# BIOMETRIC EXP Evaluation Board USER'S GUIDE

## 1. Introduction

The Silicon Laboratories' Biometric-EXP Evaluation Board is a hardware plugin card for EFM32™ Starter Kits (STK's). The Biometric-EXP is intended to demonstrate and evaluate the biometric applications of Silicon Laboratories Si7013 Humidity and Temperature Sensor and the Si1146 Proximity/UV/Ambient Light Sensor which is capable of monitoring pulse rate and oxygen saturation (SpO2). A Biometric-EXP Software Demo is available to download to an EFM32 Wonder Gecko STK through Simplicity Studio. The software is capable of displaying humidity, temperature, UV, pulse rate, and SpO2 readings on the Wonder Gecko STK display. In addition to the Silicon Labs sensors, it is also of note that the Biometric-EXP EVB contains a Silicon Laboratories' TS3310 Boost DC-DC Converter.

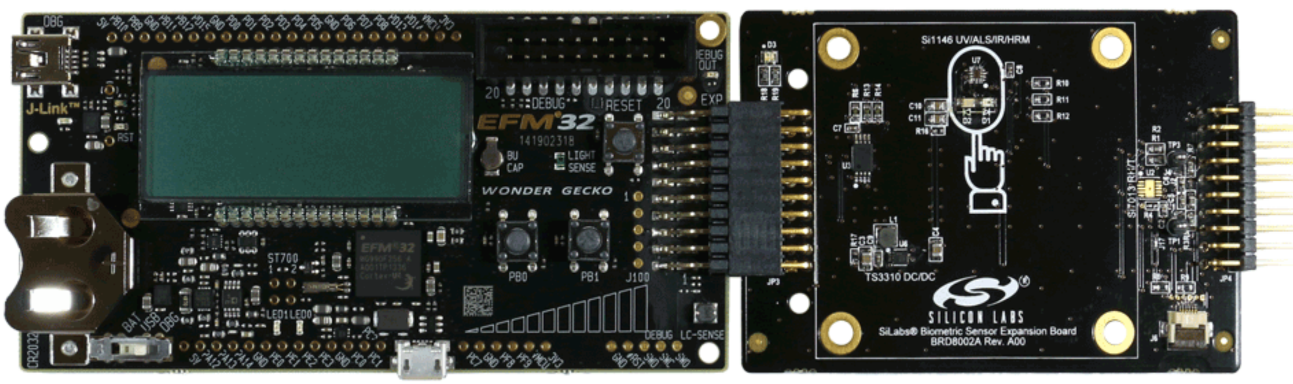


**Figure 1. EFM32 Wonder Gecko STK (Left) Connected to a Biometric-EXP (Right)**

### 1.1. Key Features

- Si7013 Humidity and Temperature Sensor
- Si1146 Proximity/UV/Ambient Light Sensor capable of monitoring Pulse Rate and SpO2
- 6-pin ribbon cable connector for attaching a wrist-based heart rate monitor EVB (*ordered separately as HRM-GGG-PS*)
- 20-pin expansion header
- Battery operated with low power optimizations for long battery life
- Demonstration software source code available
- USB debug mode allowing HRM and SpO2 samples to be transferred to a PC
- Windows GUI to visualize pulse signals and to record samples from USB debug mode
- Easy use through Simplicity Studio

## 2. Loading the Demo onto the Wonder Gecko STK

The following steps will load the demo firmware onto the Wonder Gecko STK. This process requires Simplicity Studio which is available for download at www.silabs.com/simplicity-studio.

1. Connect the Wonder Gecko STK to the PC via USB.
2. Launch Simplicity Studio.

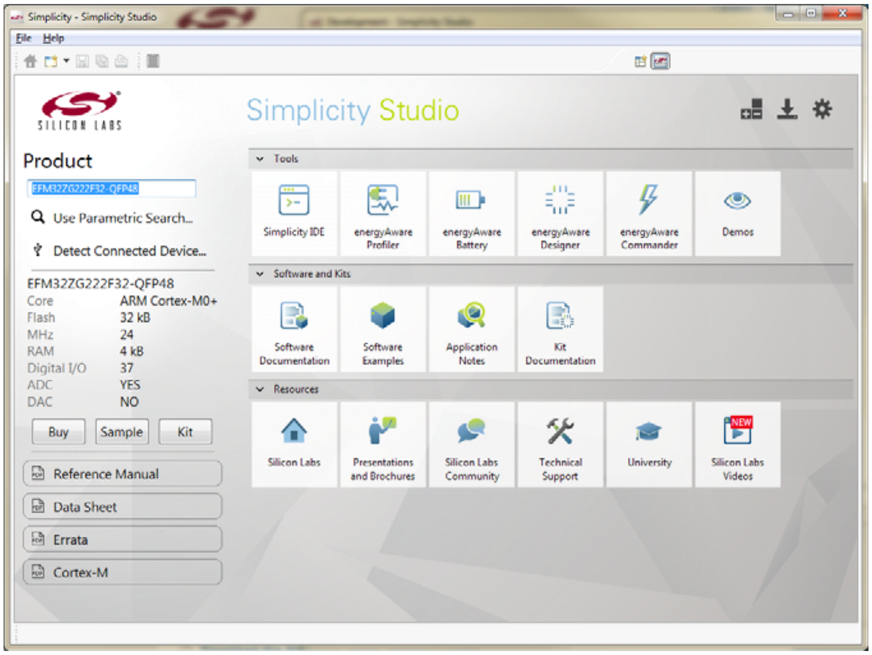



**Figure 2. Simplicity Studio**

3. Open the Simplicity IDE

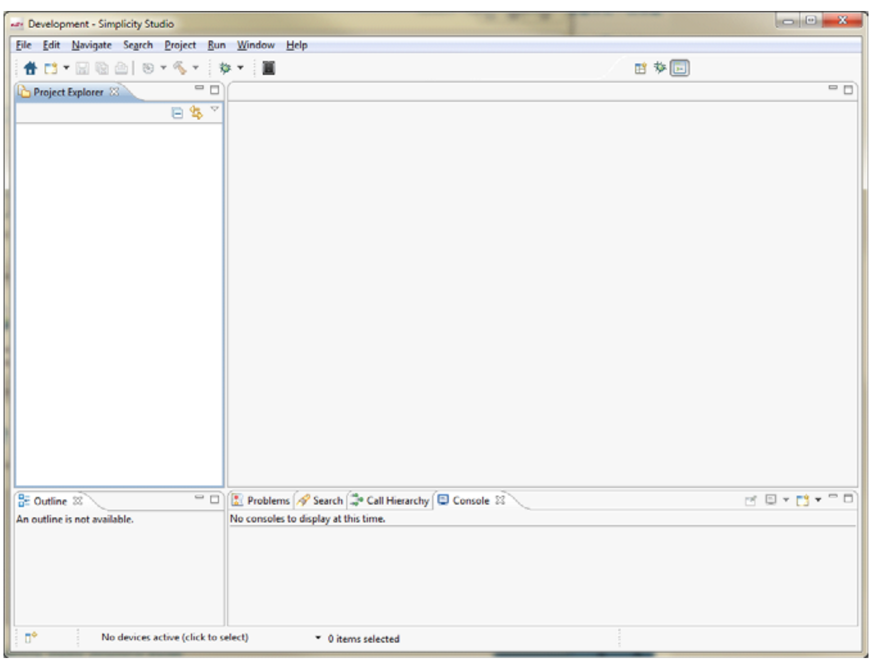
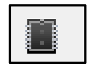



**Figure 3. Simplicity IDE**

4. From the Simplicity IDE toolbar open the flash programmer (  icon).

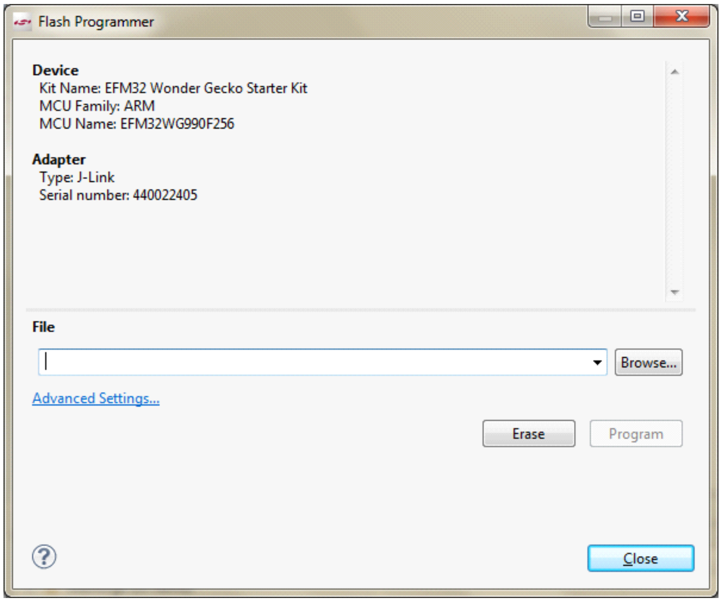



**Figure 4. Flash Programmer Dialog**

5. Ensure that the Wonder Gecko STK appears in the **Device** description at the top of the Flash Programmer dialog.
6. **Browse** to the hex file EFM32WG_Biometric_EXP_Demo.hex then click **Program**.

# 3. Running the Demo

A Silicon Labs EFM32 Wonder Gecko Starter Kit (EFM32WG-STK3800) and a Silicon Labs Biometric-EXP (see Figure 1) is needed to run the Biometric EXP Demo.

The Biometric-EXP demo application uses the Wonder-Gecko STK's LCD to display sensor output and the two push buttons, PB0 and PB1, to cycle through the modes of the demo. The full operation including startup is illustrated in Figures 5 and 6.

## 3.1. Demo Startup

Upon reset, the demo will first check whether PB0 is pressed then store the result. It will then search for a supported device on the 6-pin ribbon cable connector. If a HRM-GGG-PS, Si1143-M01-PS or Si1147-M01-PS is detected, the demo will automatically use that device for HRM measurements. In this case, the Si1146 sensor onboard the Biometric-EXP will not be utilized. SpO2 is not available with either the HRM-GGG-PS or the Si114x-M01-PS EVB's.

Following the search for a ribbon cable device, the demo will check the stored value of PB0 to enable or disable the USB debug mode accordingly and display an USB On or USB Off message for 1 second. Refer to "4. USB Debug Mode" for details on USB debug mode. Lastly, the demo will display version information then start the demo in Heart Rate Monitor mode.

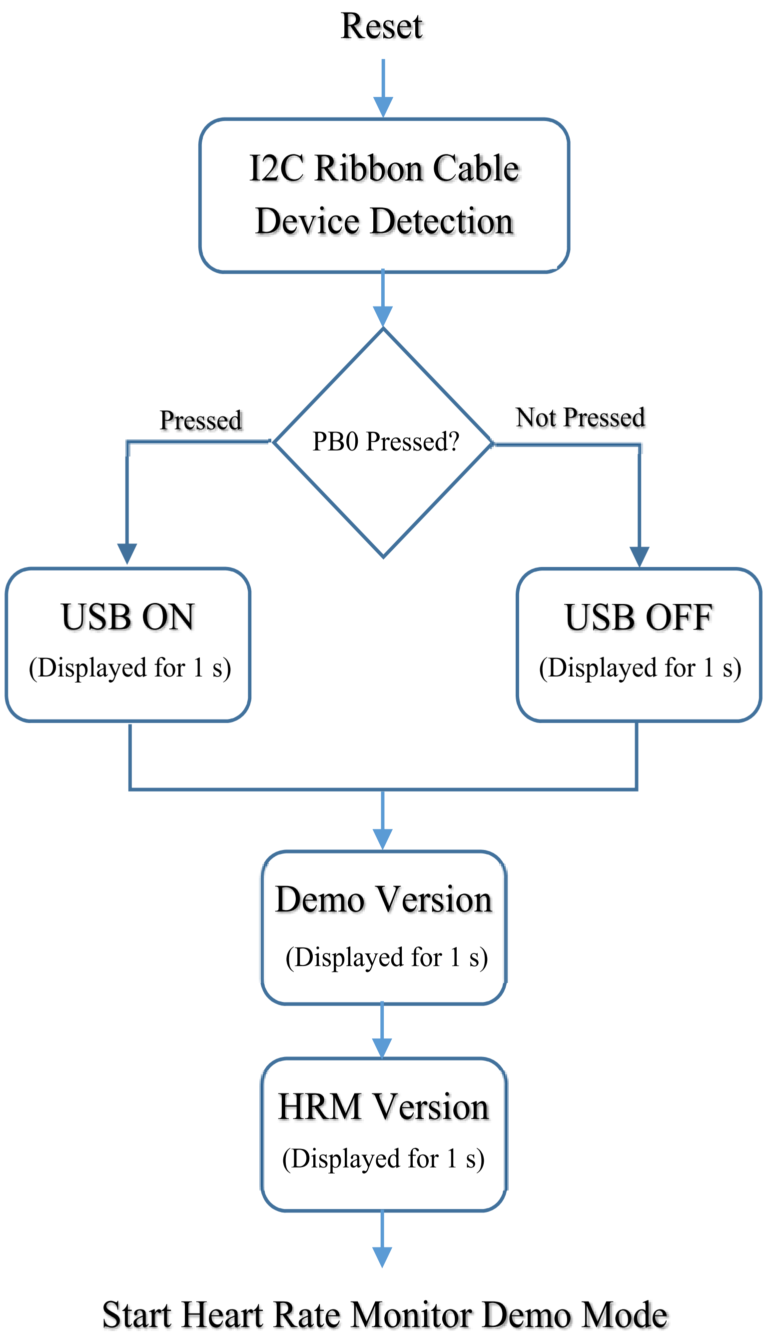



**Figure 5. Biometric-EXP Demo Startup Sequence**

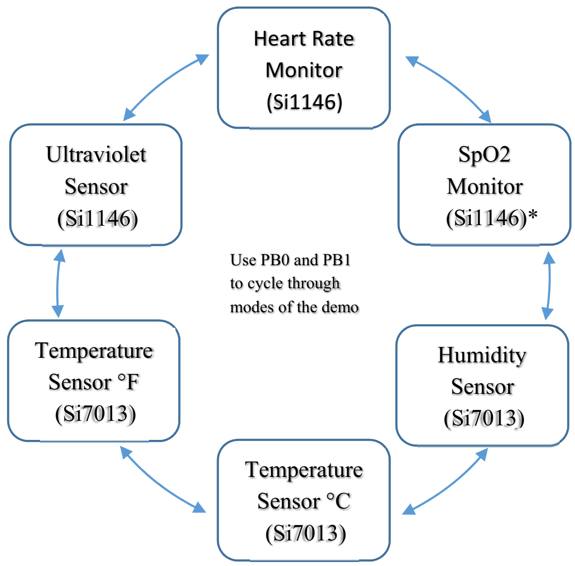



**Figure 6. Biometric-EXP Demo Modes**

***Note:** SpO2 Monitor mode is not available when using a HRM-GGG-PS, Si1143-M01-PS or Si1147-M01-PS.

## 3.2. Heart Rate Monitor Mode

When heart rate monitor demo is idle, the LCD will show the word “Pulse” followed by a message instructing the user to place his/her finger on the optical sensor. In idle mode, the sensor is not continuously sampling. Rather, it executes one sample every two seconds by performing a forced measurement. That sample is then analyzed to determine if there is skin contact with the sensor. Only when the application detects skin contact does it begin sampling continuously and running the HRM algorithm. It will remain in run mode (continuous sampling) until skin contact is removed for greater than two seconds. This approach significantly reduces power usage when idle.

When the application is acquiring the heart rate, it will display the word “Wait” on the LCD. It typically takes five to seven seconds to acquire a valid heart rate. Once a valid heart rate is measured, the display will show the heart rate. If the heart rate is not displayed within seven seconds, it is likely that the algorithm cannot get a valid pulse rate. When this occurs, the user should remove his/her finger and try it again adjusting the position of the finger and the finger pressure as needed.

Proper finger position in relation to the sensor and LEDs as well as proper finger pressure is essential for accurate measurements. The finger should fully cover both LEDs and the sensor. Proper finger position is illustrated in Figure 7.

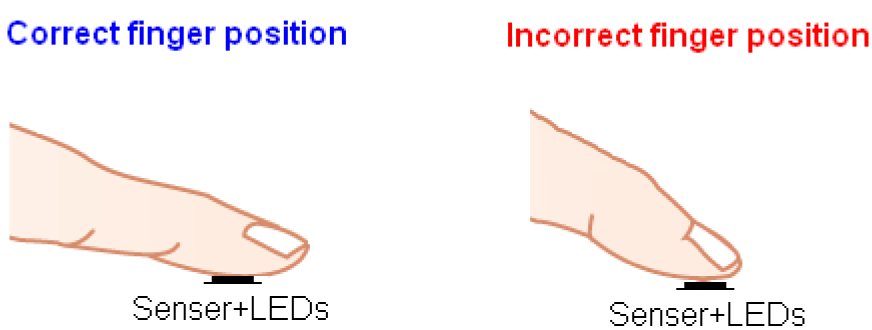



**Figure 7. Proper Finger Placement**

## 3.3. SpO2 Monitor Mode

When SpO2 mode is active, the LCD will show “SpO2” followed by a message instructing the user to place his/her finger on the optical sensor. Beyond that, SpO2 monitor mode mirrors the operation of the Heart Rate Monitor mode as described in “3.2. Heart Rate Monitor Mode” . Please note that SpO2 mode is not available when using a HRM-GGG-PS, Si1143-M01-PS, or Si1147-M01-PS device via the 6-pin ribbon cable. Even more so than HRM, proper finger position and pressure is important to achieve a good SpO2 measurement. Refer to Figure 7 for an illustration of proper finger position.

## 3.4. Ultraviolet Sensor Mode

When the UV sensor mode is active, the LCD will show “UV” followed by the measured UV index.  In this mode, the UV reading is updated every two seconds.

## 3.5. Temperature Sensor Mode

In the temperature sensor modes, the LCD will show the temperature in Fahrenheit or Celcius as indicated by an “F” or a “C” following the reading. In this mode the temperature reading is updated every two seconds.

## 3.6. Relative Humidity Sensor Mode

In the relative humidity sensor mode, the LCD will show “RH” followed by the relative humidity reading. In this modem, the relative humidity reading is updated every two seconds.

# 4. USB Debug Mode

The Biometric-EXP demo firmware includes a debug mode that enables Heart Rate Monitor and SpO2 raw samples from the sensor to be streamed to a host PC via the Wonder Gecko STK's USB interface. Only HRM and SpO2 data is available via the USB debug interface. UV, Relative Humidity, and Temperature data is not available.

## 4.1. Enabling USB Debug Mode

In order to maintain power efficiency of the demo, the USB debug mode is disabled by default. The LCD will show "USB OFF" during startup. To enable USB debug mode, the user must hold down button PB0 then press and release the Reset button. Both buttons are on the Wonder Gecko STK as shown in Figure 19. The user should hold down PB0 until the LCD shows "USB ON." At this point, USB is enabled and the demo will run normally. To later disable USB debug mode the user can press the Reset button without holding PB0.

## 4.2. Connecting to USB Debug Mode on a PC

Prior to using USB debug mode, the user must first install the Biometric-EXP Windows Evaluation Software. This will install the Windows applications and drivers necessary to use USB debug mode. The Wonder Gecko STK has two USB type connectors: a USB Mini type connector labeled J-Link on the short side of the EVB and a USB Micro type connector on the long side of the EVB. Refer to Figure 19 on page 20 for details on the component layout of the Wonder Gecko STK. The USB Micro connector is used for the USB debug interface. In addition to using the correct physical interface, the Power Source Select switch must be set to USB (center position) for proper operation.

USB debug mode utilizes a Virtual COM Port (VCP) interface to communicate between the Biometric-EXP demo and the PC. With the Windows software installed, USB debug mode enabled on the Wonder Gecko and a USB cable connecting the Wonder Gecko STK and the PC, the device will appear in Windows Device Manager as a COM port as shown in Figure 8.

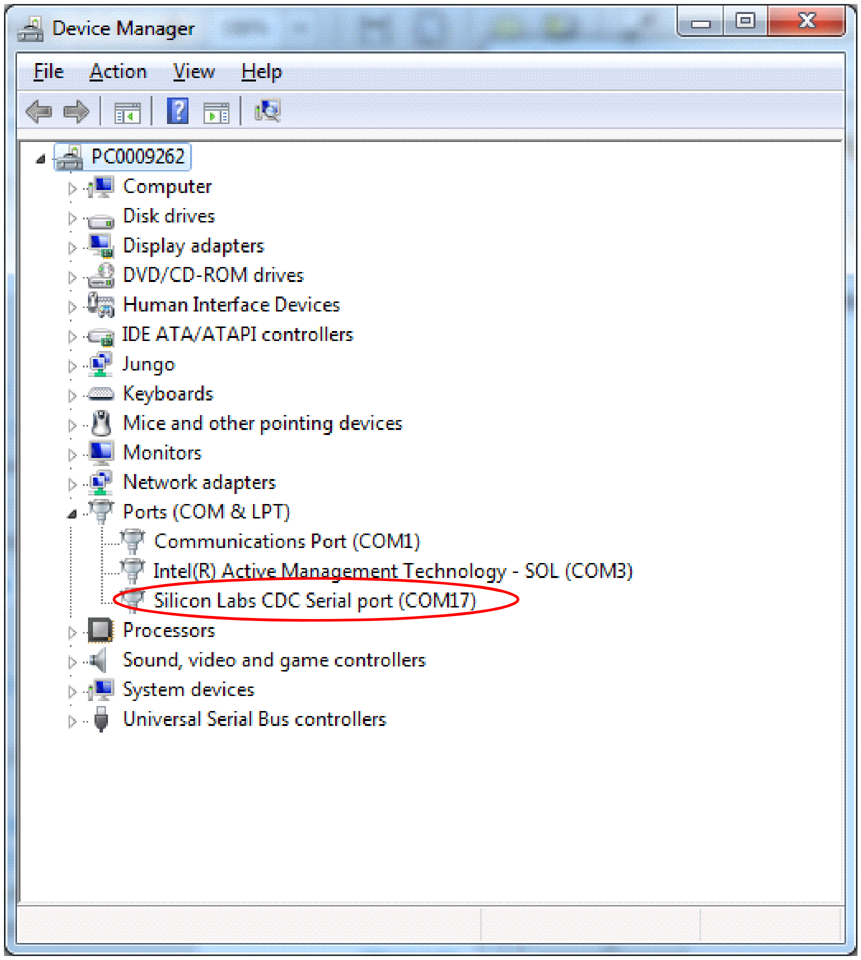



**Figure 8. Biometric-EXP Virtual COM Port Device in Windows Device Manager**

### 4.3. Windows Applications for USB Debug Mode

The Biometric-EXP Windows Evaluation Software includes two Windows applications for evaluating and debugging the Biometric-EXP Heart Rate Monitor and SpO2 functions. The Windows Graphical User Interface (GUI) demo provides a waveform display of the HRM data along with the HRM and SpO2 calculated values. The GUI demo also allows the user to record the streaming data to a file for further analysis. A screenshot of the GUI demo is shown in Figure 9.

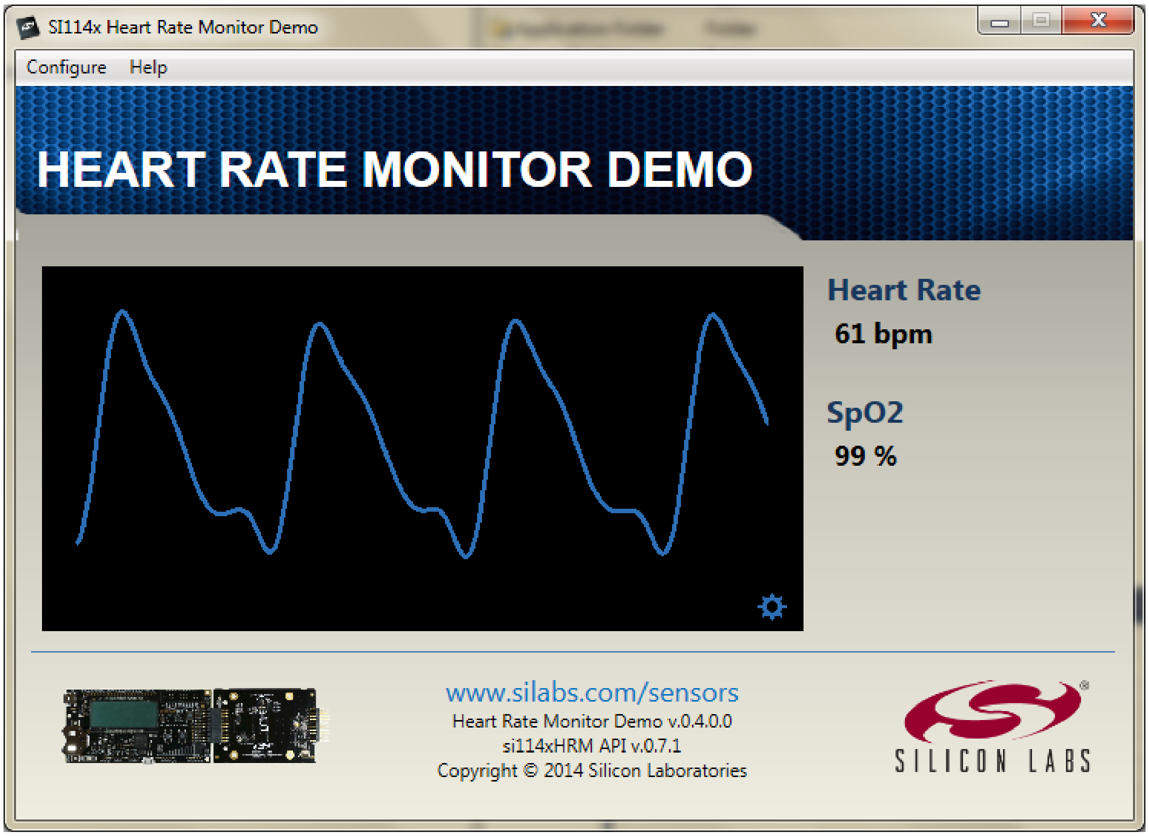



**Figure 9. Windows Graphical User Interface Demo**

The Windows Console Demo provides a running, once-per-second text output of many parameters that are used within the HRM and SpO2 algorithms including the HRM and SpO2 results. This tool can be used for advanced analysis of the HRM and SpO2 streaming data; however, the details of the parameters and how to use them to analyze a HRM-SpO2 recording is beyond the scope of this document. Refer to the HRM-SpO2 API Reference Manual available from Silicon Laboratories for further details. The C++ source code of the Console Demo is supplied within the installation. A screen shot of the Console demo is show in Figure 10.

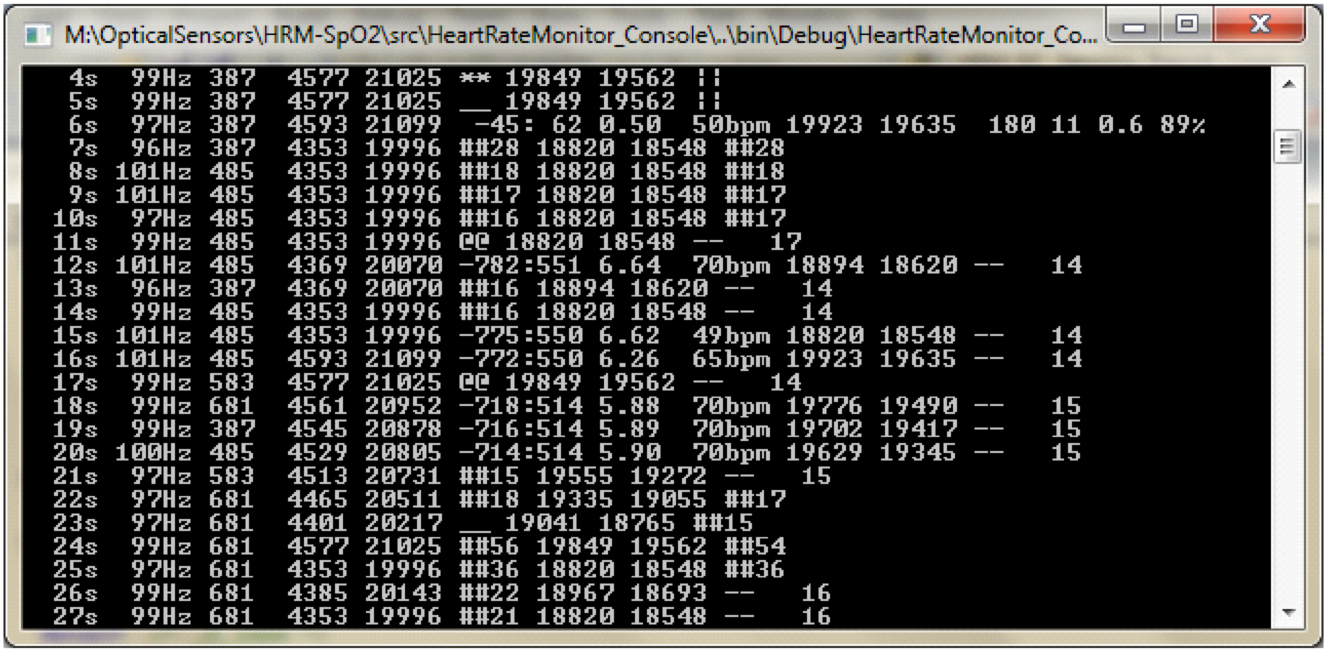



**Figure 10. Windows Console Demo**

To connect the console to the streaming output from the Biometric-EXP, the user can type –u COMx <filename> at the prompt. In this command, COMx is the VCP COM port as shown in Figure 8, and the optional input <filename> specifies the file in which the streaming data is to be stored. Note that if <filename> is not provided, the console automatically stores the data to a default file. This default file is overwritten each time the demo is run.

The console also has the ability to playback recorded files. This is done by typing `–f filename` at the prompt. In this command, filename specifies the source file containing the saved recording.

It is important to note that the USB debug interface is a one-way interface. Therefore, the applications can only take the streaming data as an input. They do not allow the user to control the Biometric-EXP software.

## 5. Importing the Source Code Project into Simplicity Studio

The following steps will import the Biometric-EXP Demo source code into Simplicity Studio resulting in a project that can be compiled, linked and debugged using the Wonder Gecko starter kit.

Simplicity Studio is available for download at www.silabs.com/simplicity-studio.

**Note:** In the near future, this software will be integrated into Simplicity Studio making the import task seamless. When the integration is complete, the procedure below will be obsolete.

1. Store the Biometric-EXP software distribution uncompressed in a folder that is accessible from the PC.
2. Start Simplicity Studio and Open the Simplicity IDE.

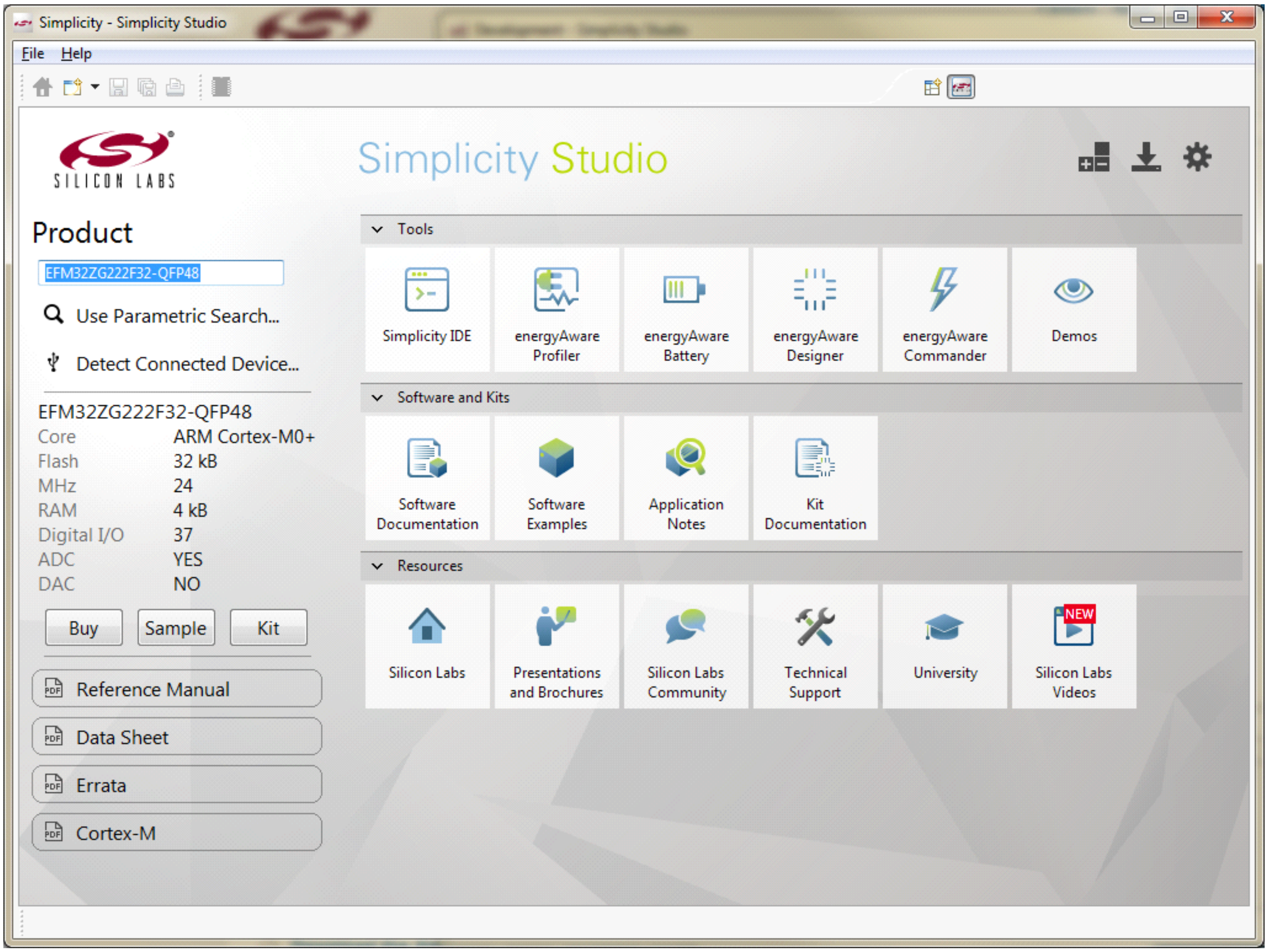



**Figure 11. Simplicity Studio**

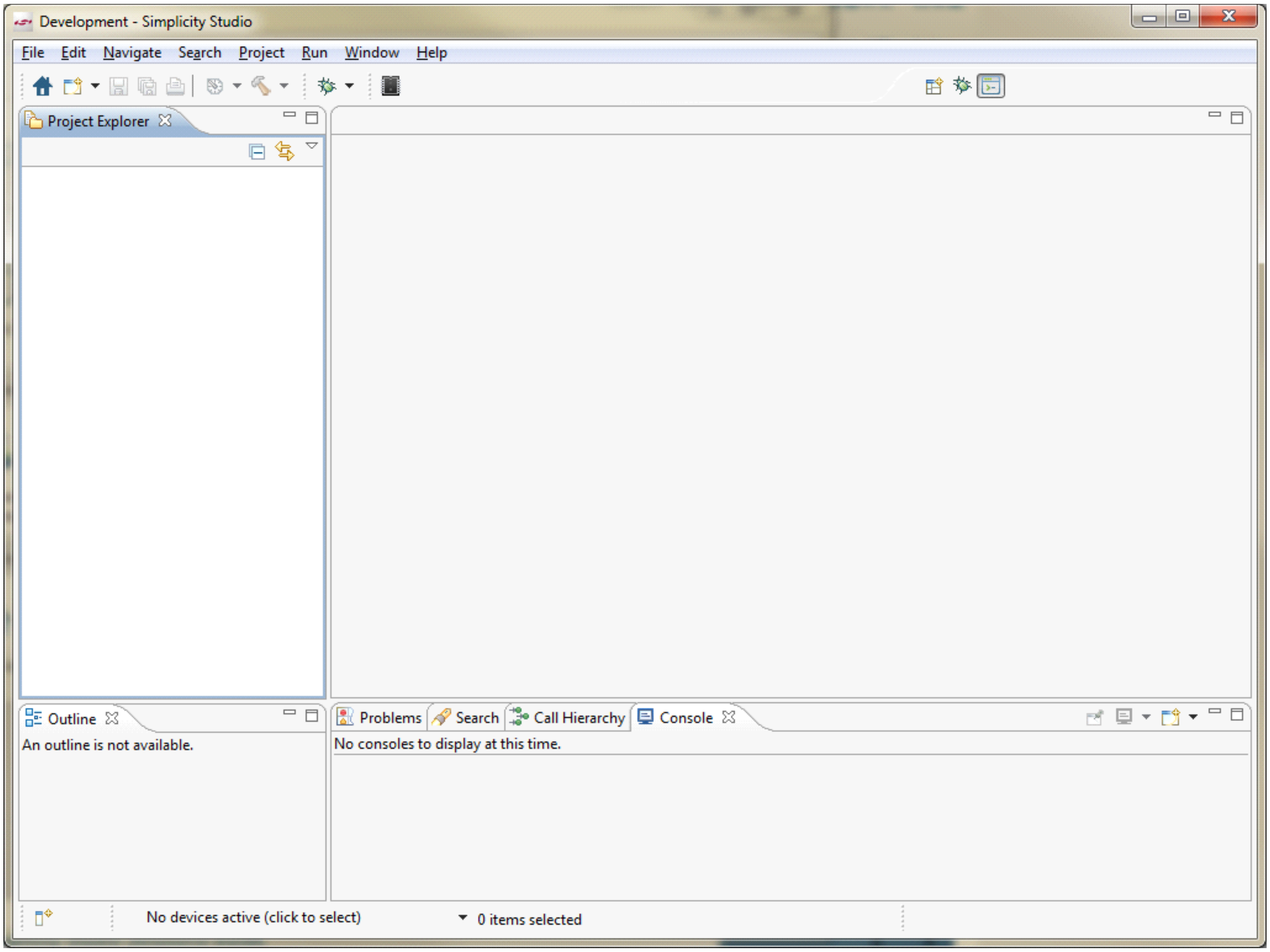



**Figure 12. Simplicity IDE**

3. In the Simplicity IDE menu select **File→Import**.
4. Under the **General** heading, select **Existing Projects into the Workspace** then click **Next**.

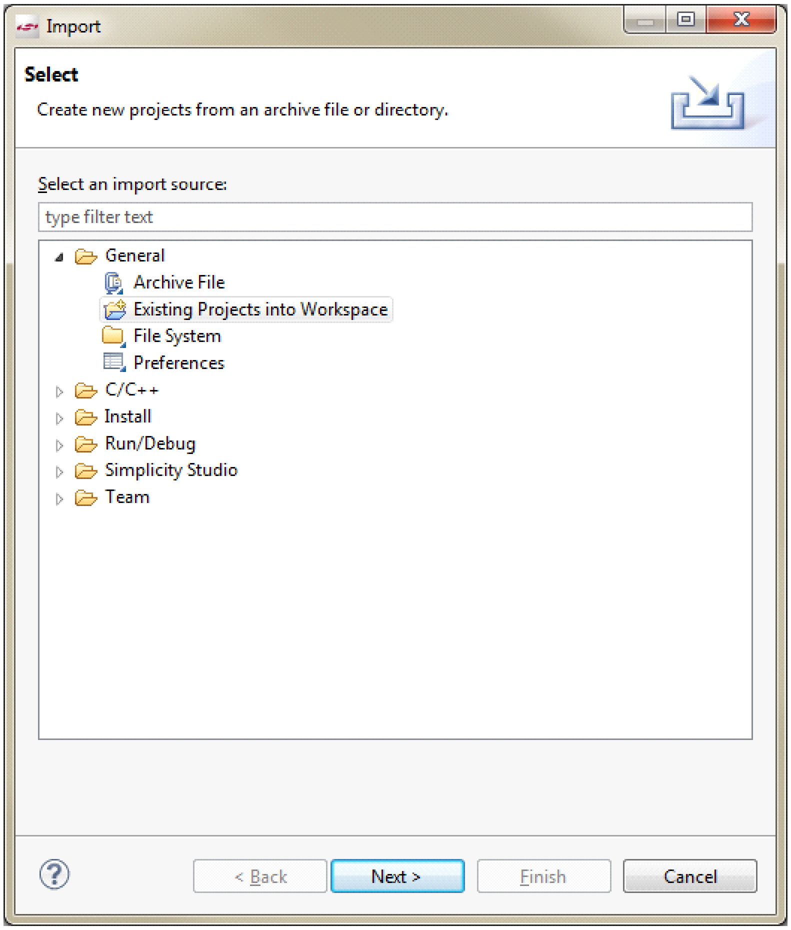



**Figure 13. Simplicity IDE Import Dialog**

5. Select **Select root directory** then **Browse** to the folder EFM32WG_Biometric_EXP_Demo in the Biometric-EXP Demo distribution.

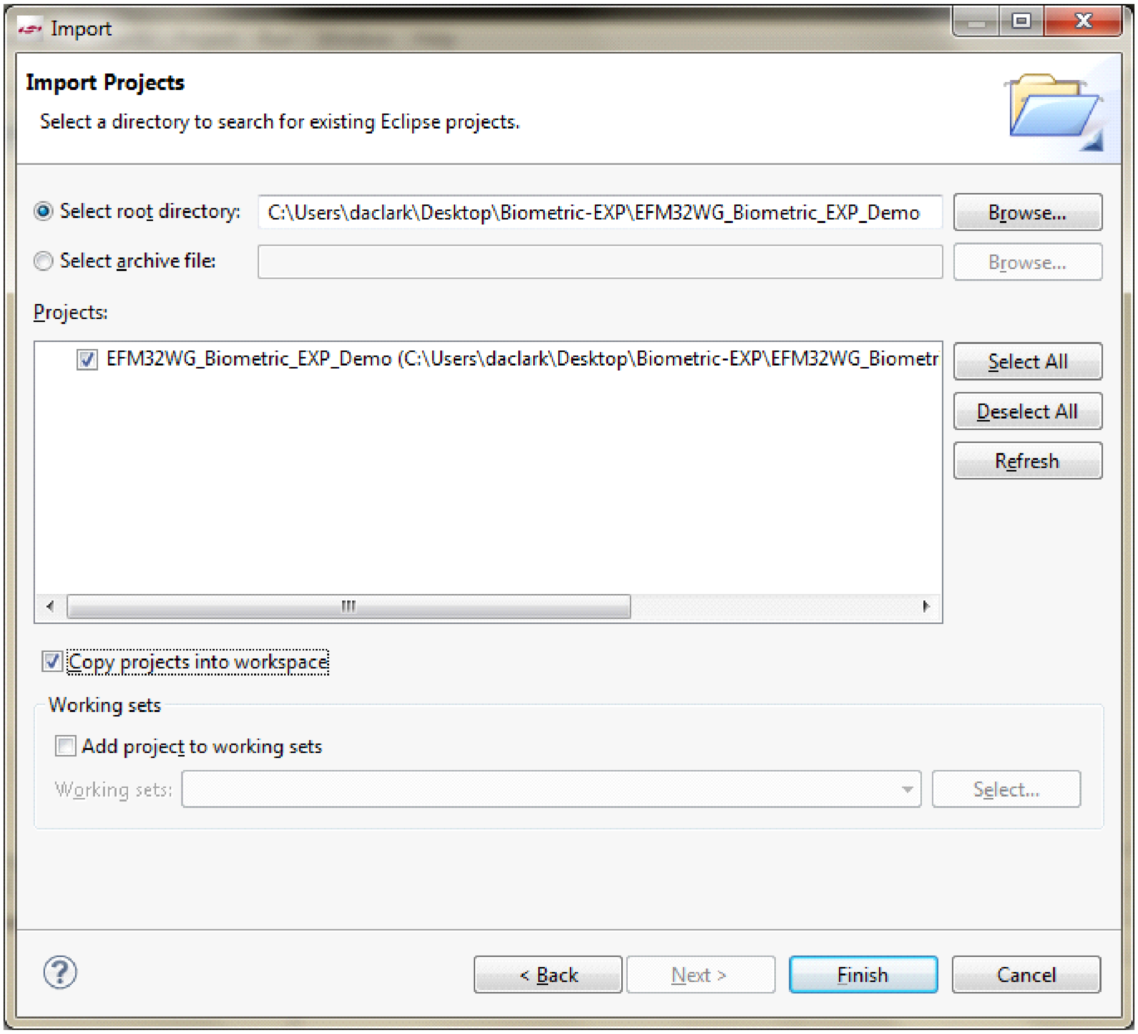



**Figure 14. Select the Project to Import**

6. Confirm that the check box for the project is checked.
7. If you wish to make a local copy within the Simplicity IDE workspace select **Copy projects into workspace**.
8. Click **Finish**.
9. The EFM32WG_Biometric_EXP_Demo project is configured to link to a binary library that is stored in a folder labeled ***lib*** in the Simplicity IDE workspace folder. This folder is not generated by the import process described in the steps above; therefore, the link will be broken.

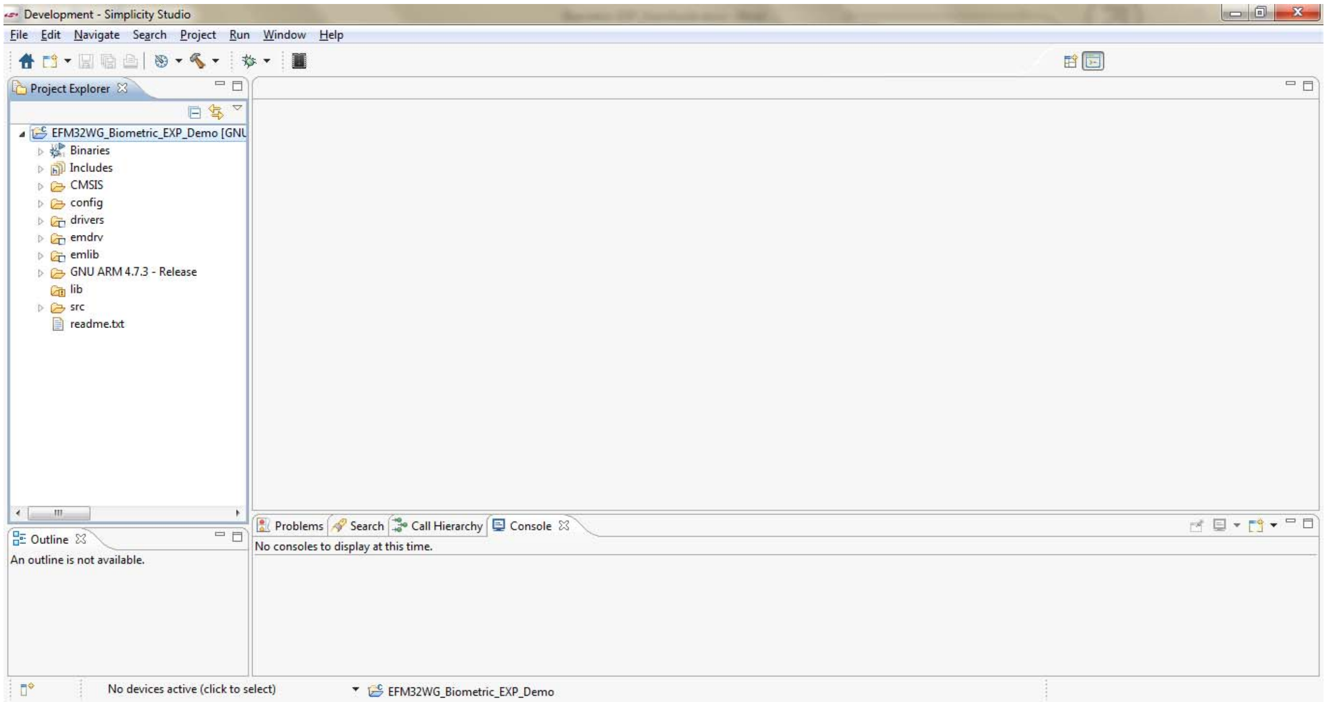



**Figure 15. Simplicity IDE with EFM32WG_Biometric_EXP_Demo Project**

To correct the link:

a. In the Simplicity IDE **Project Explorer**, right click on the **lib** folder then select **Properties**.

b. The **Resources** page of the **Properties** dialog displays the link path. Modify this path by clicking the **Edit** button then browsing to the location of the lib folder.

**Note:** Alternatively, you can manually copy the entire lib folder from the distribution to the location specified in step “b”.

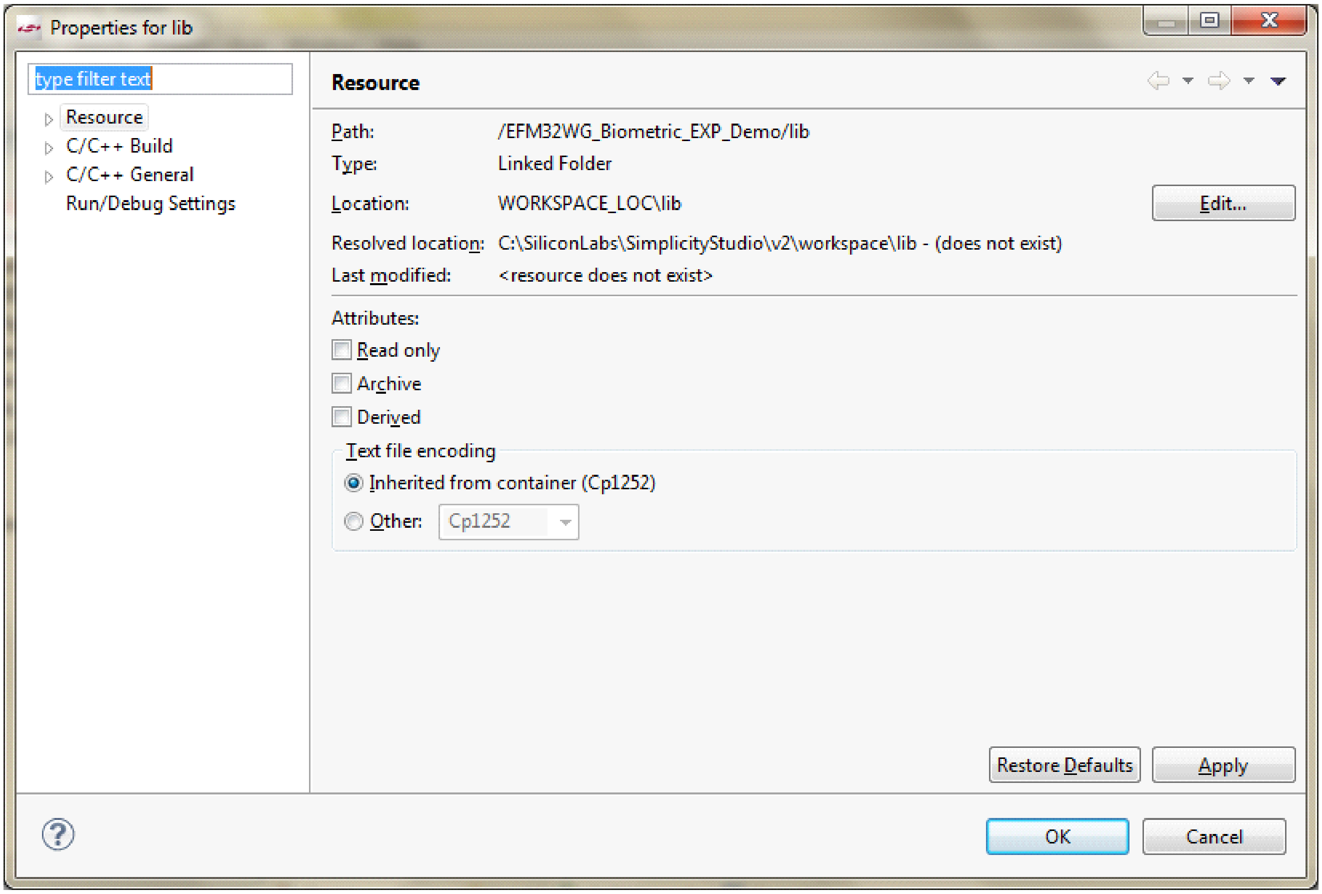



**Figure 16. Symbolic Link to the Lib Folder**

Upon completion of the steps above you should have a working project in Simplicity Studio that can be built and debugged.

10. To build the demo, simply click on the  icon in the Simplicity IDE. Note that there are two build configurations: Release and Debug. You can select between the two by clicking the down arrow next to the Hammer icon.
11. To debug the project, select the Debug build configuration then click on the  icon in the Simplicity IDE. A debug session will automatically launch and if a board is connected, the project will be loaded into the MCU.

# 6. Hardware Overview

## 6.1. Block Diagram

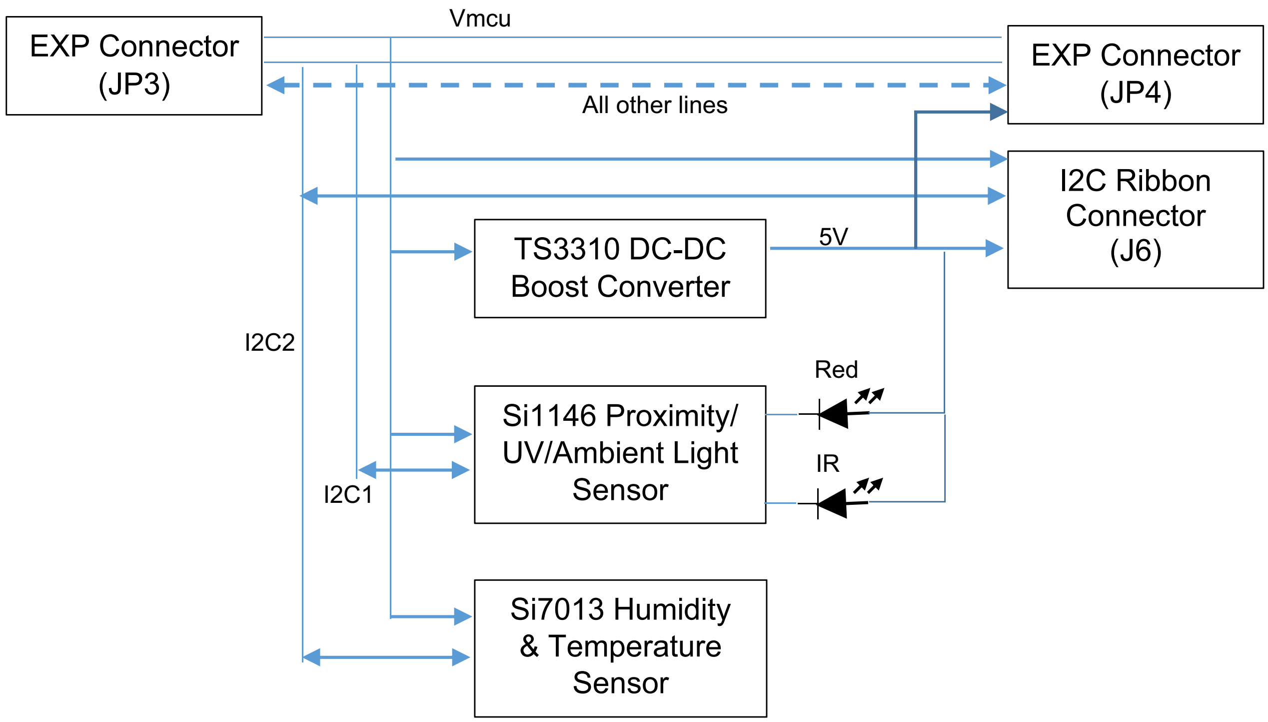



**Figure 17. Biometric-EXP Block Diagram**

## 6.2. Hardware Connectors

As illustrated in Figure 17 there are two separate $I^2C$ buses implemented on this board. The Si1146 is on its own bus while the Si7013 and the I2C Ribbon Connector J6 are on the second bus. This allows for expansion boards designed for the $I^2C$ Ribbon Connector to connect to the Biometric-EXP without the possibility of an $I^2C$ slave address conflict between any potential Si1145/Si1146/Si1147 devices on the expansion board.

Table 1 details the pinouts and signal function of the Biometric-EXP connectors JP3 and JP4.

**Table 1. Expansion Connectors (JP3 and JP4)**

| Pin # | Biometric-EXP Signal Description | WonderGecko Signal |
|---|---|---|
| 1 | GND | GND |
| 2 | VMCU | VMCU |
| 3 | Red LED D3 | PC0 |
| 4 | Not Used | PD0 |
| 5 | Green LED D3 | PC3 |
| 6 | Not Used | PD1 |
| 7 | Si7013 and $I^2C$ Ribbon Connector (J6) SDA | PC4 |

**Table 1. Expansion Connectors (JP3 and JP4) (Continued)**

| Pin # | Biometric-EXP Signal Description | WonderGecko Signal |
|---|---|---|
| 8 | Not Used | PD2 |
| 9 | Si7013 and $I^2C$ Ribbon Connector (J6) SCL | PC5 |
| 10 | Not Used | PD3 |
| 11 | Not Used | PB11 |
| 12 | Enable TS3310 Boost DC-DC Converter | PD4 |
| 13 | Not Used | PB12 |
| 14 | Si1146 and $I^2C$ Ribbon Connector (J6) INT | PD5 |
| 15 | Not Used | PC6 |
| 16 | Si1146 $I^2C$ SDA | PD6 |
| 17 | Si1146 $I^2C$ SCL | PD7 |
| 18 | Not Used | 5V |
| 19 | Not Used | GND |
| 20 | 3.3 V | 3.3 V |

Table 2 details the pinouts and signal descriptions of the 6-pin $I^2C$ connector J6.

**Table 2. 6-Pin $I^2C$ Connector (J6)**

| Pin # | Signal Description |
|---|---|
| 1 | I2C SCL |
| 2 | 5V |
| 3 | I2C SDA |
| 4 | GND |
| 5 | INT |
| 6 | VMCU |

### 6.3. Hardware Component Layout

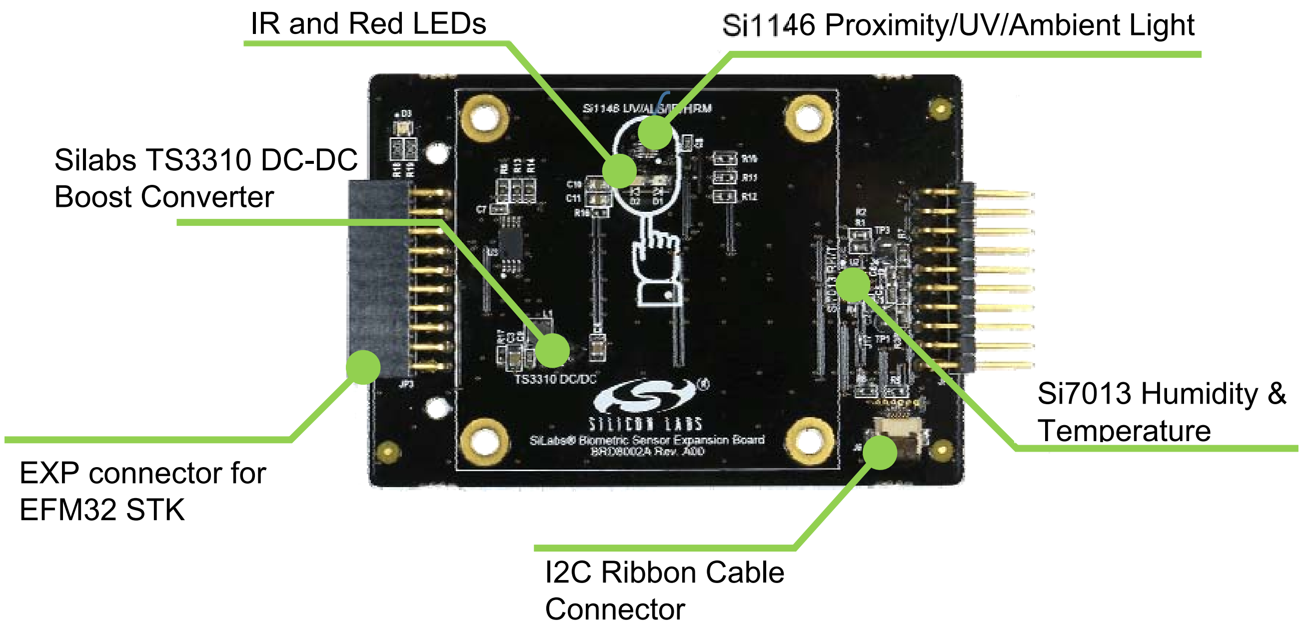



**Figure 18. Biometric-EXP Hardware Component Layout**

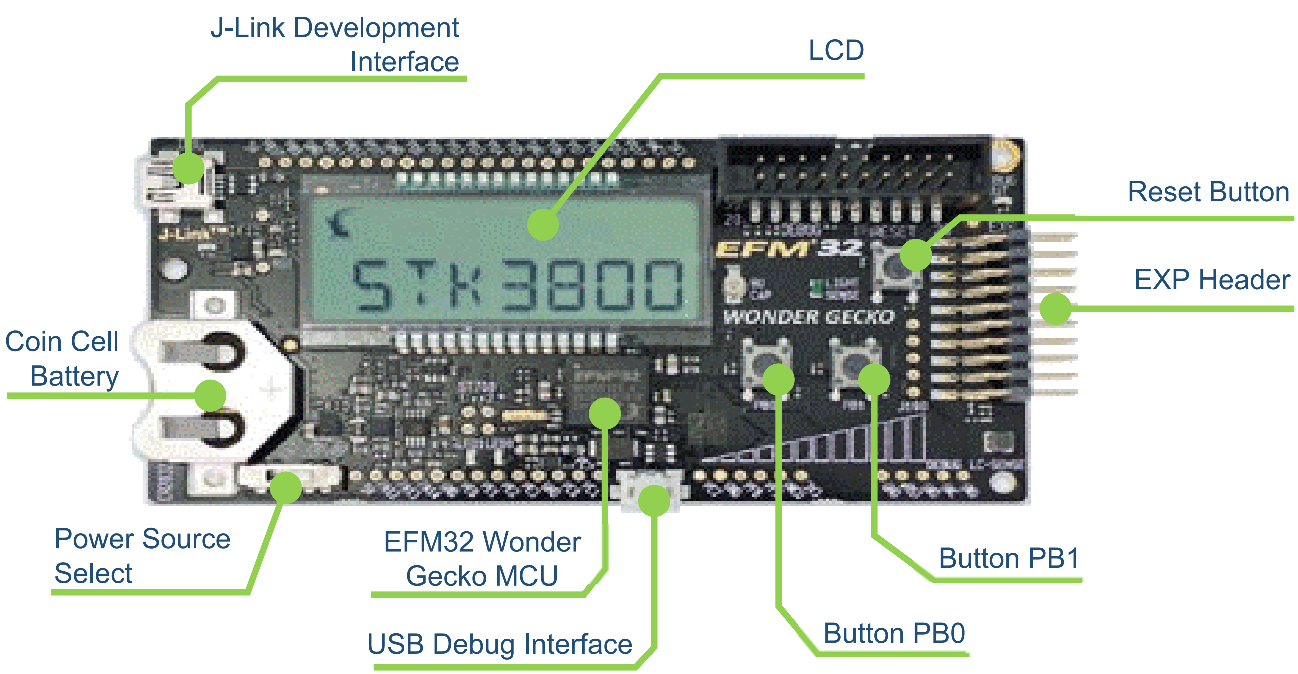



**Figure 19. Wonder Gecko STK Component Layout**

## 6.4. Schematic

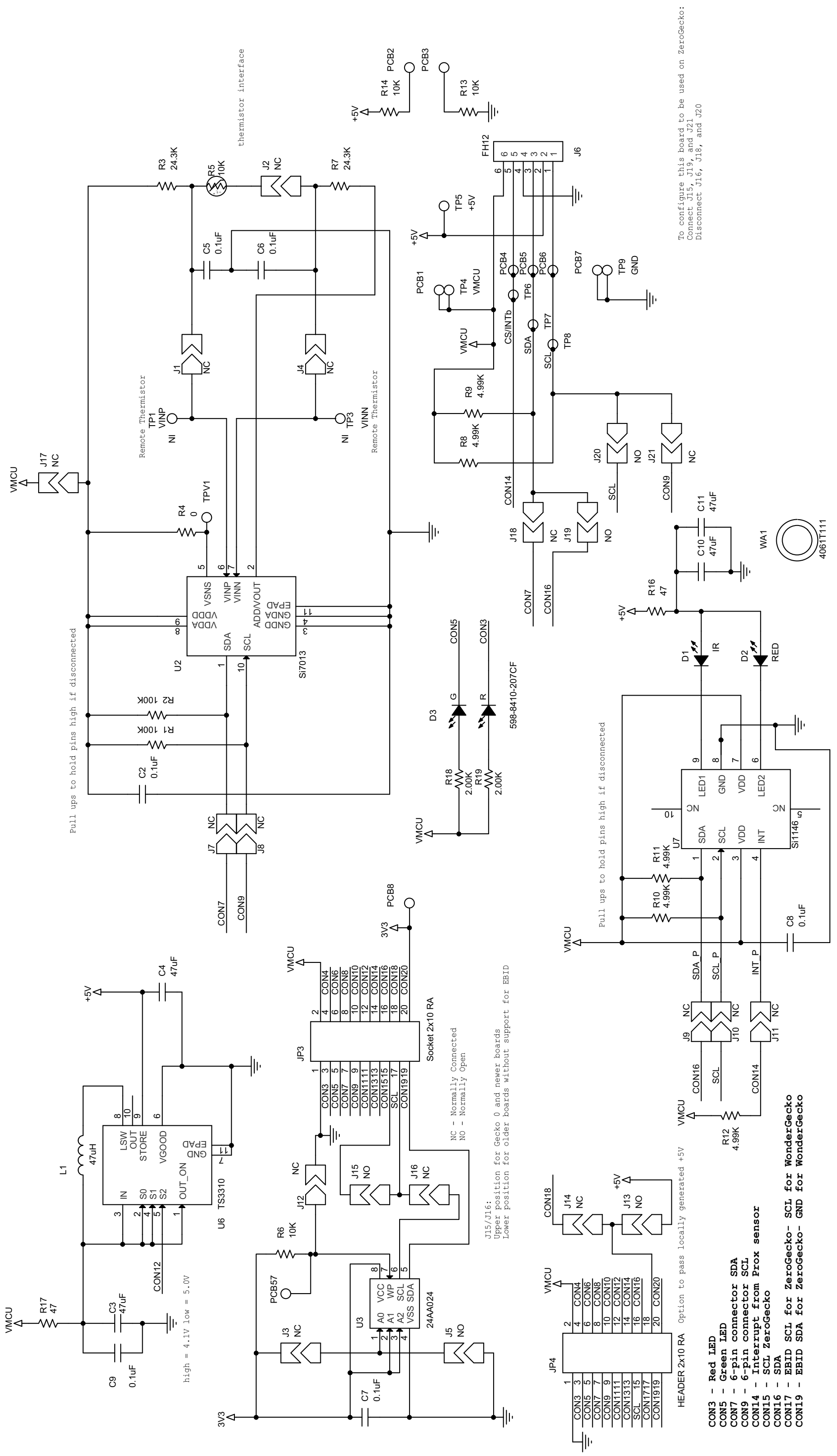



Figure 20. Biometric EXP Schematic

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