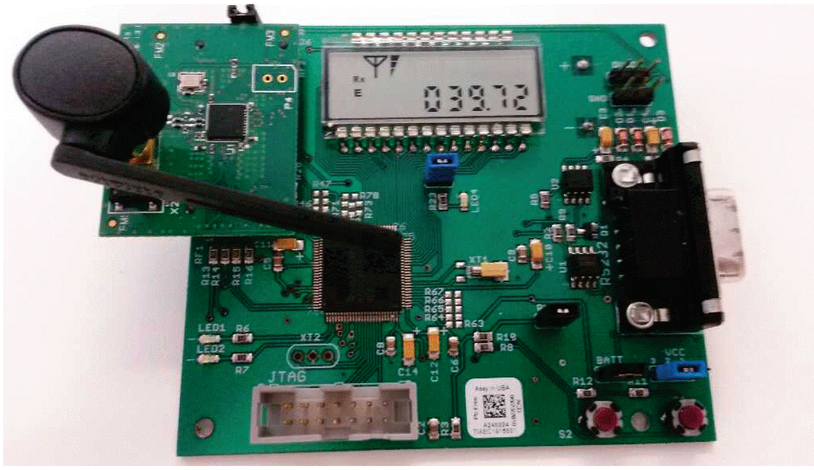

Figure 8. IHD Metering Data

The test is successful. Both the SMB and the in-home display present the same data. The IHD lags one second behind the Smart meter board’s LCD because the IHD screen updates every second. In conclusion, the SMB 3.0 and the in-home display both show about 40 watts when a 40 watt load is connected to the power outlets of the SMB 3.0.

6 References

- CC1120 (169MHz) http://www.ti.com/tool/cc1120emk-169
- CC1120 (420-470MHz) http://www.ti.com/tool/cc1120emk-420-470
- CC2530 http://www.ti.com/tool/cc2530emk
- Smart Electrical Meter Development Platform (SMB 3.0) Design Guide (literature number: TIDU213)
- http://www.ti.com/smartgrid