# MAXREFDES103# Health Sensor Band User Guide

*UG7145; Rev 0; 1/20*



## Abstract

This user guide provides information about preparing and running the MAXREFDES103# health sensor band. This platform uses a high-sensitivity PPG biosensor, power-management IC (PMIC), and microcontrollers from Maxim Integrated® in a wrist-worn design that allows the capture of biometric signals important to healthcare. The platform also contains algorithms for calculating heart health based on the biosensor measurements.

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## Detailed Hardware Description

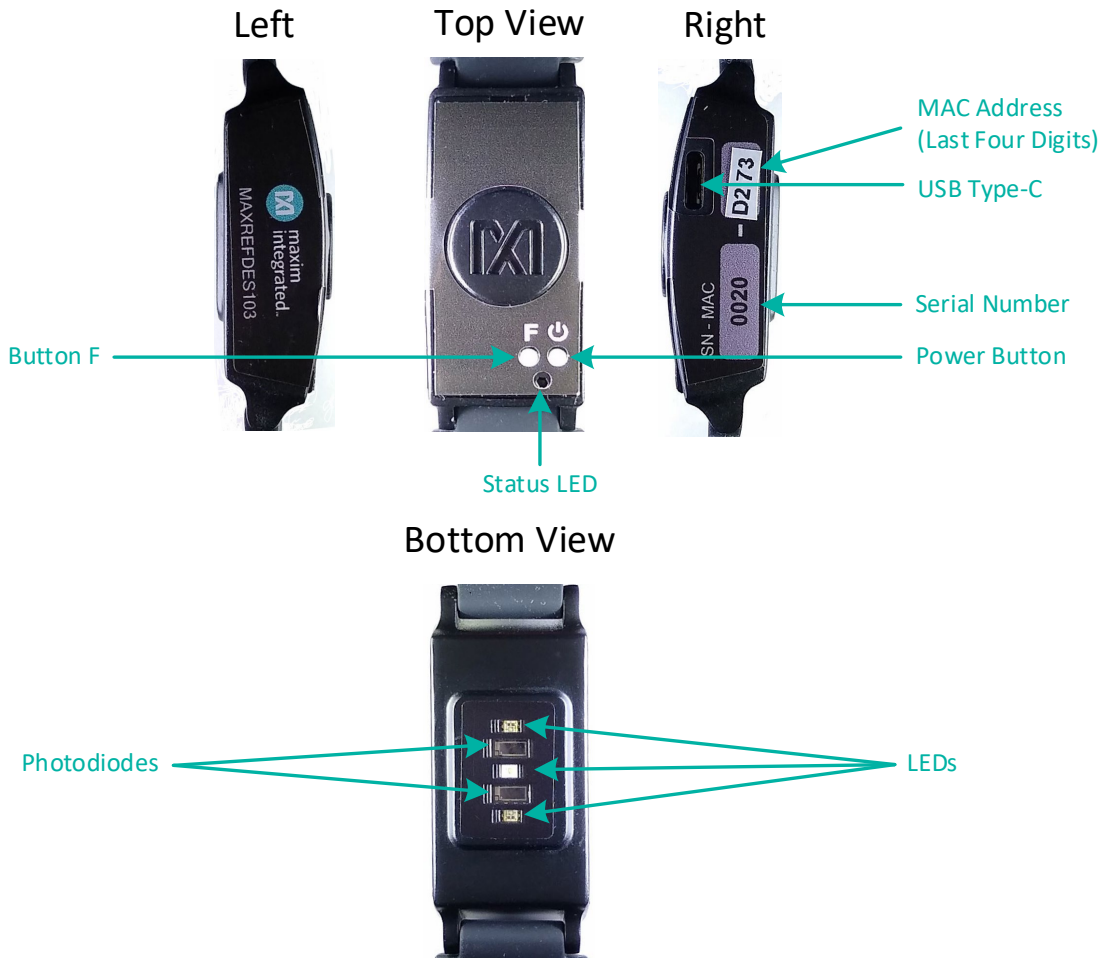


*Figure 1. MAXREFDES103# wearable form factor in detail.*

## Required Equipment

The MAXREFDES103# platform includes the following components:

- Micro board
  - MAX32630 microcontroller
  - MAX20303 power-management IC (PMIC)
  - Dual-mode Bluetooth® connection
  - Tri-color status LED
- Sensor board
  - MAX86141 analog front-end and optical heart rate sensor with one green LEDs, one red LED, one IR LED, and two photodiodes

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    - MAX32664 microcontroller with embedded heart-rate algorithm
    - Three-axis accelerometer
    - MAX4740 quad SPDT switch which, in combination with the MAX86140/41, enables different LED and PD configurations
    - One green LED, two combination RGB LEDs (One of these RGB LEDs is currently not used by the algorithm. The extra LED is reserved for future use: To simplify the design, the extra LED and the MAX4740 may be removed for the heart rate, $SpO_2$ use case.)
- MAXDAP Pico Adapter board to be used during a firmware upgrade for the micro board
- Two USB Micro-B cables for firmware upgrade of the micro board or for PC communication with the micro board or charging of the health sensor band
- Health sensor band enclosure
- Battery
- One USB Type-C™ cable for PC communication with the micro board (Windows® 7 or Windows 10) or charging of the health sensor band

Additional requirements:

- PC (Windows 10 only) with Bluetooth connection for data streaming and logging
- Android® device with Bluetooth connection for data streaming and logging

*Android is a registered trademark of Google Inc.*
*USB Type-C is a trademark of Universal Serial Bus Implementers Forum, Inc.*
*Windows is a registered trademark of Microsoft Corporation.*

## System Diagram

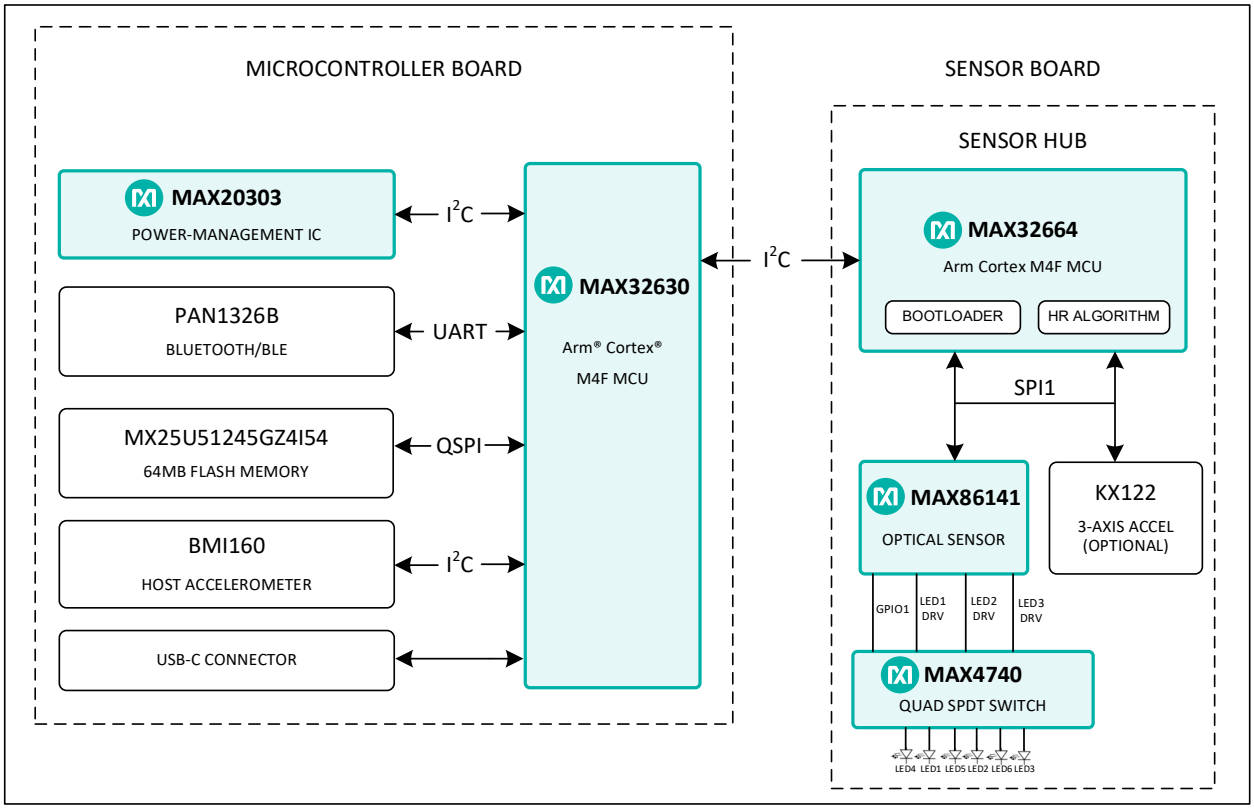


*Figure 2. MAXREFDES103# system diagram.*

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## Operating the Health Sensor Band

### Power On/Off

The MAXREDES103# can be powered on by pressing and holding the power button for at least one second.

Alternatively, the device powers on when connected to a PC using a USB Type-C cable or when connected to a MAXDAP Pico Adapter board.

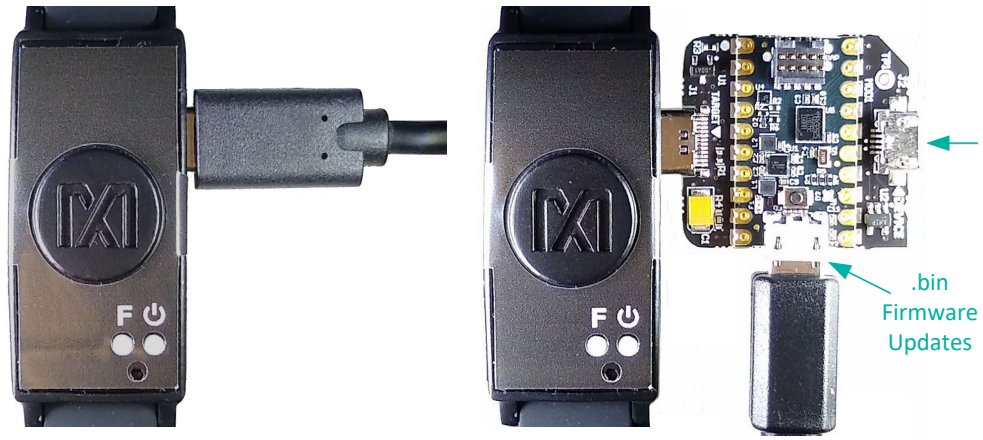


*Figure 3. USB Type-C cable (left) and MAXDAP Pico Adapter board (right).*

The MAXDAP Pico Adapter board has two USB Micro-B connectors. The bottom connector next to the pushbutton is used for updating the .bin firmware of the micro board. The right connector next to the “Device” label is used for the serial connection between the MAXREFDES103# and the PC. Both connectors provide power to the MAXREFDES103#.

To power off, press and hold the power button on the MAXREFDES103 for at least 12 seconds.

Note: If the device becomes unresponsive, a hard reset to the device may be performed by using the power-off and power-on procedures.

### Button Functionality

Table 1 describes the functionality of the two buttons.

## Table 1. Button Functionality

| Button | Short Press | Long Press (3s) | Extra Long Press (12s) |
|---|---|---|---|
| **Power Button** | Turn off/on status LED; to power on, press for 1s | Power off (after a 3s press, LED blinks magenta and if the button is released while blinking magenta, the device is powered off) | Power off |
| **Button F** | Start/stop data collection (flash logging) | N/A | N/A |

### Color Definitions for LED Status

Table 2 describes the state of the device for a given color and blinking status.

## Table 2. Color Definitions for LED Status

| LED Color | Solid (No Blinking) | Fast Blink | Slow Blink |
|---|---|---|---|
| **Red** | Failure detected – needs system reset | Communications with MAX32664 | Battery critically low (<10%) |
| **Green** | USB connected | Streaming USB data | Device is ready |
| **Blue** | Bluetooth Low Energy (Bluetooth LE, or casually known as BLE) connected | Streaming Bluetooth LE data | Reserved |
| **Magenta** | Reserved | Fast blinks for 2s after a power button long press. If the button is released while fast blinking, then the device is powered off | Reserved |
| **Cyan** | Reserved | Flash logging active | 5 blinks indicate that flash logging is complete |
| **Yellow** | System is initializing | MAX32664 programming is active | Battery low (10% to 25%) |
| **White** | MSD mode | Reserved | Reserved |
| Off | LEDs have been turned off | N/A | N/A |

## How to Position the Device on the Wrist

Position the health sensor band approximately one finger width up the arm from the wrist bone. If possible, wear the health sensor band on the non-dominant hand, as this improves the quality of the data. The health sensor band should fit tightly but comfortably around the wrist. Make sure the skin has direct contact with the openings for the LED/photodiodes at the center of the back of the health sensor band.

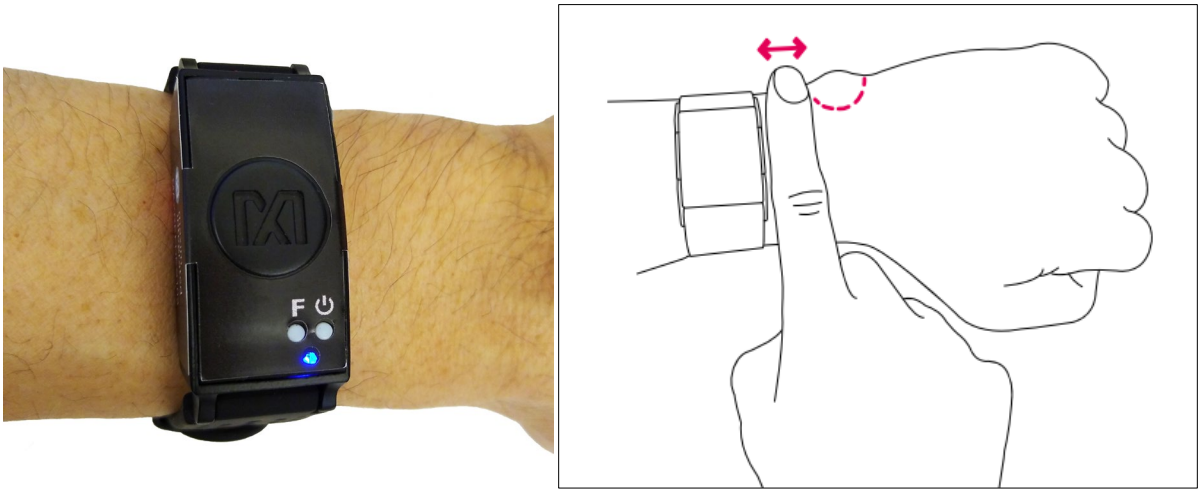

*Figure 4. PPG measurement.*

## Software Updates

The MAXREFDES103# has been pre-loaded with the firmware that was available during production. A firmware upgrade is strongly recommended to ensure that the most recent set of firmware is loaded. To update the firmware, perform the following steps in this exact order:

1. Install the PC GUI using the .msi file
2. Flash the micro board .bin file
3. Flash the algorithm .msbl file

### Installing the PC GUI

1. Uninstall any previously installed versions of the DeviceStudio GUI.
2. Download and extract the Eval Package for either Windows 10 (supports USB and Bluetooth) or Windows 7 (supports only USB) from the Maxim website for the MAXREFDES103#.

   Note: The software package includes the latest firmware .bin, algorithm .msbl, and the corresponding Windows application .msi. **All three must be updated to ensure compatibility.**

3. Double click on the .msi file. Check the box for "I accept the terms in the License Agreement." Click **Install**, and then click **Finish**.

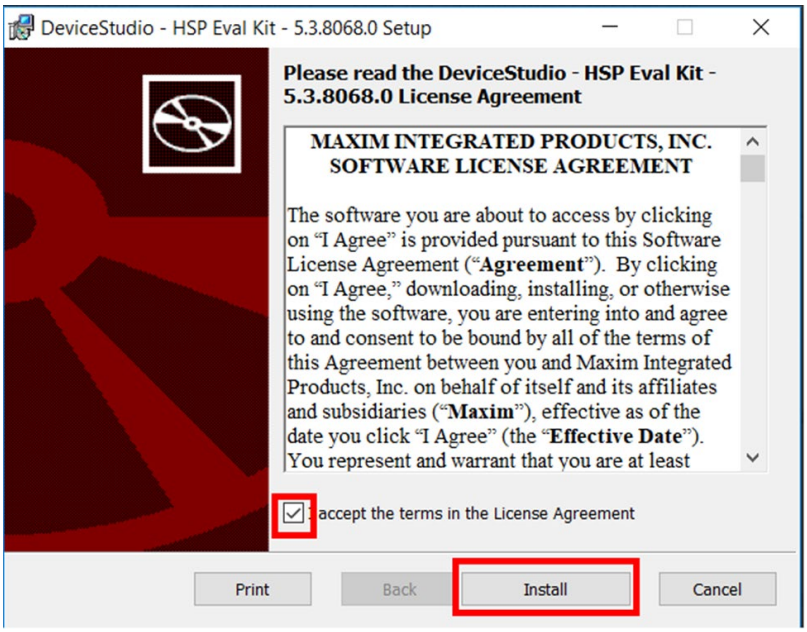


*Figure 5. Install the .msi file.*

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## Updating the Micro Board Firmware (.bin) on the MAXREFDES103#

Firmware upgrades to the MAX32630 may be performed using the provided MAXDAP Pico Adapter board per the following steps.

Note: The software package includes the latest .bin firmware, .msbl algorithm, and the corresponding .msi Windows application. **All three components must be updated to ensure compatibility.**

1. Connect the MAXDAP Pico Adapter board .bin firmware updates port to the PC using the USB Micro-B cable.

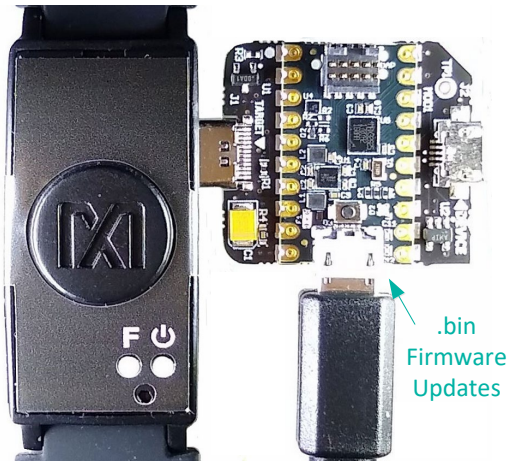



*Figure 6. MAXDAP Pico Adapter .bin firmware updates port connected to the PC.*

2. Wait for the Windows drivers to install. After the drivers have installed, the PC recognizes the device, which shows up as a drive named **DAPLINK** on the PC.

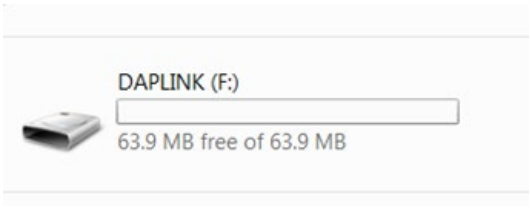



*Figure 7. DAPLINK drive on the PC.*

3. To flash the host firmware to the MAX32630, drag and drop the .bin binary file into the DAPLINK drive on your PC.

4. The MAXREFDES103# **does not automatically reset** after flashing the micro board with the new firmware. Press and release the reset button on the MAXDAP Pico Adapter board to restart the health band. The button is located below the top USB Micro-B connector.

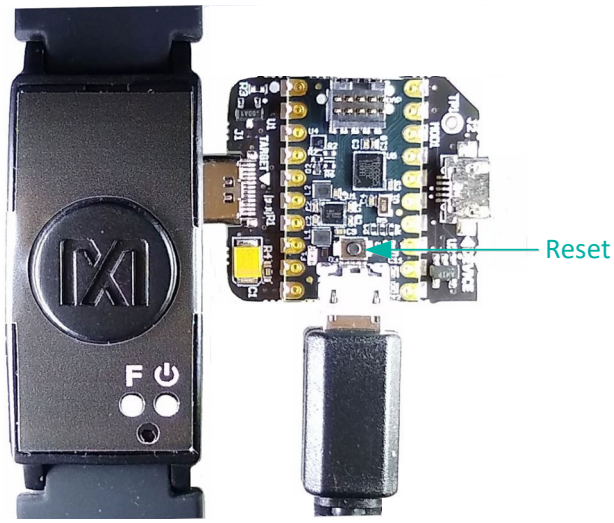



*Figure 8. Reset button on the MAXDAP-TYPE-C Pico Adapter board.*

## Updating the MAX32664 Sensor Hub Algorithm Firmware (.msbl)

After the host firmware binary is updated to the micro board, the .msbl Biometric Sensor Hub algorithm must be updated with the PC GUI by performing the following steps.

Note: The software package includes the latest .bin firmware, .msbl algorithm, and the corresponding .msi Windows application. **All three components must be updated to ensure compatibility.**

1. Open the Maxim DeviceStudio Windows application.
2. Connect the MAXDAP Pico Adapter board device port to the PC using the USB Micro-B cable. Wait five seconds.

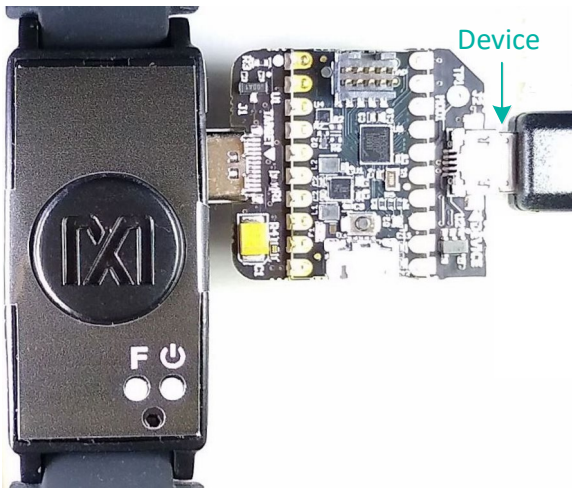



*Figure 9. MAXDAP Pico Adapter board device port connected to the PC.*

3. Select the **Serial over USB/Bluetooth** scan option, then click **Scan**.

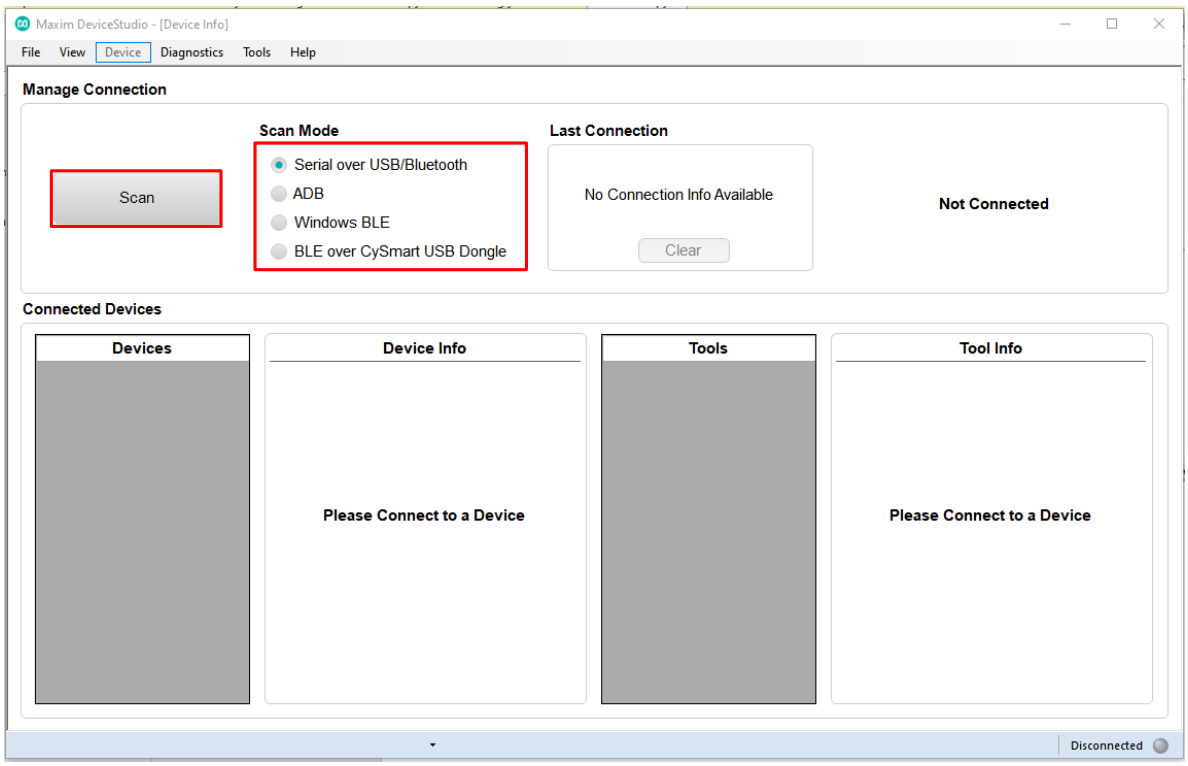



*Figure 10. Maxim DeviceStudio scan options.*

4. Verify that the **Devices** list in the **Connected Devices** section shows **PPG**.

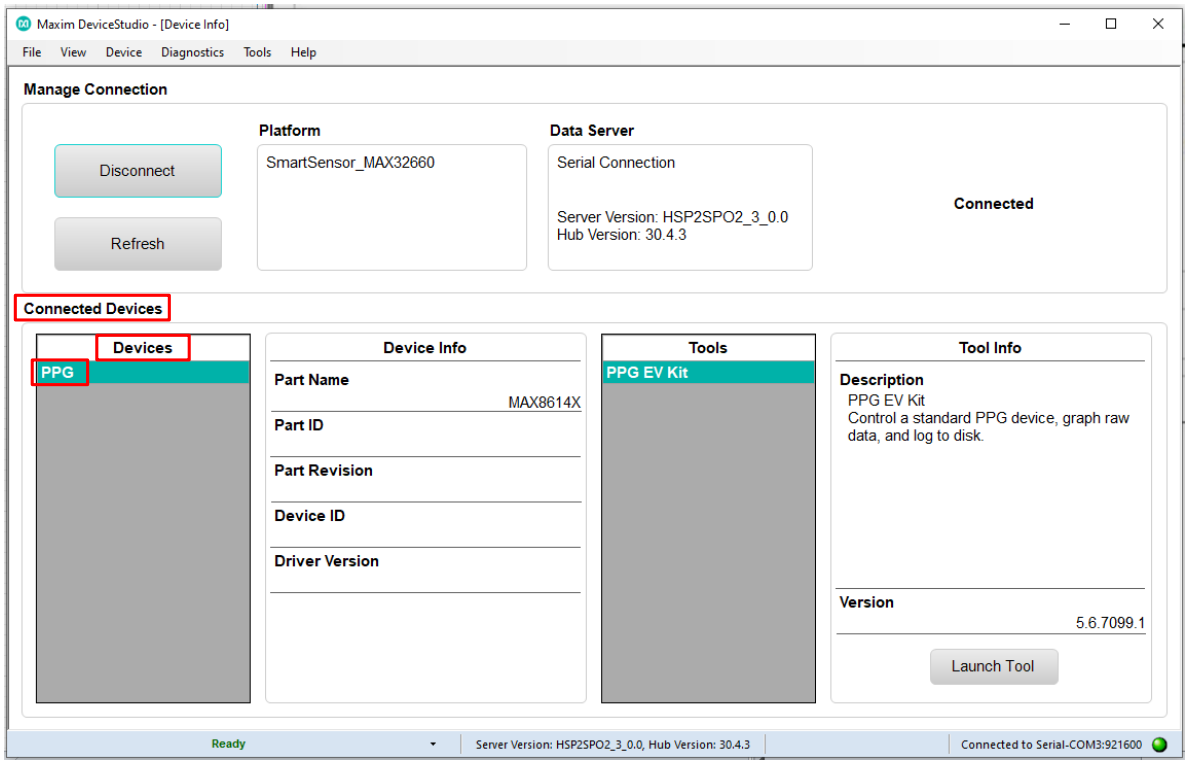



*Figure 11. Maxim DeviceStudio connected devices.*

5. Go to the **Device** tab and select **Update SmartSensor_MAX32664 Software**. Then select **Update Firmware** and select the *.msbl file from the extracted Eval Package and click **Open**.

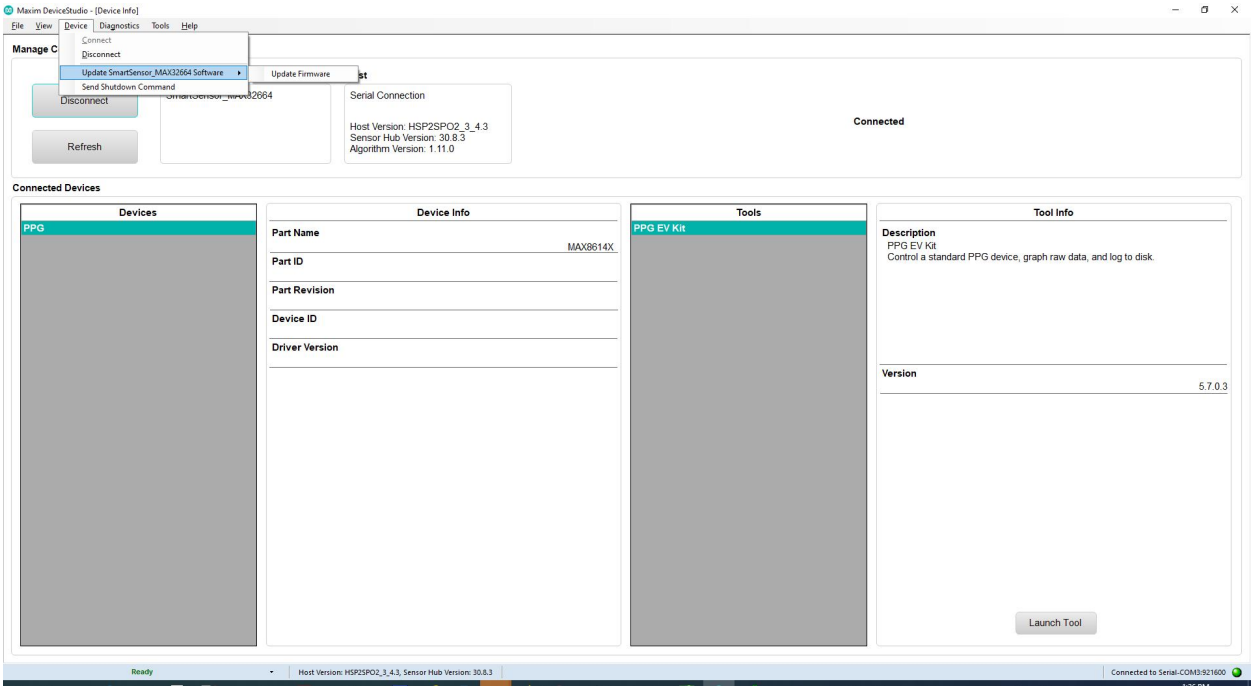



*Figure 12. Device tab to update the MAX32664 .msbl.*

6. Click **OK** on the **Warning!** pop-up window.

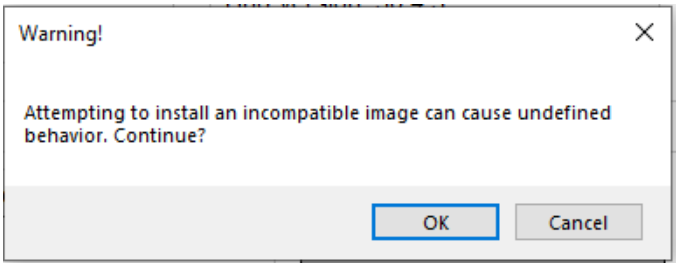



*Figure 13. Warning message.*

The embedded algorithm for heart-rate and $SpO_2$ measurement is uploaded to the MAX32664 microcontroller on the sensor board.

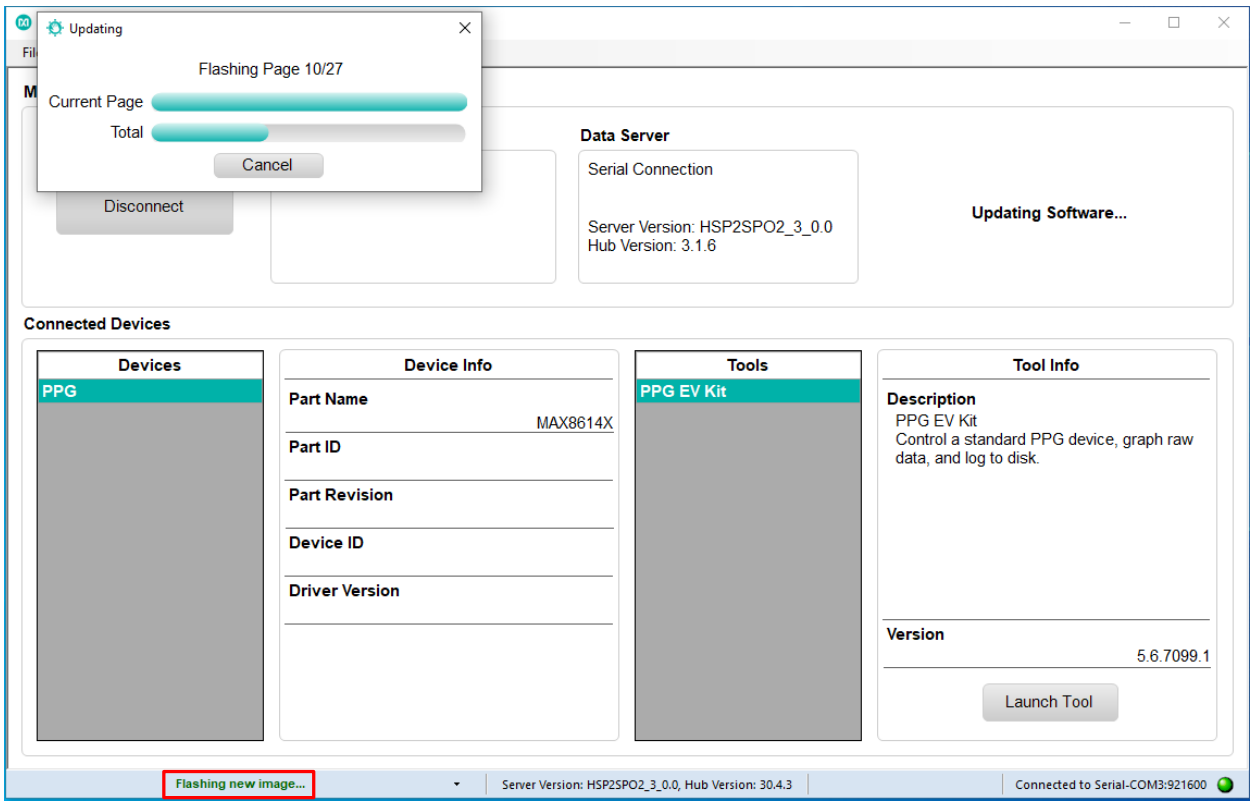



*Figure 14. Upload the embedded heart-rate algorithm to the MAX32664.*

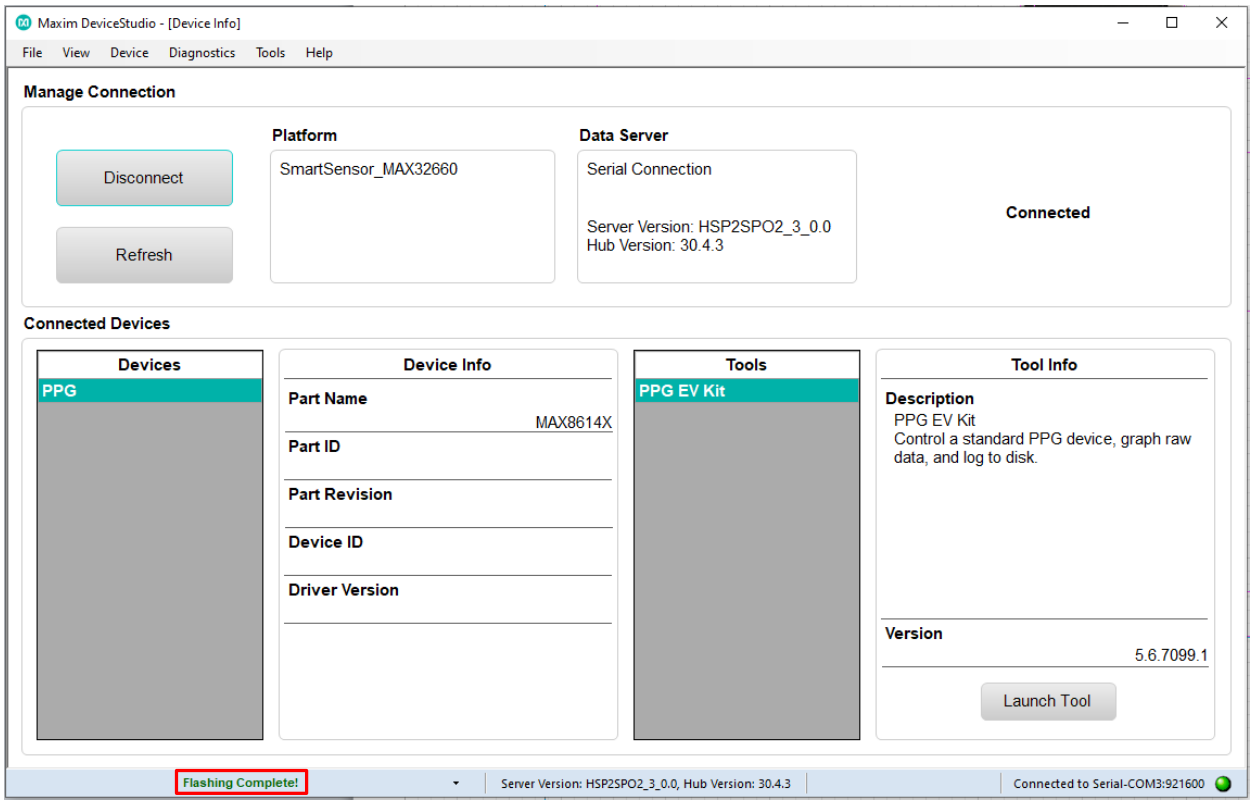



*Figure 15. .msbl file flashed successfully.*

## Evaluation GUIs

The MAXREFDES103 is compatible with two evaluation GUIs: the DeviceStudio PC GUI and the Maxim Health Sensor Platform GUI App for Android.

The DeviceStudio PC GUI provides the ability to configure the algorithm, as well as to view and log the processed/raw data. In raw data mode, the algorithm is disabled and the AFE settings may be configured. In algorithm mode, the embedded Maxim-supplied algorithm is configured and processed, and raw data for heart rate and $SpO_2$ are displayed. DeviceStudio also has a parser utility that converts the logged data in flash memory to .csv format.

The Maxim Health Sensor Platform GUI allows the display of processed data and the logging of data through an Android app. The app displays the processed data from the embedded algorithm for:

- Heart Rate
- $SpO_2$

In addition to displaying the data from the embedded algorithm, the app includes additional algorithms:

- Heart Rate Variability
- Respiration Rate
- Sleep Quality

### Using the DeviceStudio PC GUI

The Windows 10 PC GUI currently supports connection to the MAXREFDES103# through USB or Bluetooth LE. The Windows 7 PC GUI only supports connection to the MAXREFDES103# through USB.

#### *Installing the Windows 7 Driver for the PC GUI*

To use the PC GUI on a Windows 7 PC, installing the driver manually might be required. To manually install the USB serial driver, perform the following steps:

1. Uninstall any previously installed versions of the DeviceStudio GUI.
2. Download the Windows 7 Eval Package from the Maxim website for the MAXREFDES103#.
3. Extract the .zip file to a known location.
4. Open **Device Manager**, which can be found in the Windows Control Panel.
5. If manual driver installation is needed, the MAXREFDES103# appears under **Other devices** as **CDC DEVICE**. Right-click **CDC DEVICE** and select **Properties**.

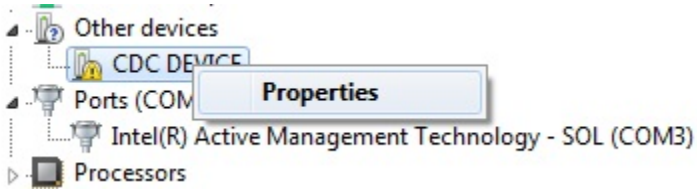



*Figure 16. CDC DEVICE in Device Manager.*

6. If **Update Driver…** is grayed out, click **Change Settings**, and then click **Update Driver…**

7. Select **Browse my computer for driver software**.

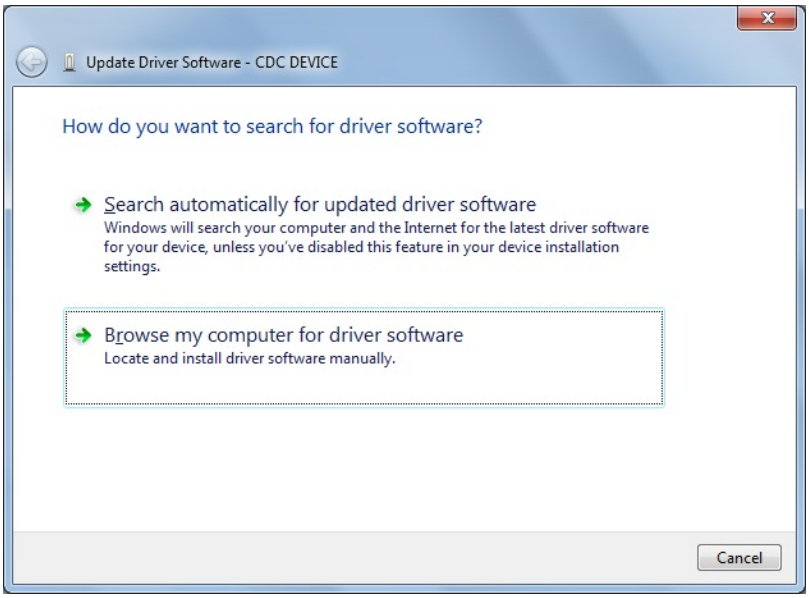



*Figure 17. Locate and install the driver manually.*

8. Navigate to the location of the.zip file that was extracted in step 3, then click **Next**.

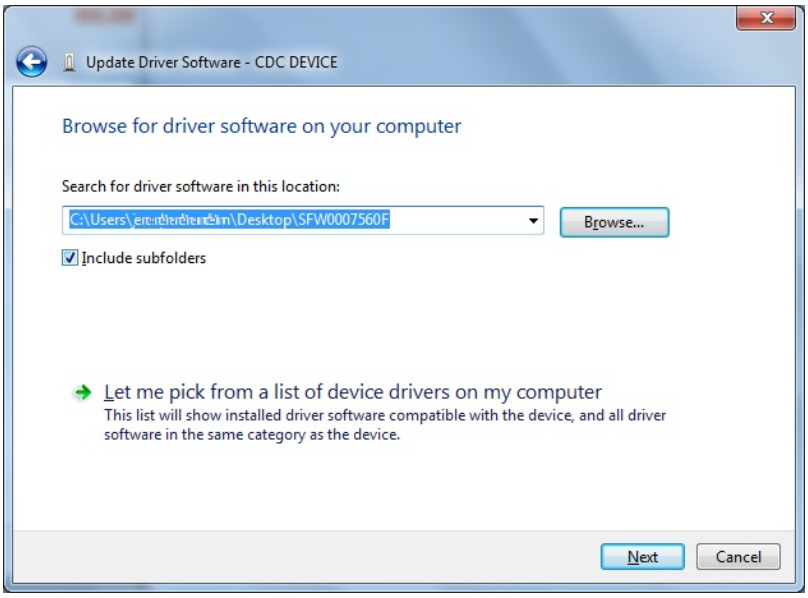



*Figure 18. Browse to the extracted release package.*

9. When prompted by the **Windows Security** window, click **Install this driver software anyway**.

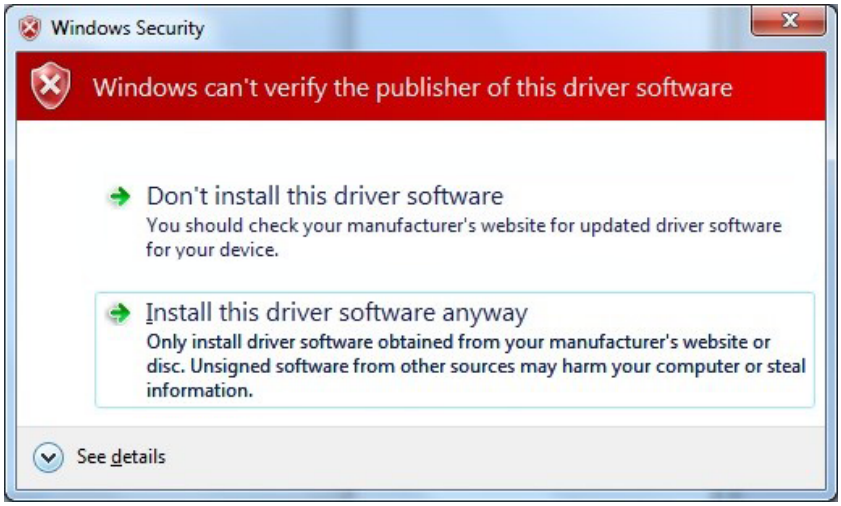



*Figure 19. Select Install this driver software anyway.*

10. After the driver is installed successfully, the MAXREFDES103# appears as an Mbed® Serial Port. (The COM port number used may be different from COM4.)


*Figure 20. Mbed Serial Port in Device Manager.*

### *USB Connection*

1. Connect the health sensor band to the PC with a USB Type-C cable (or with the MAXDAP Pico Adapter board using a USB Micro-B cable).

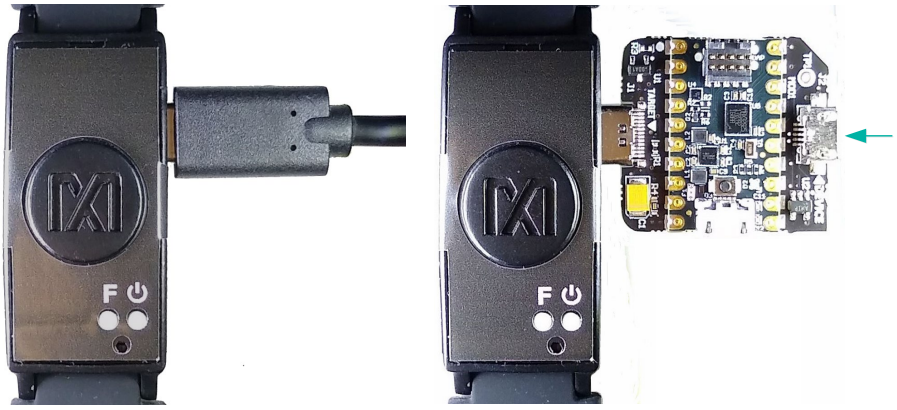


*Figure 21. USB connection to PC using a USB Type-C cable (left) and MAXDAP Pico Adapter board device port (right).*

*Mbed is a registered trademark of Arm Limited.*

2. Under **Scan Mode**, select **Serial over USB/Bluetooth**, then click **Scan**.

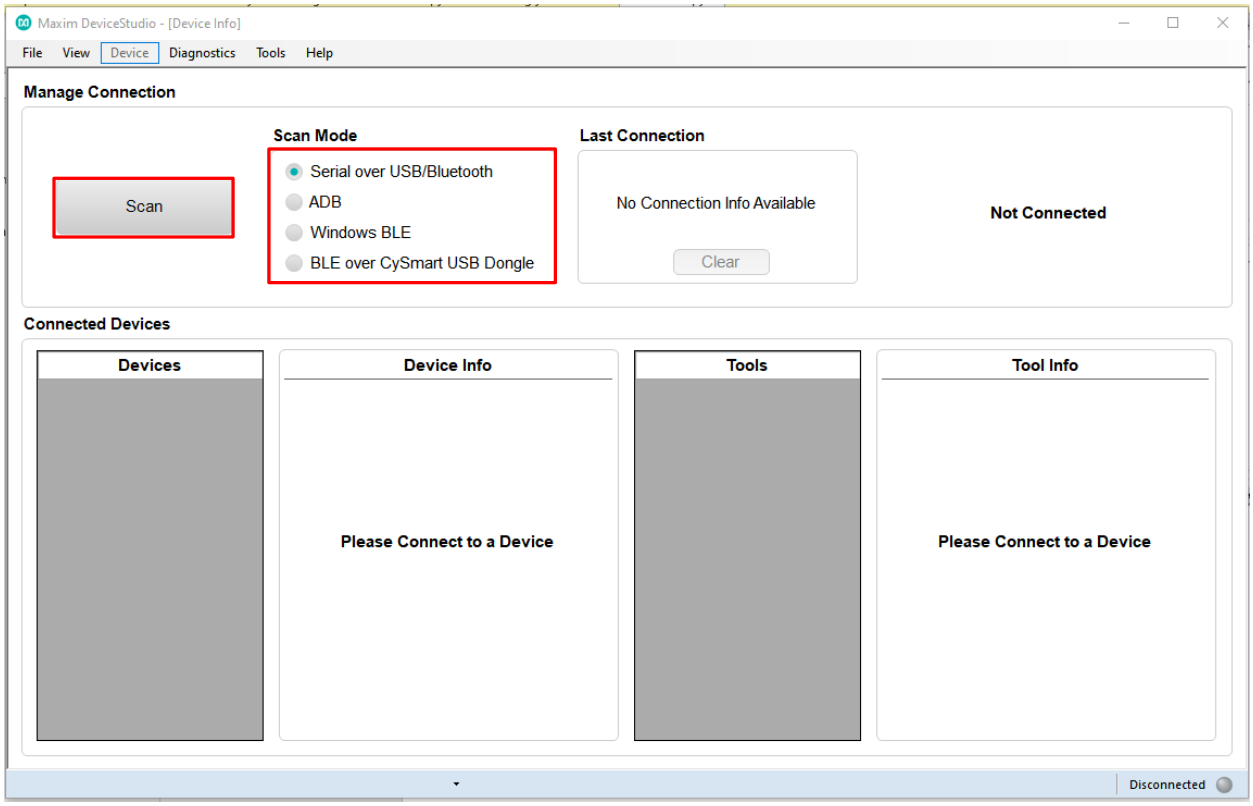



*Figure 22. Scan for available devices.*

3. Verify that the **Devices** list in the **Connected Devices** section shows **PPG**.

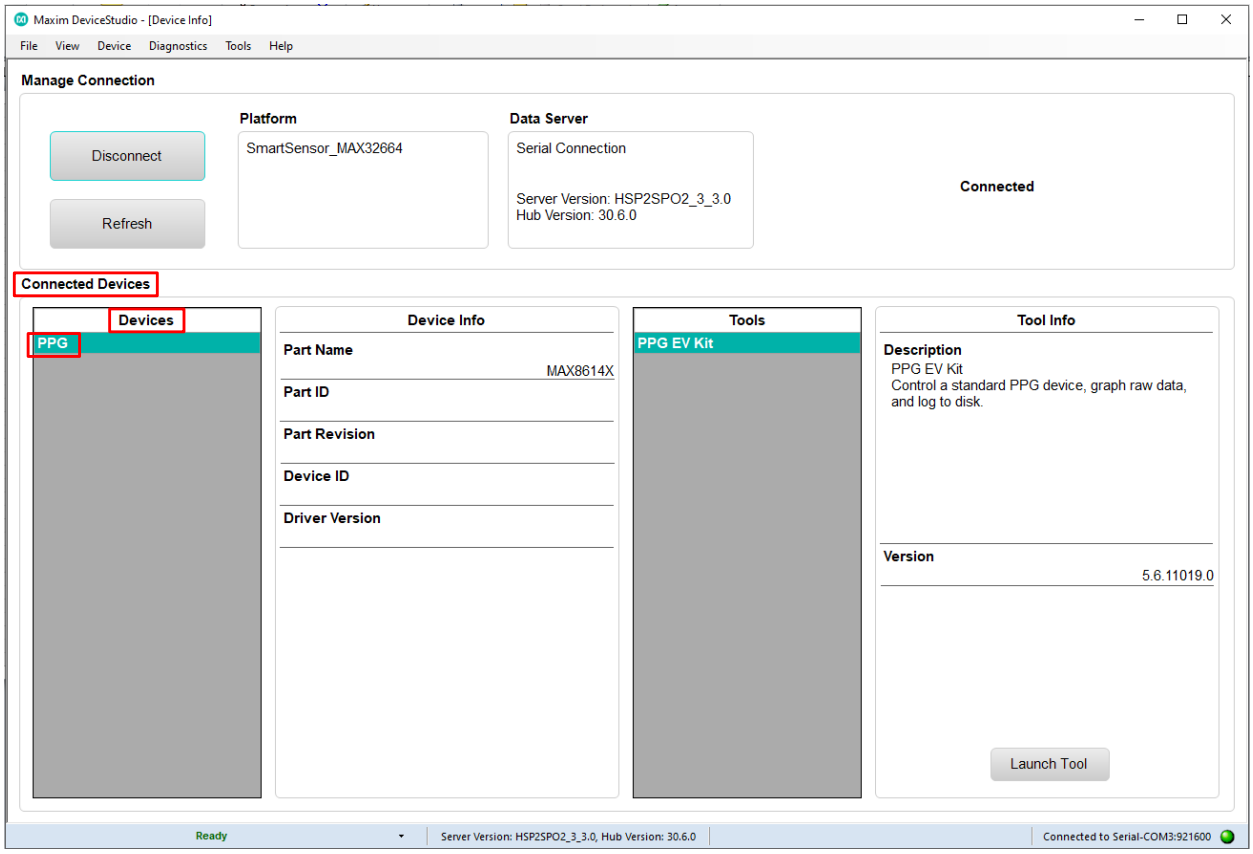



*Figure 23. Successful connection over USB.*

### *Bluetooth LE Connection for Windows 10*

1. Under **Scan Mode**, select **Windows BLE** and click **Scan**.

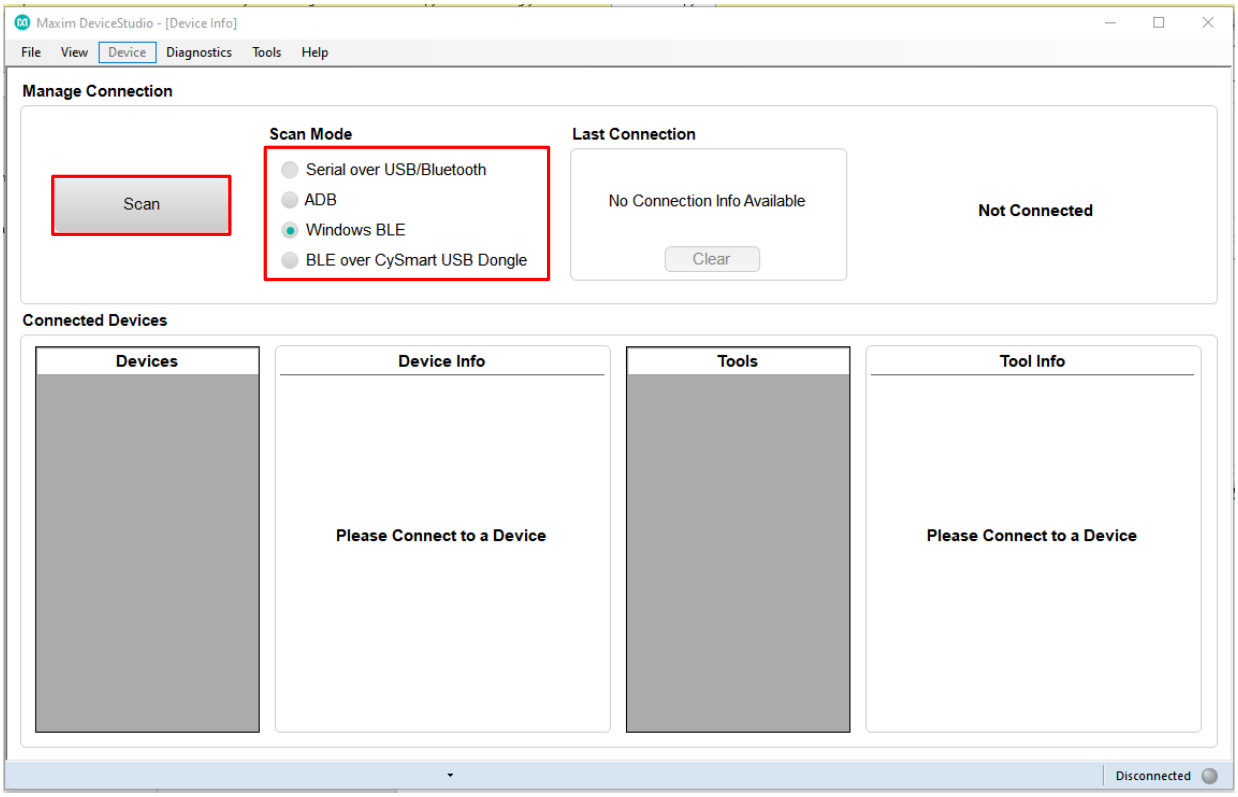



*Figure 24. Scan for available Windows BLE devices.*

2. Select the health sensor device for pairing. (The highest signal strength in dBm will usually be the closest health sensor device, and each MAXREFDES103# is labeled with the last four digits of the MAC address). Click **Connect**.

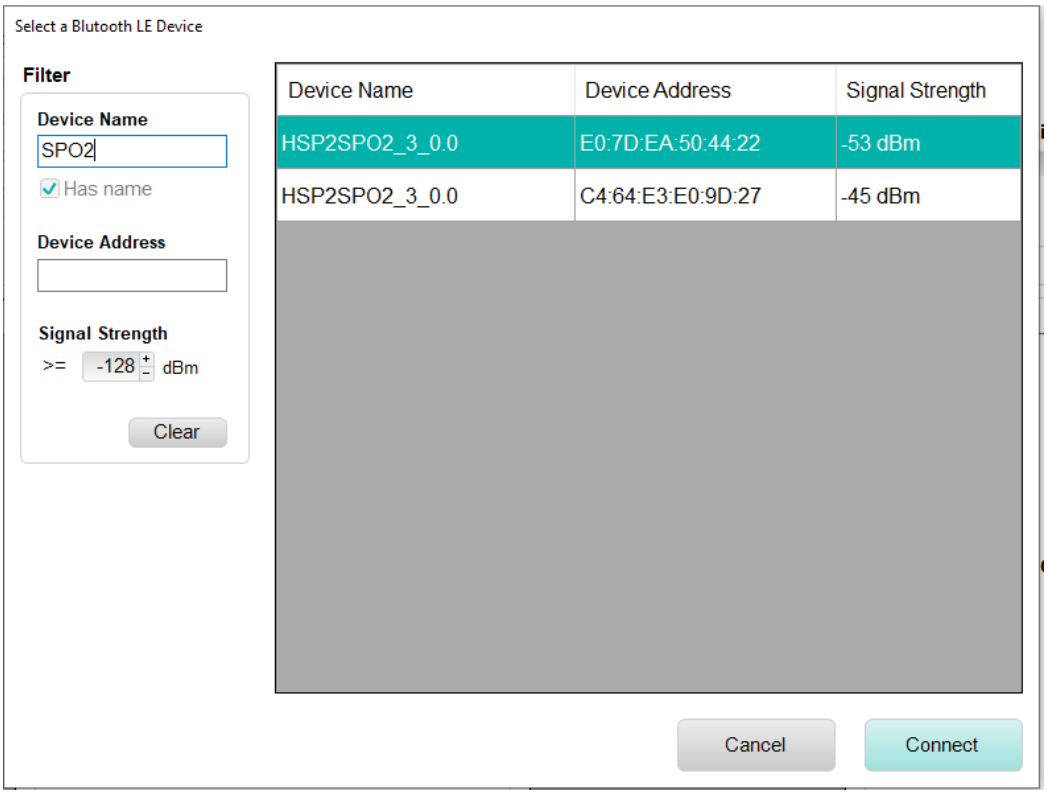



*Figure 25. Bluetooth LE device selection.*

3. Verify that the **Devices** list under **Connected Devices** shows **PPG**.

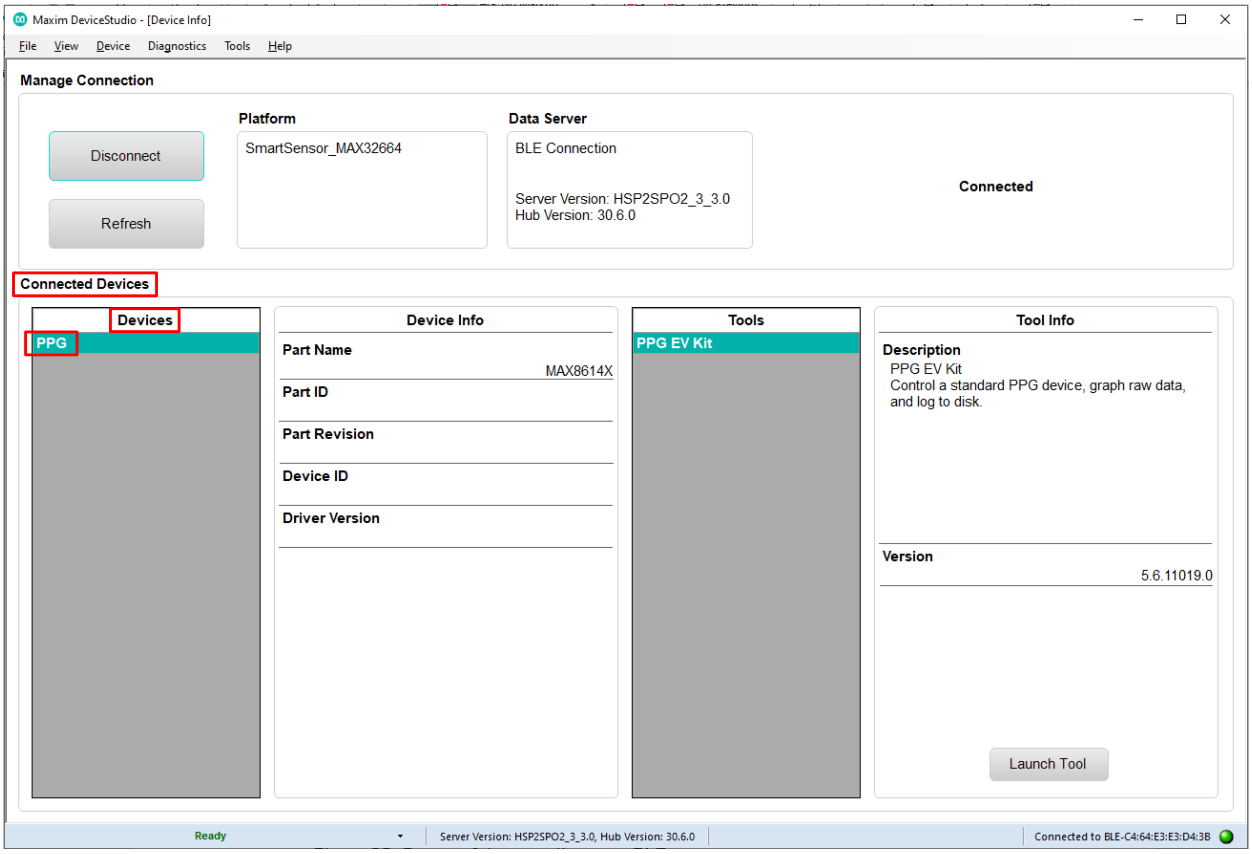



*Figure 26. Successful connection over Bluetooth LE.*

### *Starting the PPG Measurement*

1. Click **Launch Tool**.
2. Select **Algorithm** to allow the MAX32664 algorithm to dynamically adjust the AFE settings and measure the heart rate and $SpO_2$.
3. Select **0:Continuous HRM and SpO2** to configure the algorithm to run continuously.
4. Select **SCD** to enable skin contact detection.
5. Select **AEC** to enable automatic exposure control.
6. Click **Default** to configure the AEC to the default settings.
7. Select **Accelerometer** to plot the accelerometer data.
8. Select **Algorithm Data** to see the algorithm data: HR (bpm), HR confidence (%), RR peak interval (R-to-R msec), RR Confidence, Activity, $SpO_2$ (%), SpO2 Confidence (%), R Value, SpO2 % Completion (for one-shot), Low Signal Flag, Motion Flag, $SpO_2$ State, and SCD State.
9. Select **Log to File** and **Write Header** to save the data to a file.
10. Click **Start Monitoring** to show the measurement data.

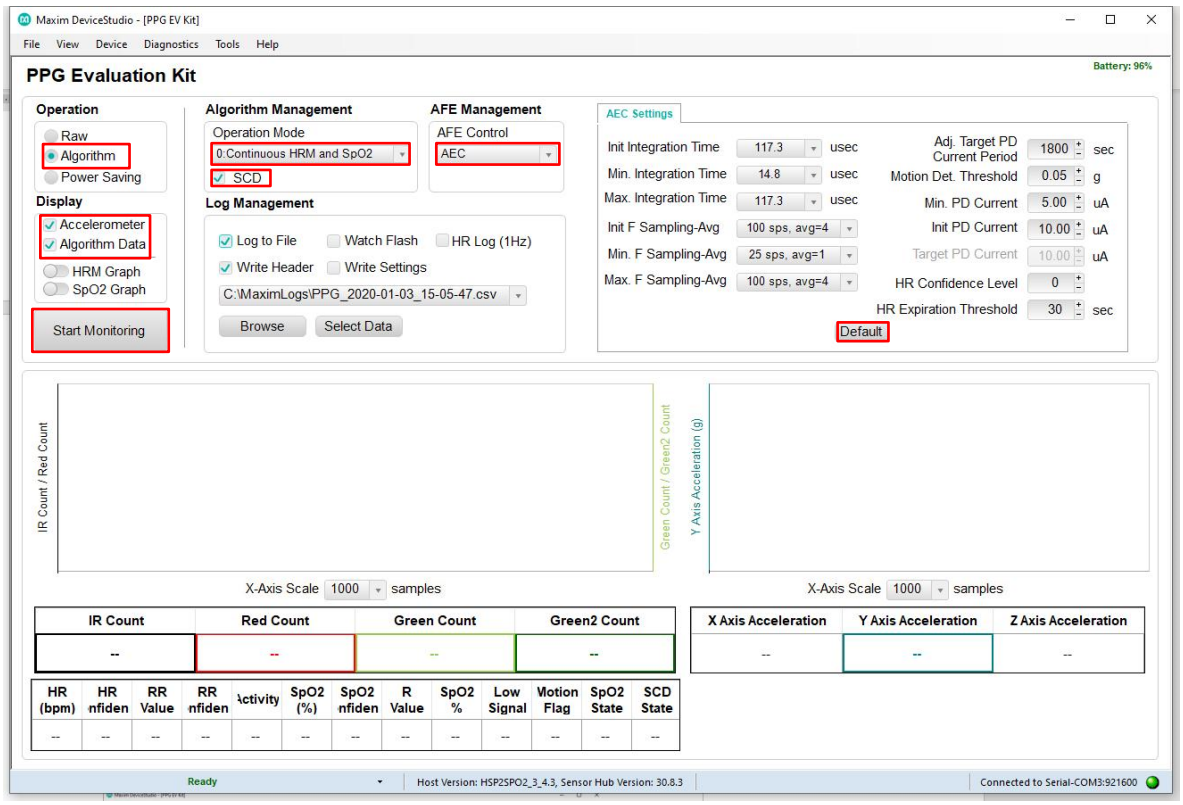



*Figure 27. Configure for Algorithm mode.*

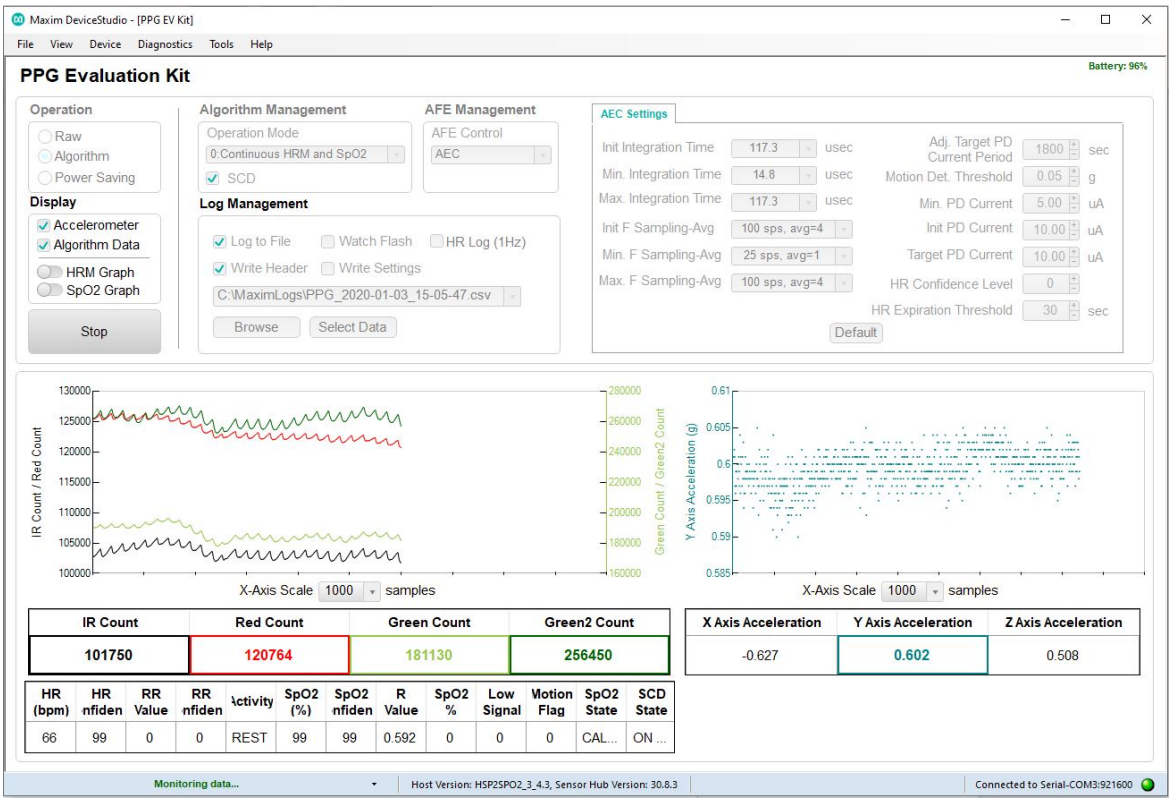



*Figure 28. Measurement data displayed.*

***Data Format of the Log File***

## Table 3. Data Table Column Definitions for the Log File (PPG_*.csv)

| Log File Headings | Description |
|---|---|
| Time | Timestamp in minutes, seconds, and tenths of seconds (MM:SS.T) |
| Sample Count | Data index ranging from 0 to 255 for monitoring if samples are dropped during Bluetooth transmission |
| Green Count | Green counts detected by photodiode 1 |
| Green2 Count | Green counts detected by photodiode 2 |
| IR Count | IR counts |
| Red Count | Red counts |
| X Axis Acceleration (g) | Acceleration in x-axis, in unit of g |
| Y Axis Acceleration (g) | Acceleration in y-axis, in unit of g |
| Z Axis Acceleration (g) | Acceleration in z-axis, in unit of g |
| Operating Mode | 0: Continuous HRM and continuous $SpO_2$<br>1: Continuous HRM and one-shot $SpO_2$<br>2: Continuous HRM<br>3: One-shot HRM<br>4: One-shot HRM and one-shot $SpO_2$<br>5: Activity tracking<br>6: $SpO_2$ calibration |
| Heart Rate (bpm) | Heart rate, in unit of beats per min |
| HR Confidence (%) | Heart-rate algorithm extraction confidence; a threshold confidence >85% is recommended |
| RR | R-to-R peak interbeat interval time (ms) of the QRS heart beat wave |
| RR Confidence (%) | R-to-R confidence level, 0 to 100% |
| Activity | 0: Rest<br>1: Other<br>2: Walk<br>3: Run<br>4: Bike<br>5: Rhythmic |
| R Value | $SpO_2$ R value (R is defined in Maxim Application Note 6845) |
| SPO2 Confidence (%) | $SpO_2$ confidence level; 0 to 100% |
| SPO2 (%) | $SpO_2$ value; 0 to 100% |
| SPO2 Percent Complete | $SpO_2$ percent complete (only applicable for one-shot mode); 0 to 100% |
| Low Signal Quality | 0: Good $SpO_2$ signal quality<br>1: Low $SpO_2$ signal quality |
| Motion Flag | 0: Little or no motion<br>1: Excessive motion |
| WSPO2 Low Pi | 0: Normal Perfusion Index<br>1: Low Perfusion Index |
| Unreliable R | 0: Measurement of $SpO_2$ R is reliable<br>1: Measurement of $SpO_2$ R is not reliable |
| SPO2 State | 0: LED adjustment<br>1: Computation<br>2: Success<br>3: Timeout |
| SCD State | Skin contact state:<br>0: No decision<br>1: Off skin<br>2: Contact with object<br>3: On skin |
| SAMPLE Time | Timestamp in seconds |

| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z | AA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Time | Sample C | Green Co | Green2 Co | IR Count | Red Coun | X Axis Acc | Y Axis Acc | Z Axis Acc | Operating | Heart Rat | HR Confic | RR | RR Confic | Activity | R Value | SpO2 Con | SpO2 (%) | SpO2 Perf | Low Signa | Motion Fl | WSPO2 Lo | Unreliabl | SpO2 Stat | SCD State | SAMPLE Time | |
| 2 | 57:58.8 | 0 | 140768 | 139169 | 28425 | 30573 | -0.789 | 0.283 | -0.557 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 44063 | |
| 3 | 57:58.8 | 1 | 238779 | 270037 | 28203 | 30415 | -0.788 | 0.285 | -0.565 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 44063 | |
| 4 | 57:58.9 | 2 | 197539 | 309576 | 28096 | 30344 | -0.796 | 0.284 | -0.559 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 44063 | |
| 5 | 57:58.9 | 3 | 174896 | 281813 | 28045 | 30317 | -0.792 | 0.287 | -0.56 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 44063 | |
| 6 | 57:59.0 | 4 | 168444 | 270334 | 28006 | 30293 | -0.788 | 0.287 | -0.567 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48646 | |
| 7 | 57:59.0 | 5 | 164085 | 262955 | 27979 | 30275 | -0.787 | 0.286 | -0.559 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48646 | |
| 8 | 57:59.0 | 6 | 163432 | 261765 | 27981 | 30276 | -0.797 | 0.287 | -0.558 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48646 | |
| 9 | 57:59.0 | 7 | 162968 | 260989 | 27988 | 30281 | -0.793 | 0.283 | -0.561 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48646 | |
| 10 | 57:59.1 | 8 | 162701 | 260414 | 28004 | 30275 | -0.79 | 0.289 | -0.56 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48646 | |
| 11 | 57:59.1 | 9 | 162634 | 260036 | 28040 | 30290 | -0.784 | 0.285 | -0.56 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48646 | |
| 12 | 57:59.2 | 10 | 162573 | 259854 | 28066 | 30310 | -0.79 | 0.287 | -0.56 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48646 | |
| 13 | 57:59.2 | 11 | 162558 | 259878 | 28101 | 30331 | -0.788 | 0.289 | -0.56 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48646 | |
| 14 | 57:59.3 | 12 | 162625 | 260085 | 28135 | 30347 | -0.794 | 0.286 | -0.56 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48647 | |
| 15 | 57:59.3 | 13 | 162793 | 260460 | 28171 | 30370 | -0.787 | 0.281 | -0.559 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48647 | |
| 16 | 57:59.3 | 14 | 162994 | 260971 | 28207 | 30378 | -0.793 | 0.287 | -0.561 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48647 | |
| 17 | 57:59.4 | 15 | 163219 | 261574 | 28242 | 30397 | -0.788 | 0.286 | -0.564 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48647 | |
| 18 | 57:59.4 | 16 | 163419 | 262264 | 28268 | 30410 | -0.781 | 0.28 | -0.558 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48647 | |
| 19 | 57:59.5 | 17 | 163635 | 263030 | 28286 | 30419 | -0.78 | 0.282 | -0.562 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48647 | |
| 20 | 57:59.5 | 18 | 163841 | 263799 | 28311 | 30427 | -0.807 | 0.29 | -0.562 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48647 | |
| 21 | 57:59.5 | 19 | 164080 | 264602 | 28334 | 30433 | -0.792 | 0.292 | -0.558 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48647 | |
| 22 | 57:59.6 | 20 | 164388 | 265470 | 28360 | 30436 | -0.788 | 0.286 | -0.554 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48647 | |
| 23 | 57:59.6 | 21 | 164739 | 266396 | 28384 | 30443 | -0.785 | 0.286 | -0.563 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48647 | |
| 24 | 57:59.7 | 22 | 164967 | 267134 | 28336 | 30397 | -0.786 | 0.273 | -0.573 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48647 | |
| 25 | 57:59.7 | 23 | 164619 | 266873 | 56911 | 58768 | -0.8 | 0.287 | -0.572 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48647 | |
| 26 | 57:59.7 | 24 | 163651 | 265226 | 56472 | 58915 | -0.778 | 0.29 | -0.564 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48647 | |
| 27 | 57:59.8 | 25 | 162669 | 263346 | 56280 | 58795 | -0.788 | 0.293 | -0.557 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48647 | |
| 28 | 57:59.8 | 26 | 161930 | 261904 | 56194 | 58740 | -0.789 | 0.294 | -0.56 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48647 | |
| 29 | 57:59.8 | 27 | 161310 | 260786 | 56122 | 58692 | -0.775 | 0.277 | -0.57 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48647 | |
| 30 | 57:59.9 | 28 | 160797 | 259941 | 56119 | 58691 | -0.795 | 0.285 | -0.564 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48647 | |
| 31 | 58:00.0 | 29 | 160436 | 259481 | 56154 | 58707 | -0.787 | 0.287 | -0.555 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48647 | |
| 32 | 58:00.0 | 30 | 160237 | 259271 | 56168 | 58698 | -0.79 | 0.286 | -0.557 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48647 | |
| 33 | 58:00.0 | 31 | 160104 | 259134 | 56148 | 58667 | -0.792 | 0.289 | -0.564 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48647 | |
| 34 | 58:00.1 | 32 | 159988 | 259032 | 56128 | 58641 | -0.771 | 0.288 | -0.561 | 0 | 60 | 0 | 0 | 0 | OTHER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ADJUSTIN | ON OBJEC | 48647 | |

*Figure 29. Example log file PPG_.csv.*

### *Flash Logging of Data*

To log PPG data to on-board flash memory, perform the following steps.

To start flash logging from the PC GUI:

1. Set up PPG measurement on the PC GUI as instructed in the *Using the PC GUI* section and ensure that the **Log to Flash** box is checked and the **Log to File** box is unchecked.
2. Click **Start Monitoring**. Data is not streamed to the GUI or app while flash logging is enabled.
3. At this point, you can disconnect the USB Type-C cable or Bluetooth LE connection to log data while untethered.

To start flash logging from the health band:

1. Press and release Button F.

To start flash logging from the Android app:

1. Click on the three vertical dots near the top right and select the **Log to Flash** box.

If the MAXREFDES103# is still tethered to the PC device, flash logging can be stopped by pressing the **Stop** button in the GUI or app. Alternatively, Button F may be pressed and released to stop flash logging.

### *Downloading the Log File*

After flash logging is complete, download and parse the log file using the following steps:

1. Ensure that the USB Type-C cable is not connected, and power off the MAXREFDES103# by holding the power button down for 12 seconds.

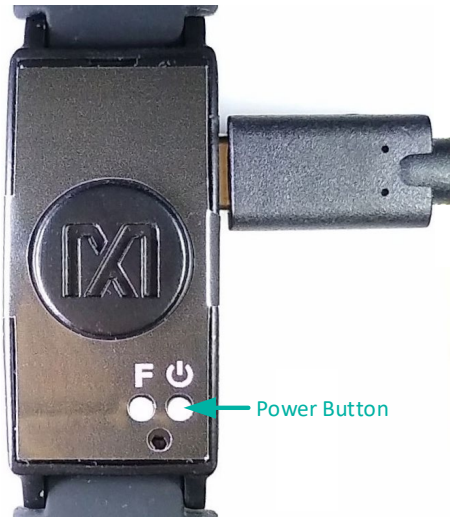



*Figure 30. Power button on the MAXREFDES103#.*

After the MAXREFDES103# is powered down, hold Button F on the MAXREFDES103# and insert the USB Type-C cable (or the MAXDAP Pico Adapter board with a USB Micro-B cable, as pictured in Figure 31) into the USB Type-C connector of the MAXREFDES103#. Continue holding Button F until the status LED is slowly flashing white.

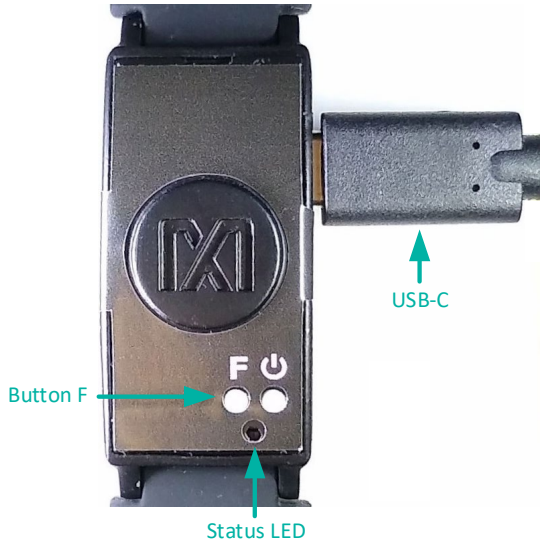



*Figure 31. MSD connection to PC using USB Type-C cable.*

2. If done correctly, the MAXREFDES103# boots into mass storage device mode.
3. The device appears in Windows Explorer as a USB drive, and you can copy-paste files from the device.
4. Copy the ".maximlog" file to your PC hard drive.

   Note: The log files are in raw binary format and need to be parsed to convert them to a readable .csv format.
5. In the PC GUI, open the **Flash Log Parser** from the **Tools** menu.

6. Select the .maximlog file, choose an output folder, and click **PARSE**. A .csv file is generated in the output folder containing the parsed log file.


*Figure 32. Flash Log Parser.*

## Maxim Health Sensor Platform App for Android

Download the latest .bin, .msbl and .apk from the Maxim MAX32664 webpage. Flash the MAXREFDES103# with the latest .bin and .msbl as previously described.

### *Installing the App*

1. After flashing the .bin, .msbl, and.apk, install and run the .apk on your Android device.

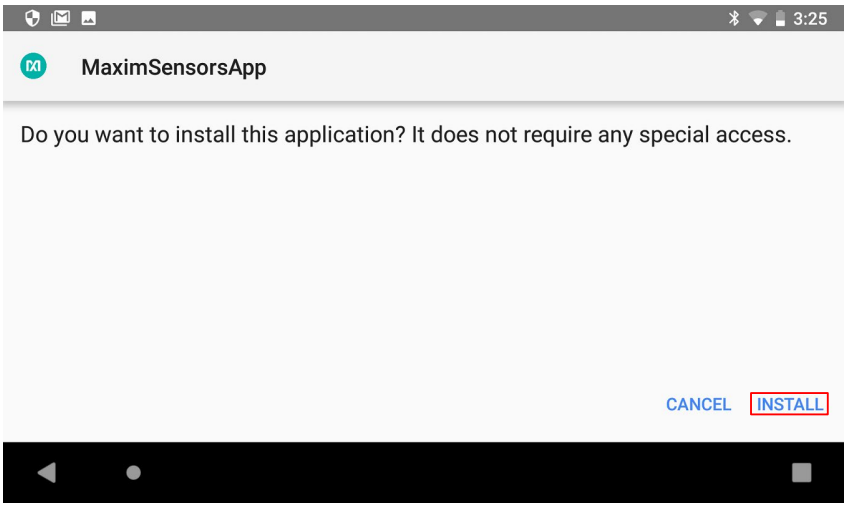



*Figure 33. Install the .apk.*

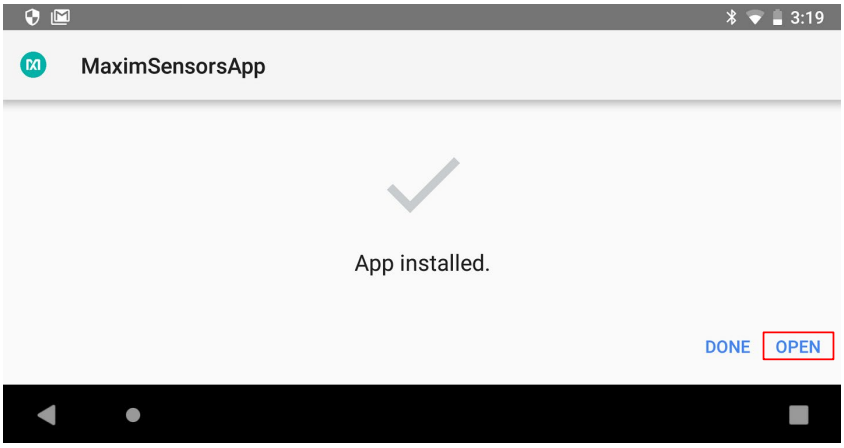



*Figure 34. Run the .apk.*

2. Grant the permissions and device location access when the .apk is installed.

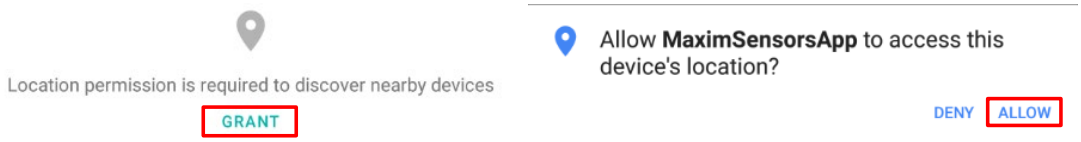



*Figure 35. Grant permissions and allow access.*

3. Click on the device named **HSPSPO2….**

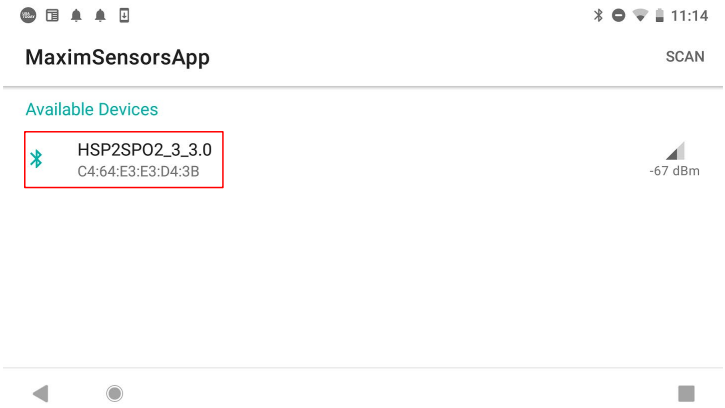



*Figure 36. Click on the device named HSPSP02….*

The main menu is displayed.

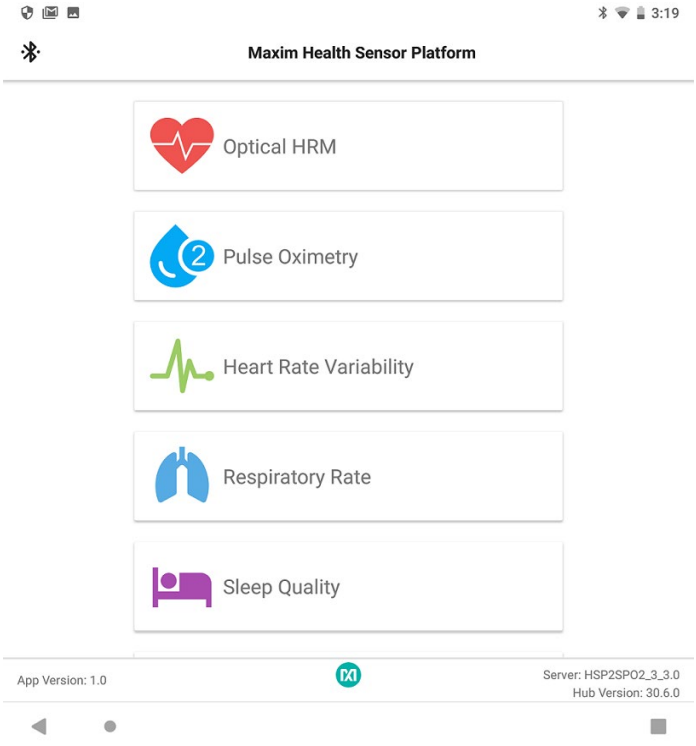



*Figure 37. Main menu of the Maxim Health Sensor Platform app.*

### *Optical Heart-Rate Monitoring*

1. In the main menu, click **Optical HRM**. The graphing of the green signal may be seen by deselecting the IR and selecting the **Green** button. Click the play icon (**START MONITORING**) in the upper right corner of the app to initiate the heart-rate measurement.

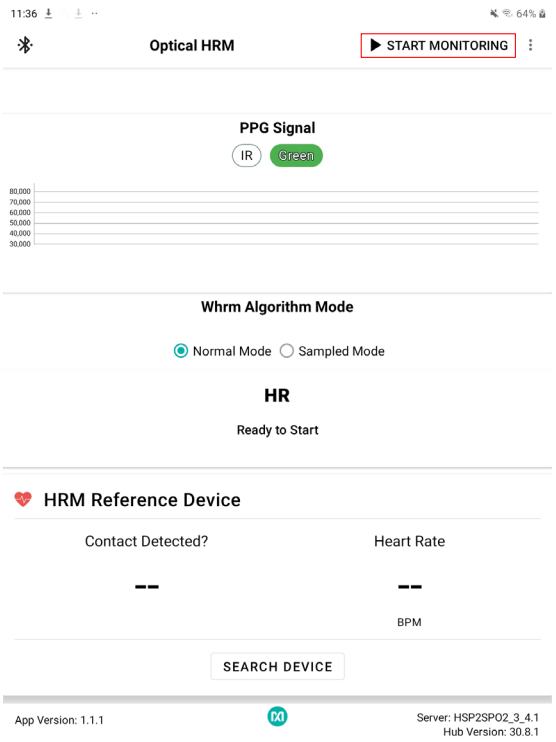



*Figure 38. Start heart-rate measurement.*

2. After a brief period, the measurement is complete, and the heart-rate measurement is displayed. Click the stop icon (**STOP MONITORING**) in the upper right corner of the app to stop the measurement.

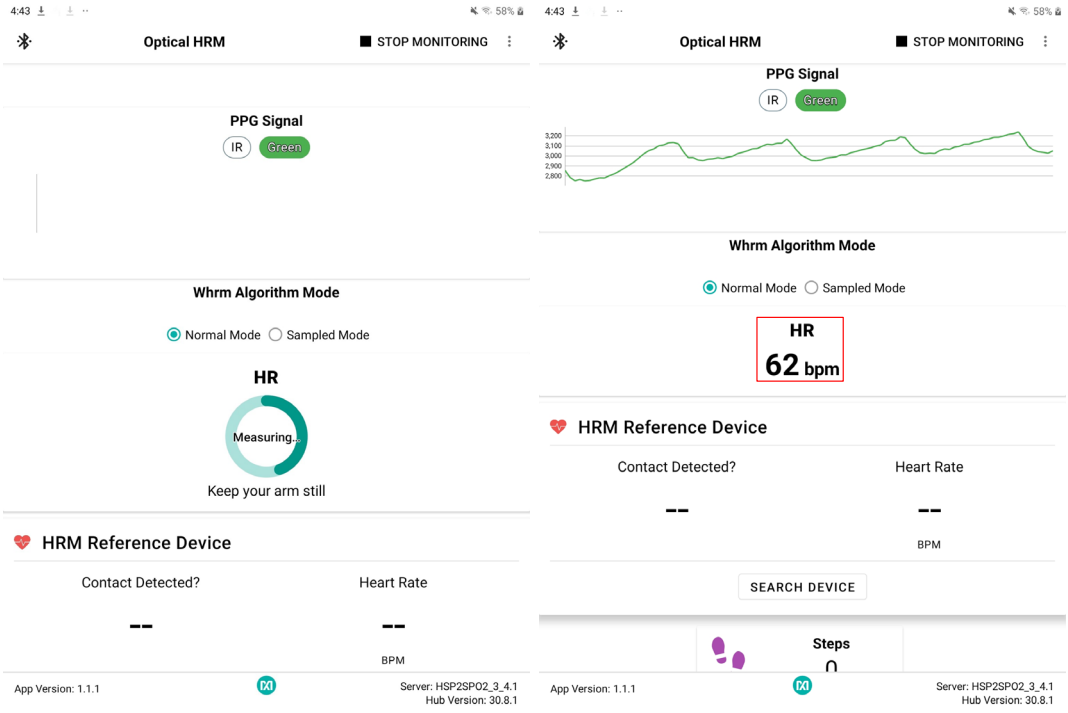



*Figure 39. Heart-rate measurement.*

***Pulse Oximetry***

1. For $SpO_2$ measurements, verify that the health sensor band is properly placed at about two fingers away from the wrist bone as shown in Figure 40. Also, the strap tightness is very important—there should be almost no gap between the device and the wrist when the enclosure is lifted up slightly.

*Figure 40. Positioning the health sensor band.*

2. Click the back button of the Android device to go back to the main menu and click **Pulse Oximetry**, then specify the mode of operation for the algorithm by selecting **Continuous** or **One Shot**. Click the play icon to initiate the $SpO_2$ measurement. It is advisable to note the date and time information for recognizing data log files generated by the Android app.

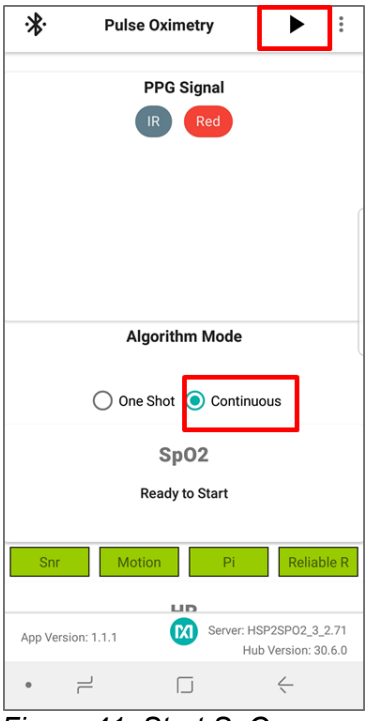



*Figure 41. Start $SpO_2$ measurement.*

3. The IR and Red signals are graphed if the **IR** and **Red** buttons have been selected. In order to retrieve a valid $SpO_2$ reading, the signals should have peaks and valleys as depicted in Figure 42. If the waveform is not correct, then the strap tightness or health sensor enclosure position may need to be adjusted.

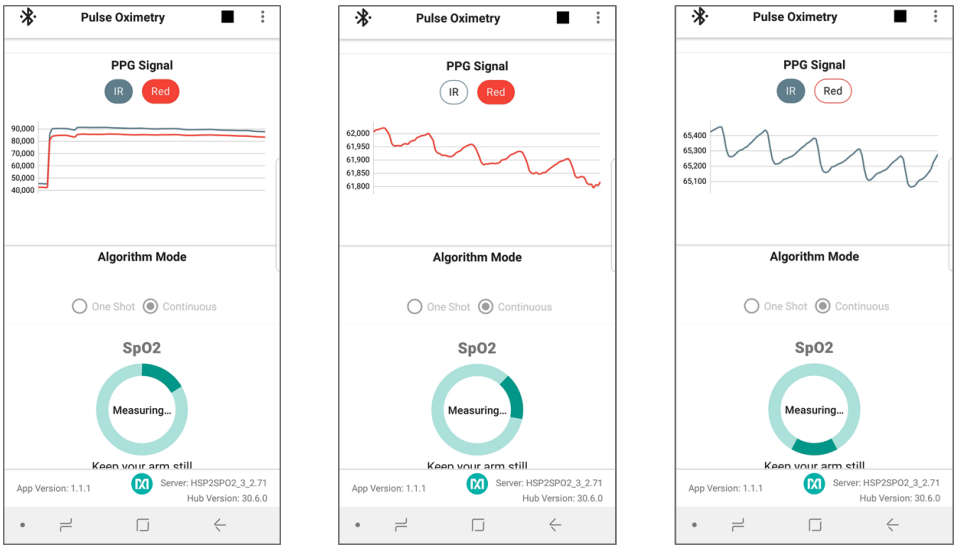



*Figure 42. IR and Red signals displayed during $SpO_2$ measurement.*

After a brief period, the measurement is complete and the $SpO_2$ measurement is displayed.

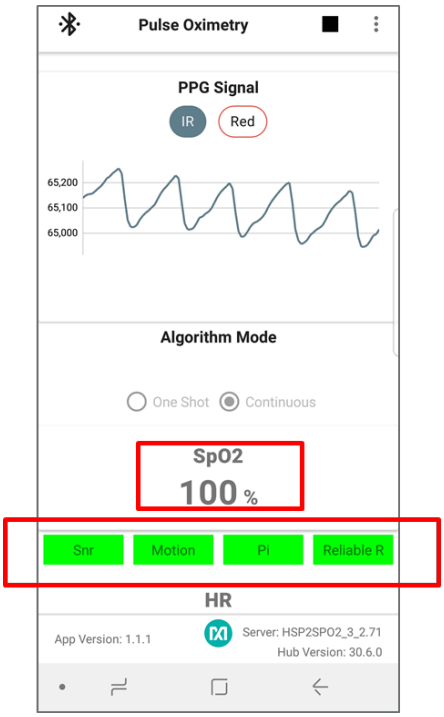



*Figure 43. $SpO_2$ measurement.*

4. Feedback on the signal quality is displayed by the color of the Snr, Motion, Pi, and Reliable R indicators. These indicators turn red during the following conditions:

   - **Snr** indicates that the signal has a low signal-to-noise ratio.
   - **Motion** indicates that movement on the health sensor band is excessive and wrist movement should be minimized in order to retrieve proper $SpO_2$ reading.

- **Pi** indicates whether the IR or Red signal's observed perfusion index are too low.
- **Reliable R** indicates that the calculated R values are not consistent, therefore $SpO_2$ is not being reported.

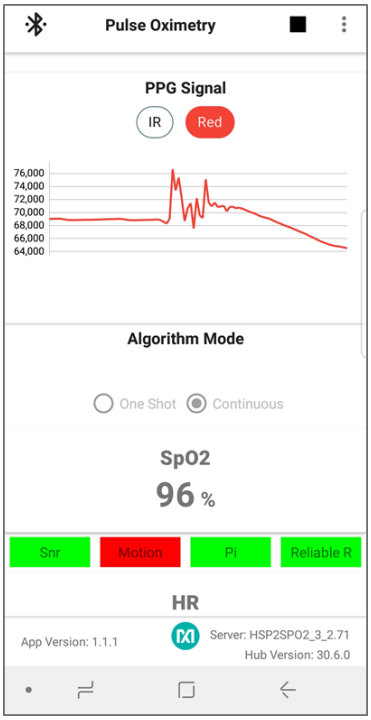



*Figure 44. Motion has turned red to indicate excessive motion.*

5. Click the stop icon to terminate the measurement.

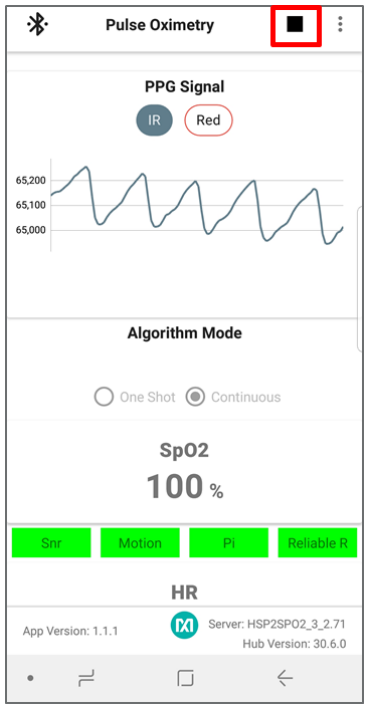
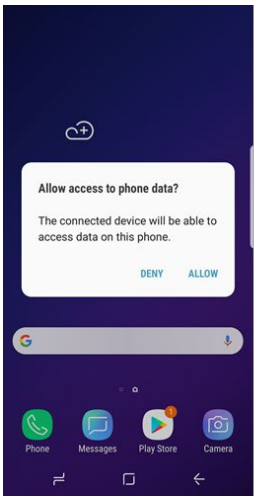



*Figure 45. Stop monitoring icon.*

6. By default, the app logs raw data and algorithm results in a .csv file. (Logging may be disabled by clicking on the three vertical dots in the top right and deselecting the log). The .csv files may be retrieved from Android device using the following steps:

   - Connect an Android device to your PC.
   - Provide proper access when prompted.
   - Browse to the MaximSensorsApp folder and retrieve the related file (MaximSensorsApp_yyyy-mm-dd-HH:MM:SS_SpO2.csv):



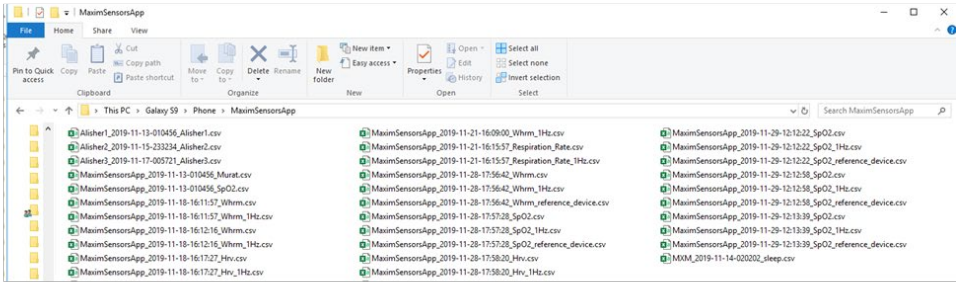




*Figure 46. Retrieving the .csv log file from the Android device.*

Follow this suggested testing protocol for the most efficient $SpO_2$ measurement:

- Subject sits still for three minutes without talking or moving. Placing the arm on top of a table prevents unexpected wrist movements.
- Wear and position the health sensor band as described earlier.
- Connect to either the PC GUI or the Android app as described earlier.
- Verify that the proper PPG waveforms for IR/Red should are observed without any noise or artifact.
- Reference $SpO_2$ data is recorded throughout the session. Reference $SpO_2$ can be recorded visually by reading the reference displayed in the finger clip or using the Android app.
- The number of participants should be at least 20 for a meaningful evaluation.

***Heart-Rate Variability***

1. Click the back button of the Android device to go back to the main menu and click **Heart Rate Variability**. The individual graphing of the avnn, sdnn, rmssd, or pnn5 data can be selected by selecting the button of interest and deselecting the other three. For instance, avnn is selected in Figure 47, and the other measurements are deselected. To start the heart-rate variability monitoring, click the play icon.

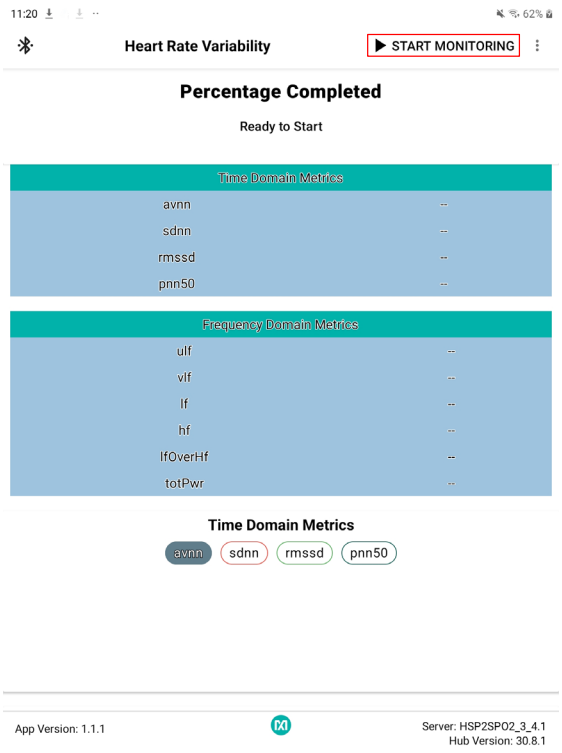



*Figure 47. Start heart-rate variability measurement.*

2. After a brief period, the measurement is complete, and the data for heart-rate variability is displayed.

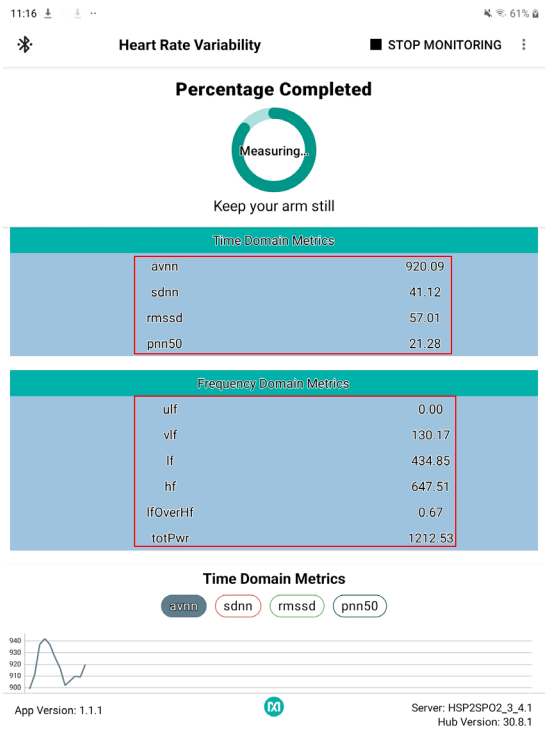



*Figure 48. Heart-rate variability measurement.*

3. Click on the stop icon to terminate the measurement.

### *Respiration Rate*

1. Click the back button of the Android device to go back to the main menu and click **Respiration Rate**, then click the play icon to initiate the respiration rate measurement.

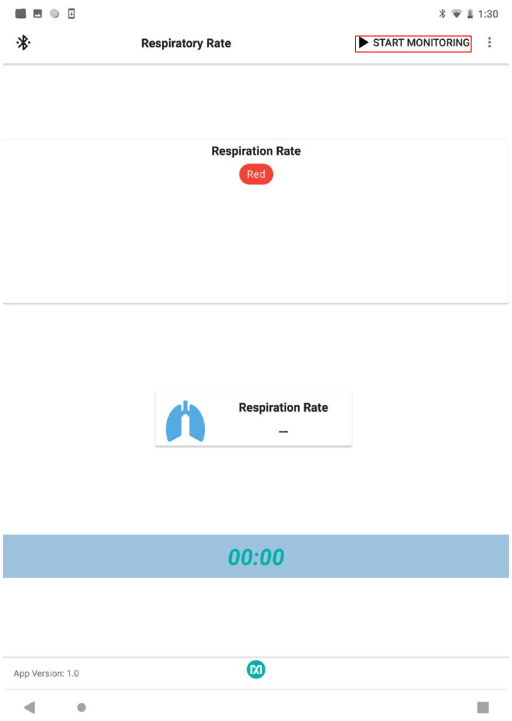



*Figure 49. Start the respiration rate measurement.*

2. After a brief period, the respiration rate is displayed.

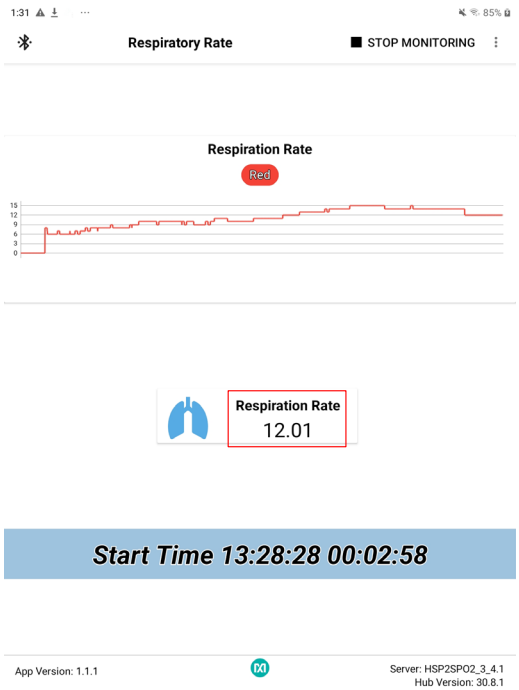



*Figure 50. Respiration rate measurement.*

3. Click the stop icon to terminate the measurement.

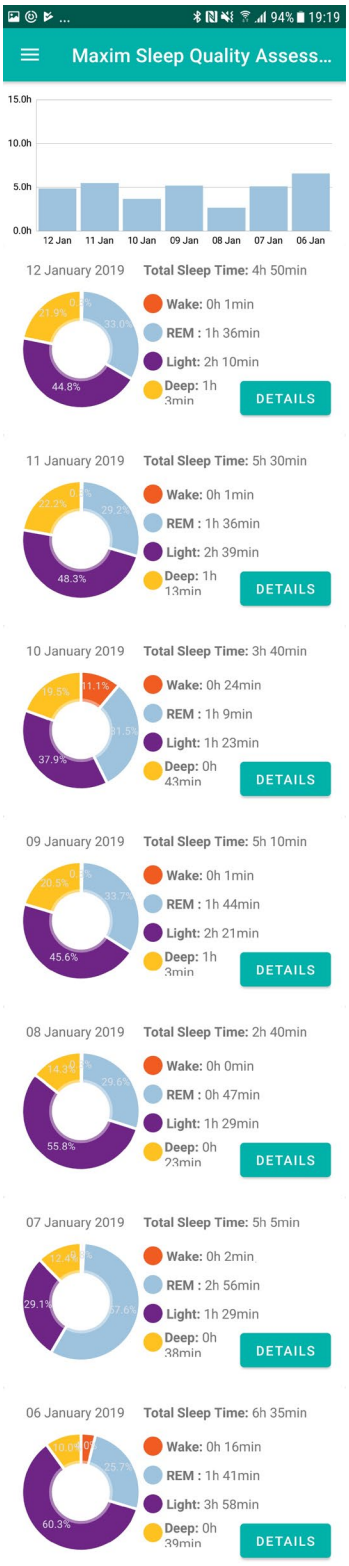



*Figure 51. Sleep quality assessment.*

## Notes on the Enclosure

The MAXREFDES103# is not an industrial-grade health band. It is intended for performance demonstration and typical design guidance. Excessive opening and closing of the enclosure lid may cause the tightness of the lid closure to be compromised. If this happens, it is recommended that the lid be taped to the sides of the enclosure.

Solvents such as alcohol should not be used to clean the mesa sticker or the cover film since solvents may cause damage to these items. The cover film on the sensors is provided to prevent dirt or sweat from interfering with the optical components.

## Time-Alignment Method for Comparing PPG Data to ECG Data

When comparing the PPG data from the MAXREFDES103# to the data from an ECG reference device, there may be some time differences between the two data sets. Consequently, post-processing of the data needs to be performed to time-align the PPG and ECG data sets, as outlined in the following procedure:

1. Downsample the PPG data to 1Hz to match the sampling rate data of the ECG data.
2. Using the Matlab function xcorr, find the time_difference, which provides the maximum correlation between the data sets.
   - If the time_difference is greater than zero, then crop the first time_difference seconds from the PPG data set.
   - If the time_difference is less than zero, then crop the first time_difference seconds from the ECG data set.
3. If one data set is larger than the other, crop the excessive data at the end so that both data sets are the same size.
4. Crop the first 30 seconds from the data sets to remove data captured during initialization.

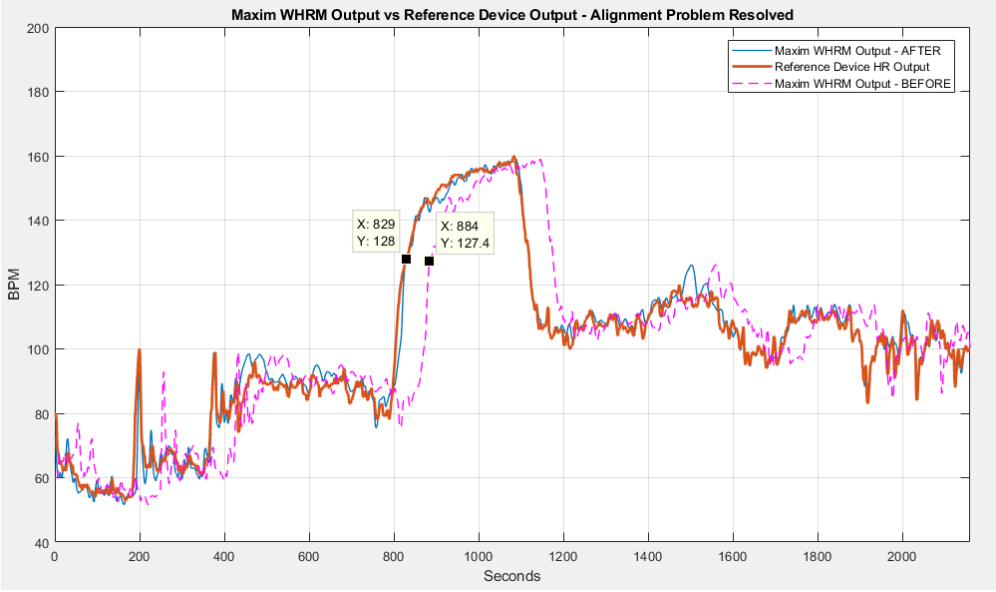



*Figure 52. PPG and ECG data sets that have been time-aligned.*

## $SpO_2$ Calibration

To obtain accurate $SpO_2$ measurements, the $SpO_2$ coefficients must be determined using the final product form factor and product cover lens. The $SpO_2$ coefficients are set by sending a message through the $I^2C$ interface, which is detailed in the MAX32664 User Guide.

For calculations used to determine the $SpO_2$ value and an explanation of how to calculate the $SpO_2$ coefficients for the end product, refer to Maxim Application Note 6845, Guidelines for SPO2 Measurement Using the Maxim® MAX32664 Sensor Hub.

## Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|---|---|---|---|
| 0 | 1/20 | Initial release | — |

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