iCE40 Ultra™ Pedometer

User's Guide

November 2014
UG76_1.1

Introduction

This guide describes how to use the iCE40 Ultra™ Mobile Development Platform for demonstrating the Pedometer application. This guide familiarizes you with the process of setting up your environment for Pedometer design. It guides you through the hardware and software required to successfully run your Pedometer demonstration.

The document discusses complete demonstration steps and the associated designs.

After you complete the procedures in this guide, you will be able to:

- Set up the iCE40 Ultra Mobile Development Platform properly and become familiar with its main features.
- Work and become familiar with the software required for Pedometer demonstrations.
- Utilize the additional hardware required to run the demonstrations.
- Understand the design details of the Pedometer demo implemented on iCE40 Ultra.
- Run the demo along with an Android phone.
- Use other Lattice documentation in conjunction with this guide.

This document assumes that you have already installed the Lattice iCEcube2 and the Lattice Diamond® Programmer software and are familiar with basic tasks. If you need more information on these software, please refer to the iCEcube2 and Diamond Programmer help.

For details on specific board features and other information, refer to:

- EB90, iCE40 Ultra Mobile Development Platform User's Guide
- DS1048, iCE40 Ultra Family Data Sheet

This document is divided into two sections. The first section describes the Pedometer demonstration in detail and the second section describes the Pedometer design. The Pedometer demonstration is performed using the Bluetooth (BLE) interface with the Processor.

Pedometer Demonstration

This section describes the Pedometer demonstration in detail.

Pedometer Demonstration Setup

The Pedometer demonstration setup consists of the following components.

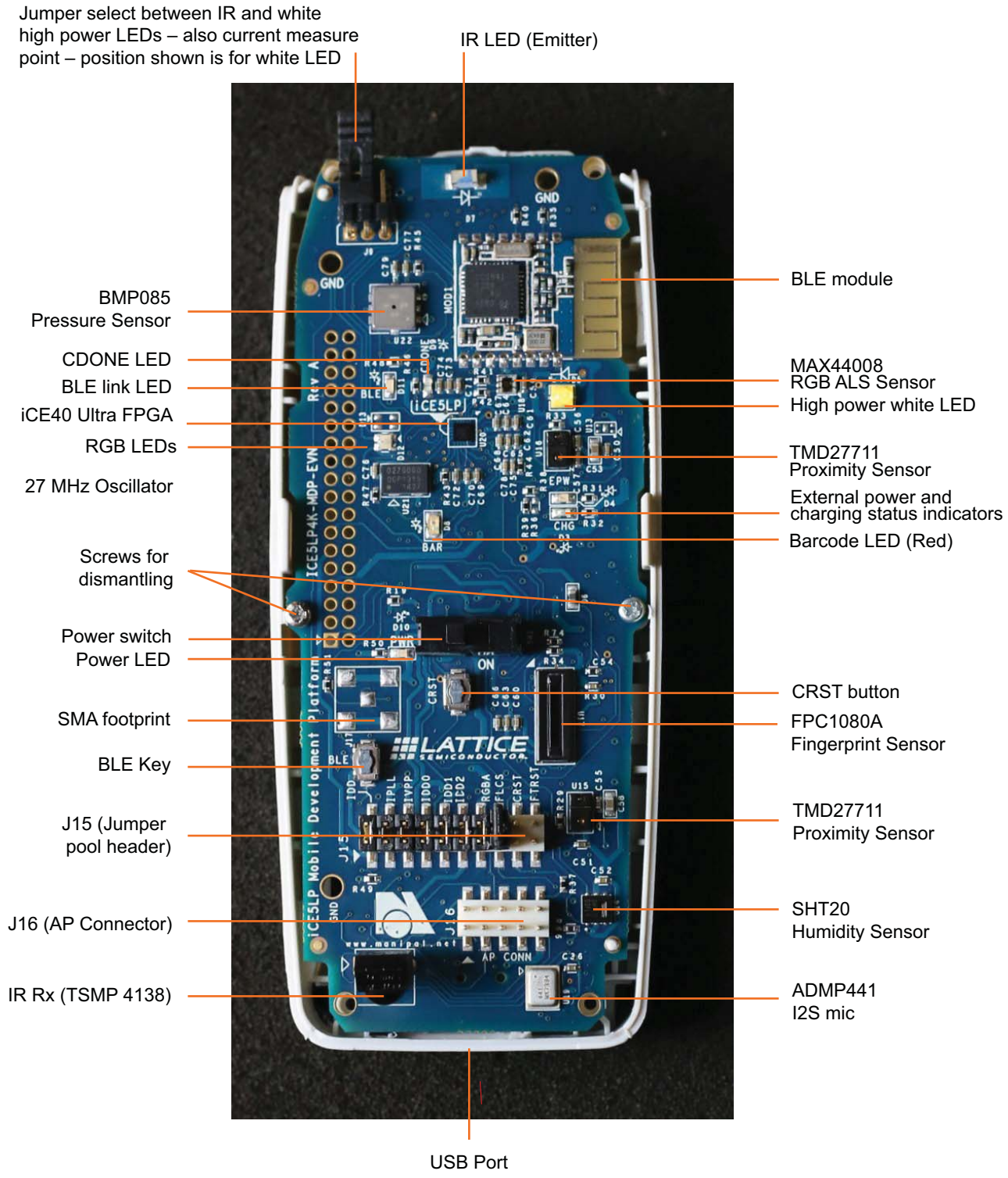
- Android phone with Kitkat (Beta) 2.0 or higher version
- iCE40 Ultra Mobile Development Platform

Figure 1. Android Phone and iCE40 Ultra Mobile Development Platform

iCE40 Ultra Mobile Development Platform Default Jumper Settings

The details of the iCE40 Ultra Mobile Development Platform default jumper settings are shown in Figure 2

Figure 2. Default Jumper Settings



Note: In the J15 jumper, set the FLCS pins.

Programming the iCE40 Ultra Mobile Development Platform

To program the iCE40 Mobile Development Platform:

1. Connect Aardvark to the J16 header of the iCE40 Ultra Mobile Development Platform as shown in Figure 3.

Figure 3. Cable Connection to iCE40 Ultra Mobile Development Platform

2. Hold the CRST switch and turn to ON the iCE40 Ultra Mobile Development Platform using switch SW2.
3. Download the .bin file provided.

   For details on programming the SPI Flash using USB, refer to EB90, iCE40 Ultra Mobile Development Platform.

Installing BLE Pedometer.apk to the Android Phone

To install BLE Pedometer.apk to the Android phone:

1. In the Android phone, select **Settings > Security > Unknown sources**.
2. Go to *Pedometer_Demo/demonstration/binaries/ BLE Pedometer.apk* folder and install the application using the command below.

   ```
   # adb install BLE Pedometer.apk
   ```

3. Deselect **Unknown sources** option.

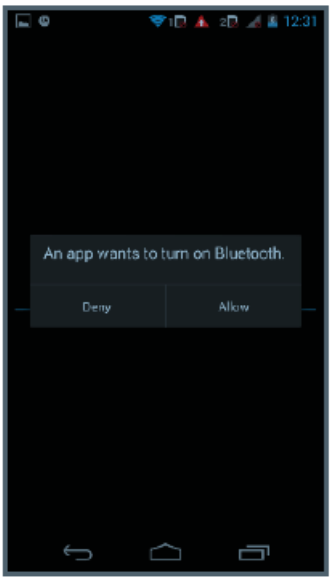
Connecting iCE40 Ultra Mobile Development Platform to Android Phone

To connect iCE40 Ultra Mobile Development Platform to Android phone:

1. In the Android phone, select **Settings > Security > Unknown sources**.
2. Go to the Apps menu and click **BLE Pedometer Demo**.
3. A message prompt appears asking for permission to activate Bluetooth on the phone, as shown in Figure 4.

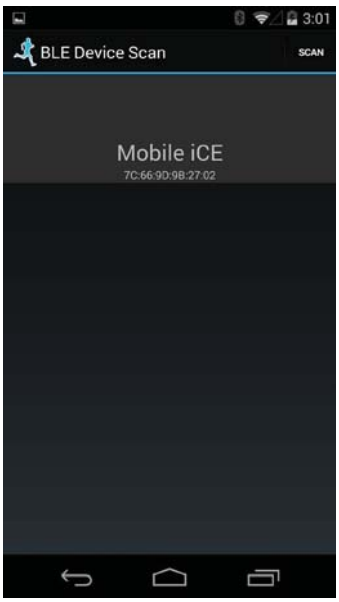
Note: The message prompt is not shown if Bluetooth is already enabled on the device.

Figure 4. Message Prompt for Enabling Bluetooth



4. Click **Allow**.
5. Bluetooth devices within the vicinity are scanned and listed. Click **iCE Mobile** as the desired device, as shown in Figure 5.

Figure 5. Selecting Bluetooth Device



6. The BLE Pedometer application interface is displayed, as shown in Figure 6. Use the **CONNECT/DISCONNECT** button to connect. The Activity Indicator displays *Connected* once the connection is established between the Android phone and iCE40 Ultra Mobile Development Platform.

Figure 6. BLE Pedometer Demo Interface

BLE Pedometer Demo Application Features

The BLE Pedometer Demo application provides the following features:

- Step Count
- Distance Miles/km
- Duration for which the activity is performed
- Calorie Expenditure
- Settings menu to offer personalization, such as for stride length

Demo Procedure

To run the demo:

1. Follow the procedure in the Connecting iCE40 Ultra Mobile Development Platform to Android Phone section. Make sure that the phone application is connected to the Bluetooth device.
2. Tap the **Start** button at the bottom of the interface. This starts the process of configuring the device. “Configuring….” is displayed in the Activity Indicator.
3. After configuration is completed, the Activity Indicator indicates “Ready...” and the application is now activated for usage.
4. Place the iCE40 Ultra Mobile Development Platform inside your pocket.
5. Perform any activity such as running or walking.
6. *Step count* and *Calories* data are indicated.

Pedometer Design

The following section describes the internal details of the Pedometer design.

Overview

The Pedometer application illustrates the near real operating environments such as off-loading the computer load and power from the main application processor of portable devices such as smartphones using Processor-FPGA(SW-HW) integrated systems. This pedometer application is implemented on the iCE40 Ultra iCE5LP 4K SWG36 device.

Design Features

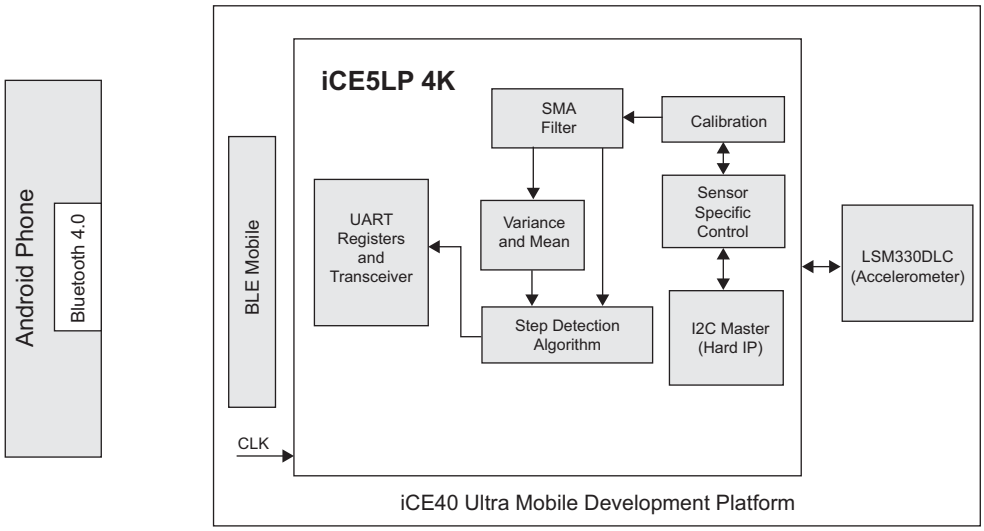
- UART Lite Transceiver
  - Operating at 9600 bps
  - Data width of 8 bits, one stop bit and no parity mode
- LSM330DLC Accelerometer for step activity
- Step detect algorithm with Dynamic threshold
- Accurate step detection for various possible device positions
  - In pockets or handheld
- Power On Reset
- Operates at system clock frequency of 27 MHz

Functional Block Diagram

Figure 7 shows the functional block diagram of the Pedometer with UART Interface. The design has seven main modules listed below.

- LSM330 DLC Sensor Configuration
- I2C Master
- Calibration
- SMA Filter
- Variance & Mean
- Step Detection Algorithm
- UART Registers and Transceivers.

Figure 7. Pedometer Functional Block Diagram



Functional Description

The design consists of the following components:

- Sensor Configuration
  - The sensor configuration module configures the LSM330 DLC Accelerometer sensor. The data from the sensor is read at a fixed interval over the I2C Lines. The FPGA's I2C Master is implemented using the onboard I2C Hard IP.
- I2C master (Hard IP)
  - The I2C master controller is used to transfer configuration data to the sensor and obtain the data from the sensors. One of the two I2C Master controllers available with the iCE40 Ultra device is used in this design. The I2C master controller configuration interface provides flexibility to perform read/write operation over I2C line for configurable number of bytes.
- Calibration
  - Data acquired from the Accelerometer sensor is normalized and removed offset in this module.
- SMA Filter
  - Output Data from the calibration module is given to SMA Filter module where Simple Moving Average is calculated for Accelerometer data for window length of 8.
- Variance and Mean
  - Output Data from the calibration module is given to

$$V = \frac{\sum_{i=1}^{i=N}(X_i - X_N)^2}{N-1}$$

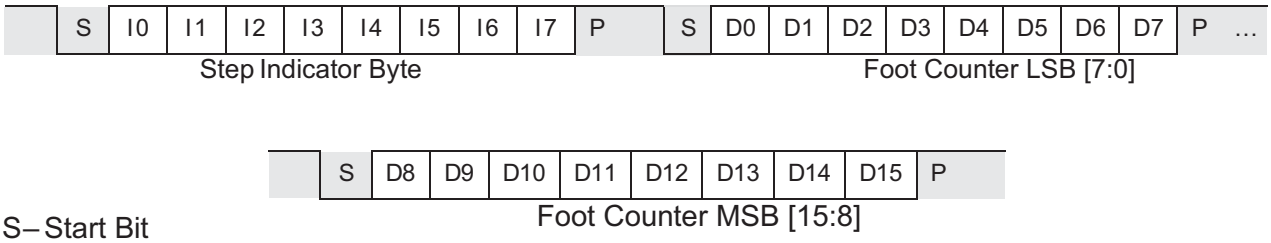
Where
V = Variance
X_i = i^{th} sample data
X_N = Mean of N samples = (Sum of N samples)/N
N = Number of samples, in this design N = 32

- Step Detection Algorithm
  - The output data from the SMA filter, Variance and Mean module is given to Step Detection Algorithm. Codes for the algorithm are available upon request. Please contact your local Lattice sales representatives for inquiries.
- UART Registers and Transceivers
  - The design supports UART Lite Transceiver operating at baud rate 9600bps. It features data width 8 bits, single stop bit and parity mode is disabled.

    The UART interface supports 3 byte write from FPGA to Android Phone. The First byte indicates valid step followed by two data bytes which contains foot counter. These bytes are passed to the transceiver for transmission to the Android phone. To start the transmit operation, tx_start signal is asserted and the data to be transmitted is provided on tx_data line. The UART IP generates a start condition followed by the data transfer and termination of operation as per UART protocol.

Timing Diagram

Figure 8. Timing Diagram of UART Interface (3-Byte Write)



Design Usage

The sequence of steps below describes the usage of Pedometer.

Foot Count Read:

1. UART sends 3 bytes of data to AP
   a. First byte is assigned with step indicator register
   b. The next two bytes consists of foot counter
2. After successful read of step indicator register, foot counter value is displayed by the AP.

Resource Utilization

Table 1. Resource Utilization

Family	Synthesis Tool	LUTs	Registers	PLBs	BRAMs	I/Os	I2Cs	SPIs
iCE40 Ultra	LSE	2262	1420	345	6	4	1	0
iCE40 Ultra	Synplify Pro	2374	1385	411	5	4	1	0

Signal Description

Table 2 lists the external interface signals.

Table 2. External Interface Signals

Signal Name	PinType	Pull-Up Required	SWG25IR Pin Assignment	Signal Description
i_sys_clk	IN	Yes	[F4]	Clocking Signal from an on-board oscillator. This clock is generated using a 27 MHz oscillator.
o_tx	OUT	Yes	[F3]	UART Interface: Serial Data
io_sensor_sda	INOUT	Yes	[C1]	I2C Interface: Data This connects the FPGA to the sensor. This is generated by the FPGA when configuring the sensor and driven by the sensor which transmits the data.
io_sensor_scl	INOUT	Yes	[E2]	I2C Interface: Clock This connects the FPGA to the sensor. This is generated by the FPGA

Board Information

For more information on procuring the iCE40 Ultra Mobile Development Platform, please contact your local Lattice Sales Representatives.

For more information on Snapdragon Board APQ8074, please go to www.intrinsyc.com.

References

- DS1048, iCE40 Ultra Family Data Sheet
- Schematics of the iCE40 Ultra Mobile Development Platform
- LSM330DLC Accelerometer Data Sheet

Technical Support Assistance

e-mail: techsupport@latticesemi.com

Internet: www.latticesemi.com

Revision History

Date	Version	Change Summary
November 2014	1.1	Updated Resource Utilization section. Modified Table 1, Resource Utilization to add support for Lattice Synthesis Engine (LSE).
June 2014	1.0	Initial release.