

# MAXREFDES103# Health Sensor Band User Guide



## 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 captures biometric signals important to healthcare. The platform also contains algorithms to calculate 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
  - Tricolor status LED
- Sensor board
  - MAX86141 analog frontend and optical heart rate sensor with one green LED, one red LED, one IR LED, and two photodiodes

*The Bluetooth word mark and logos are registered trademarks owned by Bluetooth SIG, Inc., and any use of such marks by Maxim is under license.*

- MAX32664 microcontroller with embedded heart-rate algorithm
- Three-axis accelerometer
- MAX4740 quad SPDT switch, which enables different LED and PD configurations in combination with the MAX86140/41
- One green LED, two combination RGB LEDs (one of these RGB LEDs is not used by the algorithm). The extra LED is reserved for future use: to simplify the design, the extra LED and the MAX4740 can be removed for the heart rate, SpO<sub>2</sub> use case)
- MAXDAP-TYPE-C 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

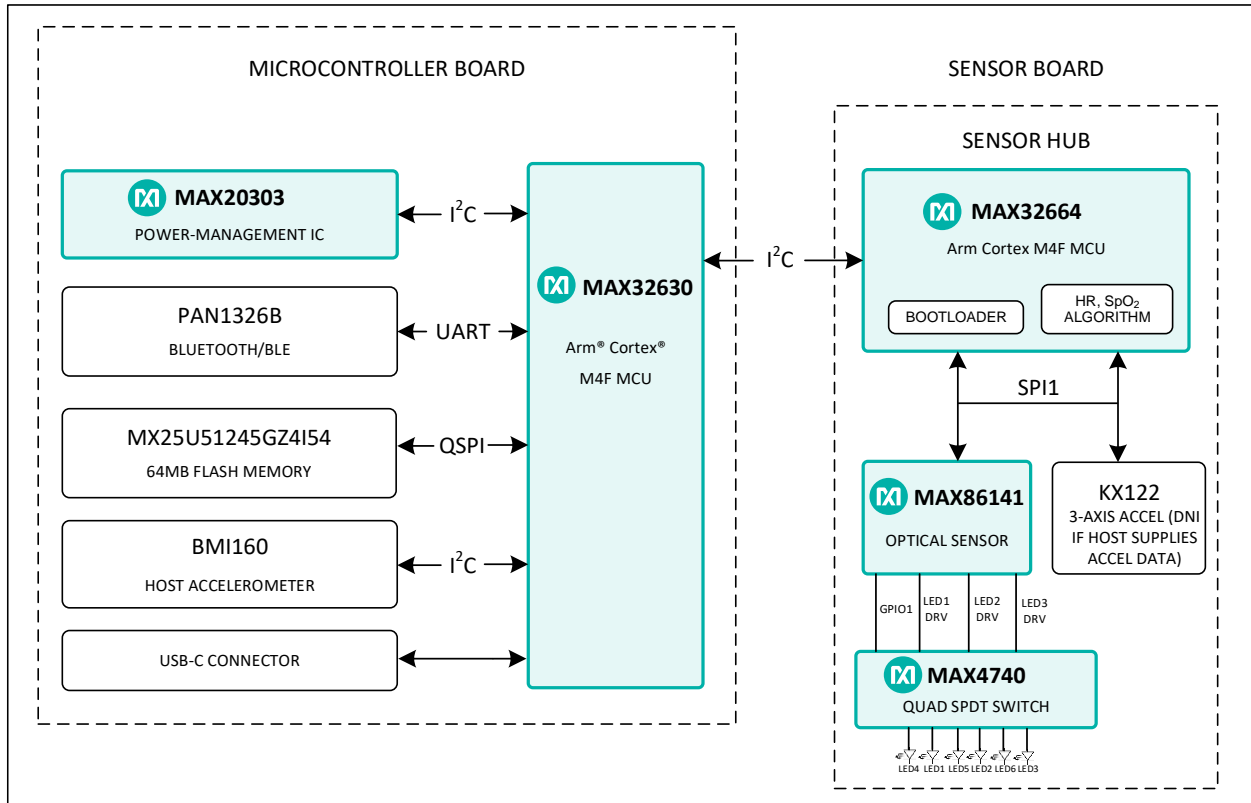


Figure 2. MAXREFDES103# system diagram.

Arm and Cortex are registered trademarks of Arm Limited.

## 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-TYPE-C Adapter board.

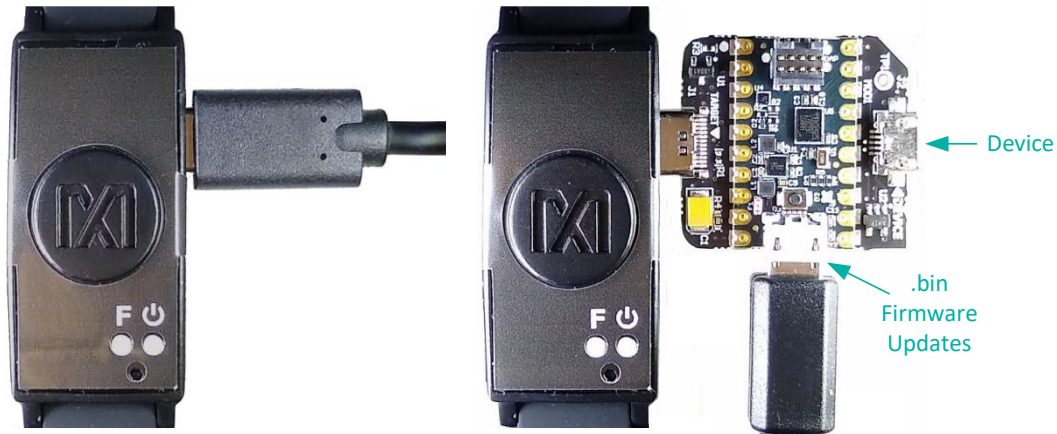


Figure 3. USB Type-C cable (left) and MAXDAP-TYPE-C board (right).

The MAXDAP-TYPE-C Adapter board has two USB Micro-B connectors. The bottom connector next to the push button updates 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#.

Press and hold the power button on the MAXREFDES103# for at least 15 seconds to power off.

Note: A hard reset can be performed on the device by using the power-off and power-on procedures if the device becomes unresponsive.



## Button Functionality

Table 1 describes the functionality of the two buttons.

**Table 1. Button Functionality**

BUTTON	SHORT PRESS	LONG PRESS (3S)	EXTRA LONG PRESS (15S)
Power Button	Turn off/on status LED (press for 1s to power on)	Press and hold the power button on the MAXREFDES103# until the LED status turns magenta and blinks fast to power off	Power off
Button F	Start/stop data collection (flash logging)	N/A	N/A

## Color Definitions for the 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 the MAX32664 failed	Battery critically low (< 10%)
Green	USB connected (no data streaming)	Streaming USB data	Device is ready (no USB connection)
Blue	Reserved	Streaming Bluetooth LE data	Bluetooth Low Energy (Bluetooth LE or BLE) connected (no data streaming)
Magenta	Reserved	Press and hold the power button on the MAXREFDES103# until the LED status turns magenta and blinks fast to power off	Reserved
Cyan	Reserved	Flash logging active	Five blinks indicate that flash logging is complete
Yellow	System is initializing	The LED status flashes yellow for 2s after the MAX32664 programming is complete	Battery low (10% to 25%)
White	Reserved	Reserved	MSD mode
Off	LEDs are 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. Wear the health sensor band on the non-dominant hand as this improves the quality of the data. The health sensor band must fit tightly but comfortably around the wrist. Ensure the skin has direct contact with the openings for the LED/photodiodes at the center of the back of the health sensor band.

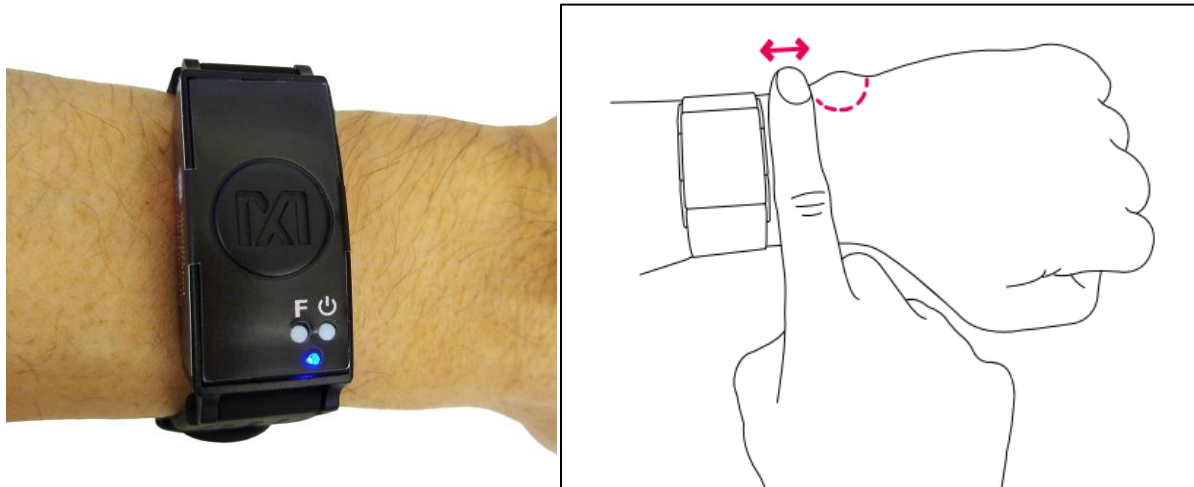


Figure 4. PPG measurement.

## Software Updates

The MAXREFDES103# is preloaded with the firmware available during production. The firmware is deprecated. A firmware upgrade is necessary to ensure the most recent set of firmware is loaded.

**The following three software and firmware must all be updated using the latest software release package.**

1. Install the Maxim DeviceStudio PC GUI using the **.msi** file.
2. Flash the micro board **.bin** file using drag and drop to the DAPLINK folder.
3. Flash the algorithm **.msbl** file to MAX32664 using the Maxim DeviceStudio PC GUI.

### Installing the Maxim DeviceStudio PC GUI

1. Uninstall any previously installed versions of the Maxim DeviceStudio PC GUI or DeviceStudio PC 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 the **.msi** file. Check the box for **I accept the terms in the License Agreement**. Click **Install** and then **Finish**.

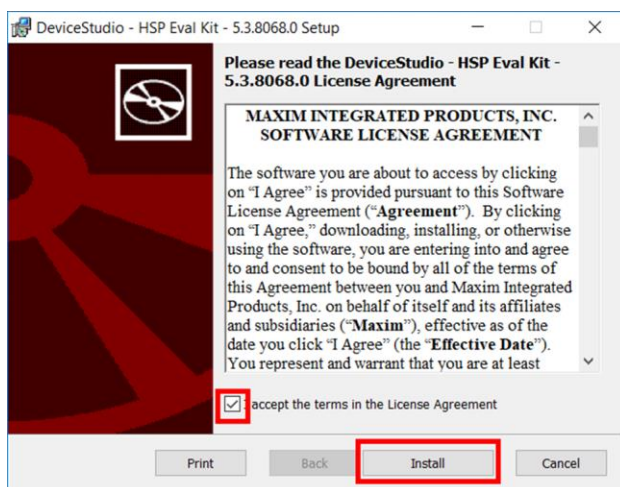


Figure 5. Install the **.msi** file.

*Maxim is a registered trademark of Maxim Integrated Products, Inc.*

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

Firmware upgrades to the MAX32630 can be performed using the provided MAXDAP-TYPE-C 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-TYPE-C Adapter board .bin firmware updates port to the PC using the USB Micro-B cable.

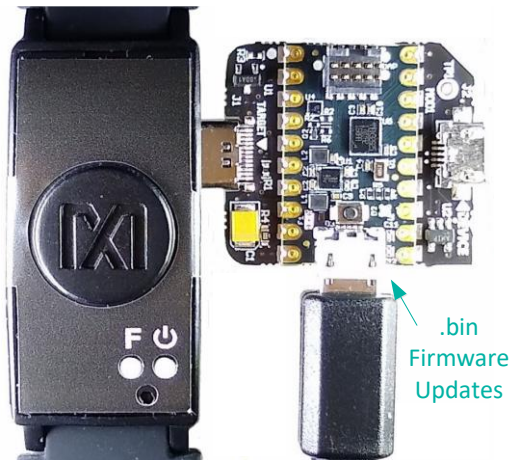


Figure 6. MAXDAP-TYPE-C Adapter .bin firmware updates port connected to the PC.

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

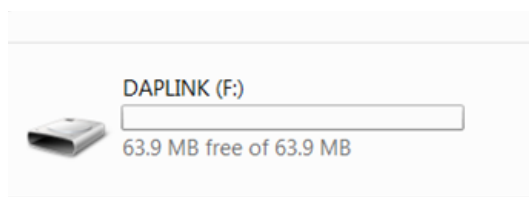


Figure 7. DAPLINK drive on the PC.

3. Drag and drop the .bin binary file into the DAPLINK drive on the PC to flash the host firmware to the MAX32630.
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-TYPE-C Adapter board to restart the health band. The button is located below the top USB Micro-B connector.

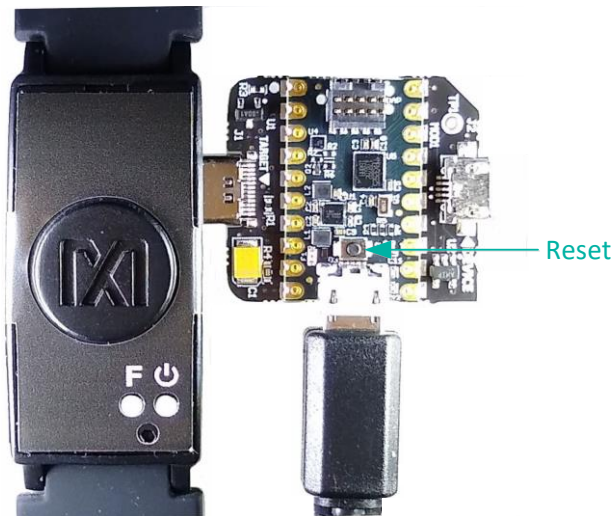


Figure 8. Reset button on the MAXDAP-TYPE-C Adapter board.

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

The host firmware binary is updated to the micro board. The .msbl Biometric Sensor Hub algorithm must be updated with the Maxim DeviceStudio PC GUI with 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 PC GUI Windows application.
2. Connect the MAXDAP-TYPE-C Adapter board device port to the PC using the USB Micro-B cable. Wait for five seconds.

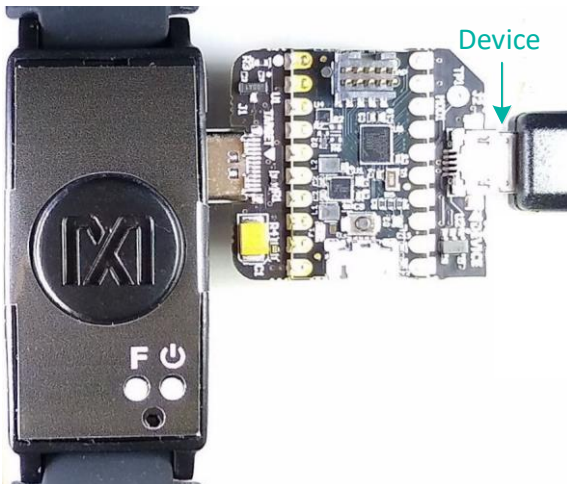


Figure 9. MAXDAP-TYPE-C board device port connected to the PC.

3. Select the **Serial over USB/Bluetooth** scan option. Click **Scan**.

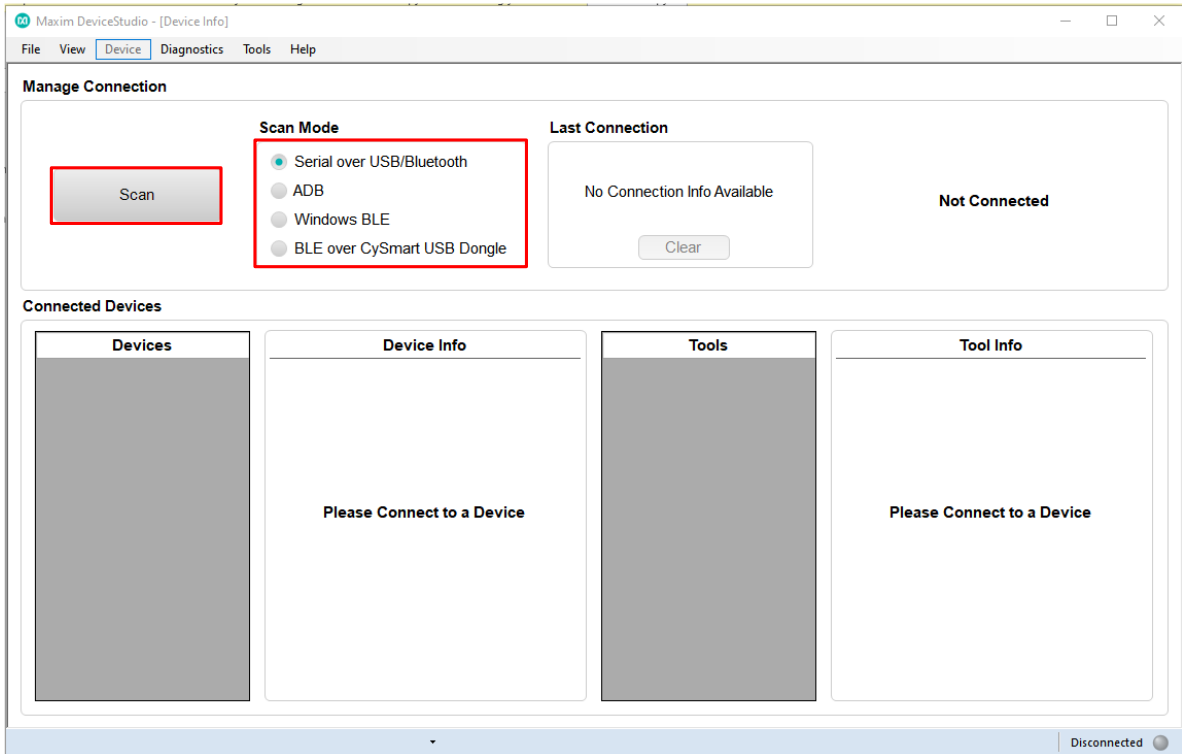


Figure 10. Maxim DeviceStudio PC GUI scan options.

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

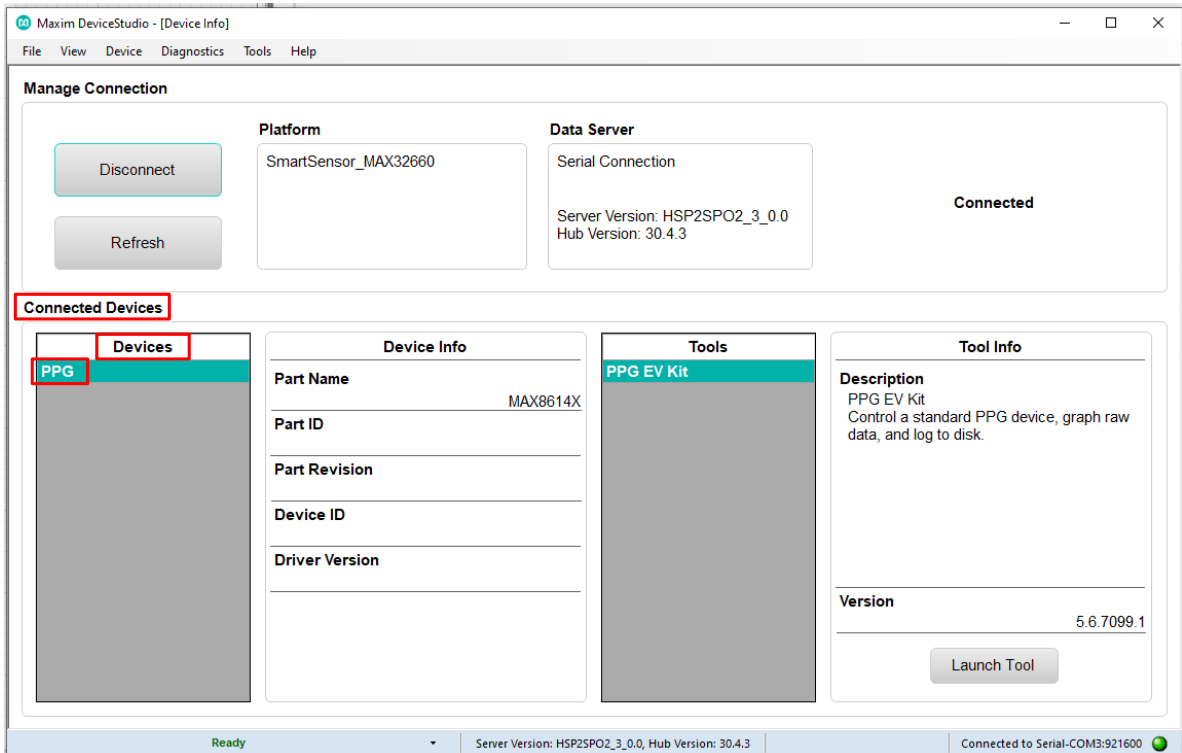


Figure 11. Maxim DeviceStudio PC GUI connected devices.

5. Go to the **Device** tab and select **Update SmartSensor\_MAX32664 Software**. Select **Update Firmware**, select the \*.msbl file from the extracted Eval Package, and click **Open**.

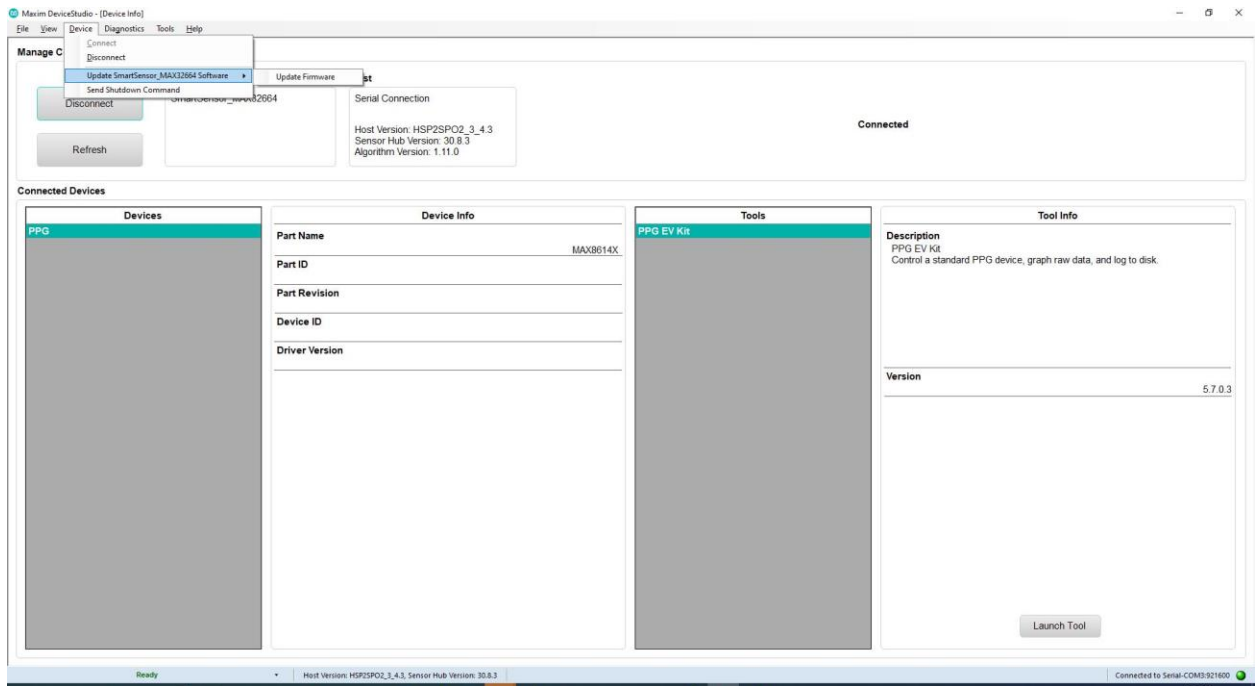


Figure 12. Device tab to update the MAX32664 .msbl.

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

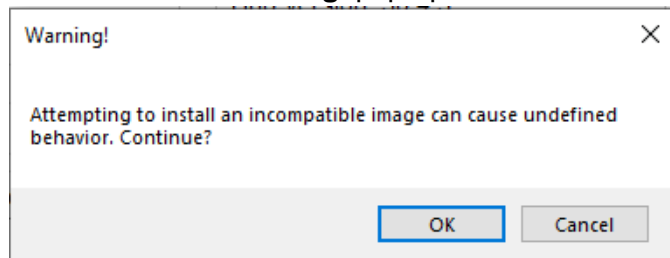


Figure 13. Warning message.

The embedded algorithm for heart rate and SpO<sub>2</sub> measurement is uploaded to the MAX32664 microcontroller on the sensor board.

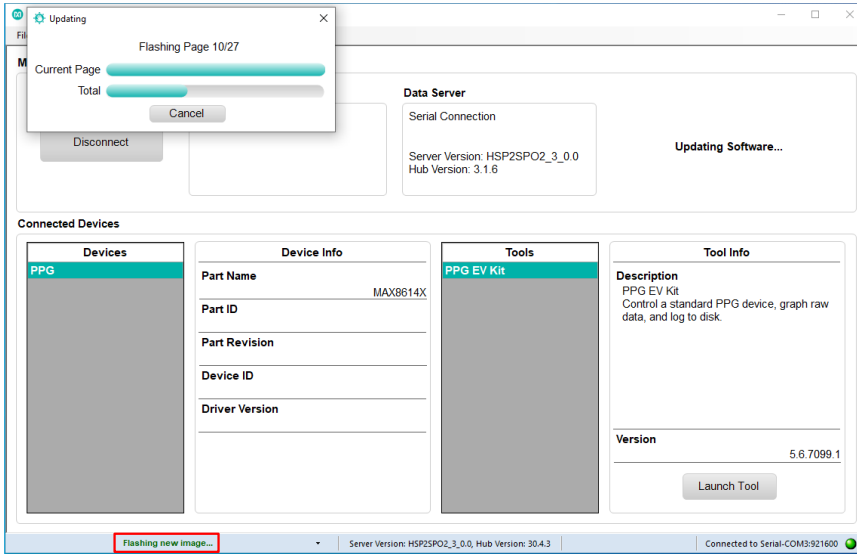


Figure 14. Upload the embedded heart-rate algorithm to the MAX32664.

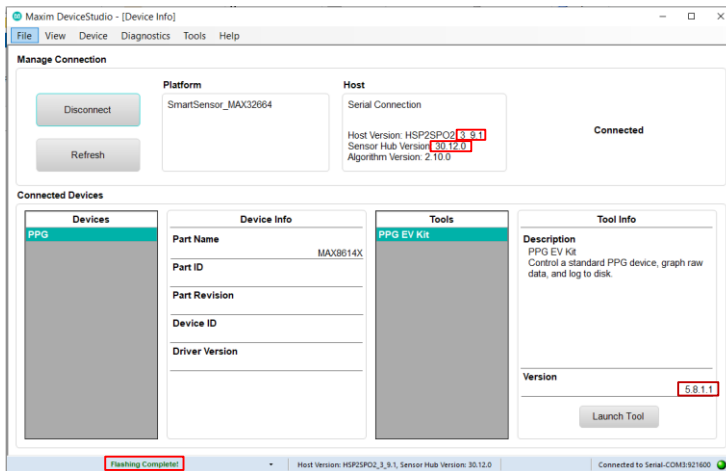


Figure 15. .msbl file flashed successfully.

**IMPORTANT:** Verify the version numbers shown in the Maxim DeviceStudio PC GUI match those in the latest software release package:

1. Verify the version number for Host Version **x.y.z** matches the version of the latest mbed-osXXX\_x.y.z.bin file.
2. Verify the version number for Sensor Hub Version **30.y.z** matches the version of the latest MAX32664C\_XXX\_30.y.z.msbl file.
3. Verify the version number in the dark red box Version **w.x.y.z** matches the version of the latest SetupHSP\_XXX\_w.x.y.z\_XXX.msi file.



## Evaluation GUIs

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

The Maxim DeviceStudio PC GUI can configure the algorithm, as well as view and log the processed/raw data. The algorithm is disabled in the raw data mode and the AFE settings can be configured. The embedded Maxim-supplied algorithm is configured and processed in the algorithm mode, and the raw data for the heart rate and SpO<sub>2</sub> are displayed. The Maxim DeviceStudio PC GUI also has a parser utility that converts the logged data in the flash memory to the .csv format.

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

- Heart Rate
- SpO<sub>2</sub>

The app includes additional algorithms in addition to displaying the data from the embedded algorithm:

- Heart Rate Variability
- Respiration Rate
- Sleep Quality

## Using the Maxim DeviceStudio PC GUI

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

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

Installing the driver manually might be required to use the Maxim DeviceStudio PC GUI on a Windows 7 PC. Perform the following steps to manually install the USB serial driver:

1. Uninstall any previously installed versions of the Maxim DeviceStudio PC GUI or DeviceStudio PC 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** in the Windows Control Panel.
5. The MAXREFDES103# appears under **Other devices** as **CDC DEVICE** if manual driver installation is needed. Right-click **CDC DEVICE** and select **Properties**.

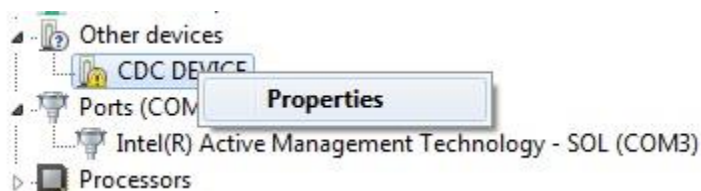
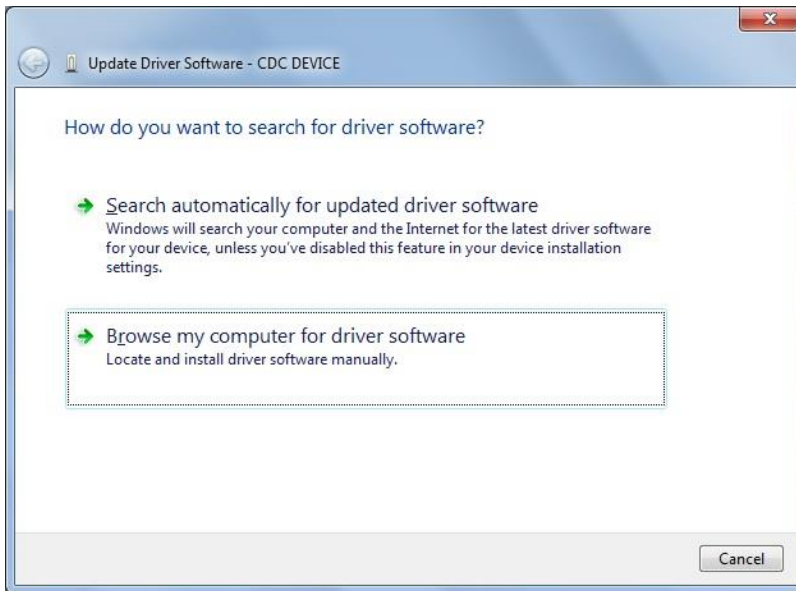


Figure 16. CDC DEVICE in Device Manager.

6. Click **Change Settings** and then click **Update Driver...** if **Update Driver...** grays out.
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 extracted in step 3. Click **Next**.



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

9. Click **Install this driver software anyway** when prompted by the **Windows Security** window.

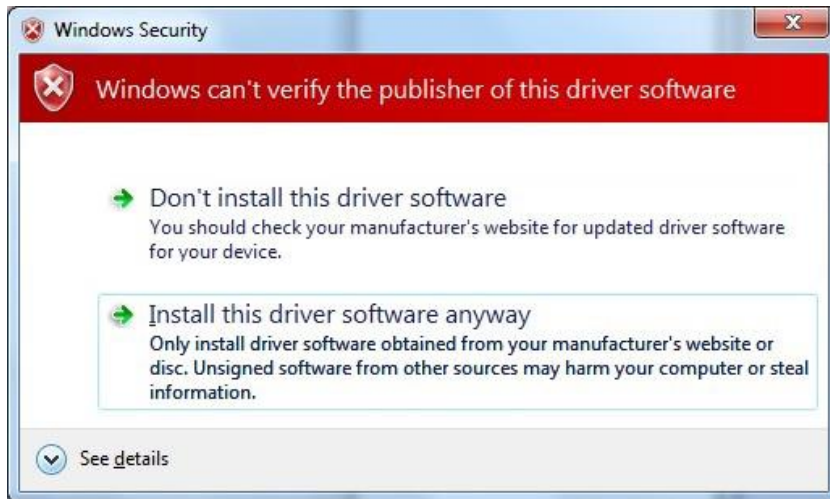


Figure 19. Select install this driver software anyway.

10. The MAXREFDES103# appears as an Mbed® Serial Port after the driver is installed successfully. (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-TYPE-C Adapter board using a USB Micro-B cable).

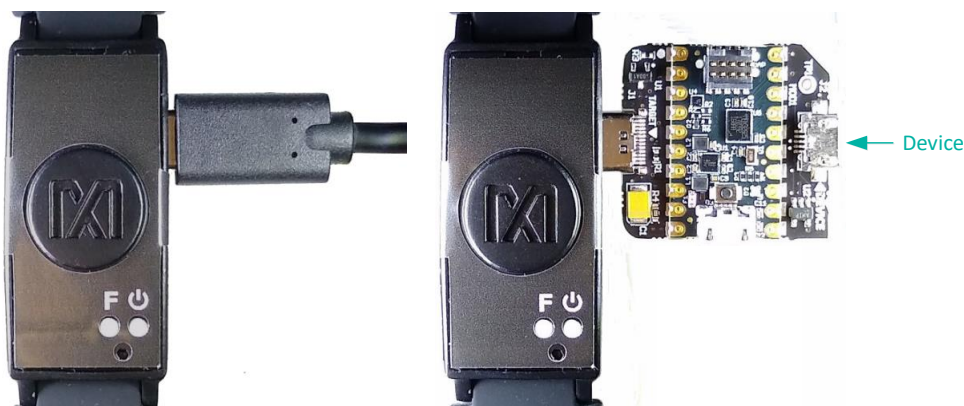


Figure 21. USB connection to PC using a USB Type-C cable (left) and MAXDAP-TYPE-C Adapter board device port (right).

Mbed is a registered trademark of Arm Limited.

2. Select **Serial over USB/Bluetooth** under **Scan Mode**. Click **Scan**.

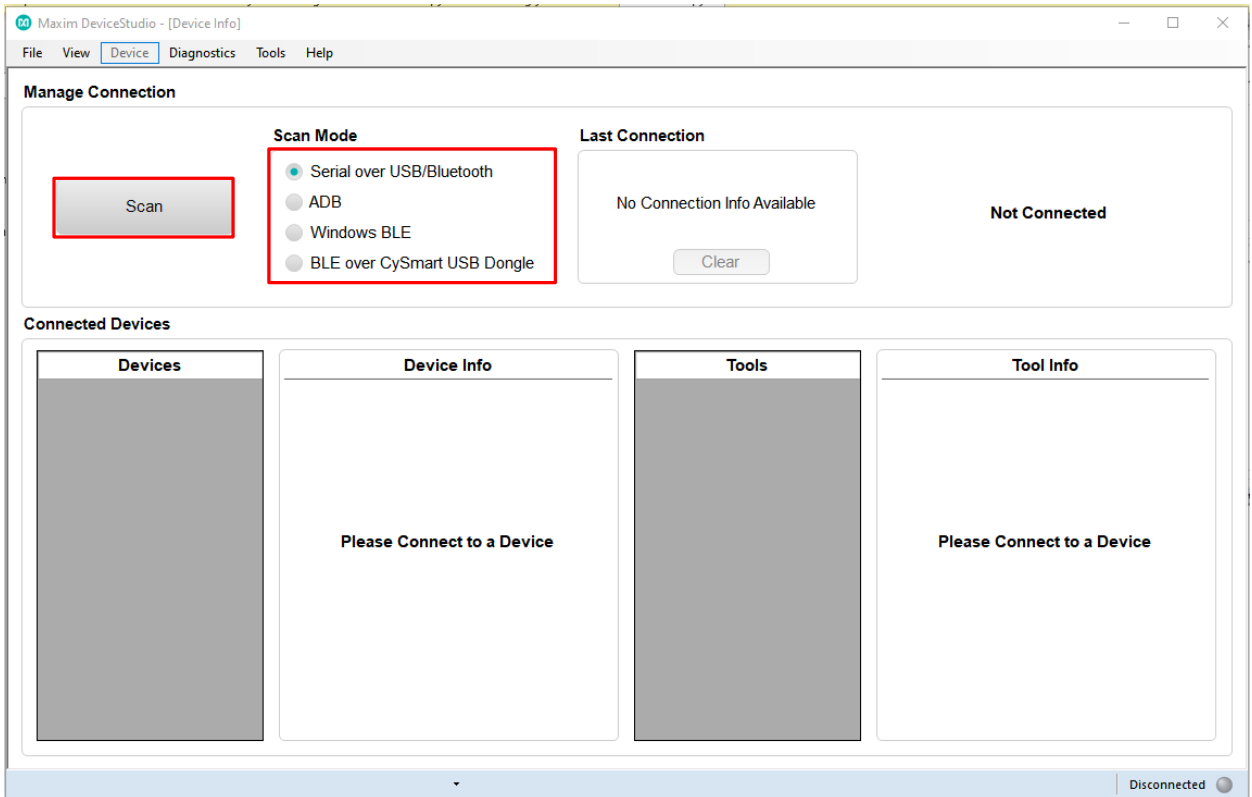


Figure 22. Scan for available devices.

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

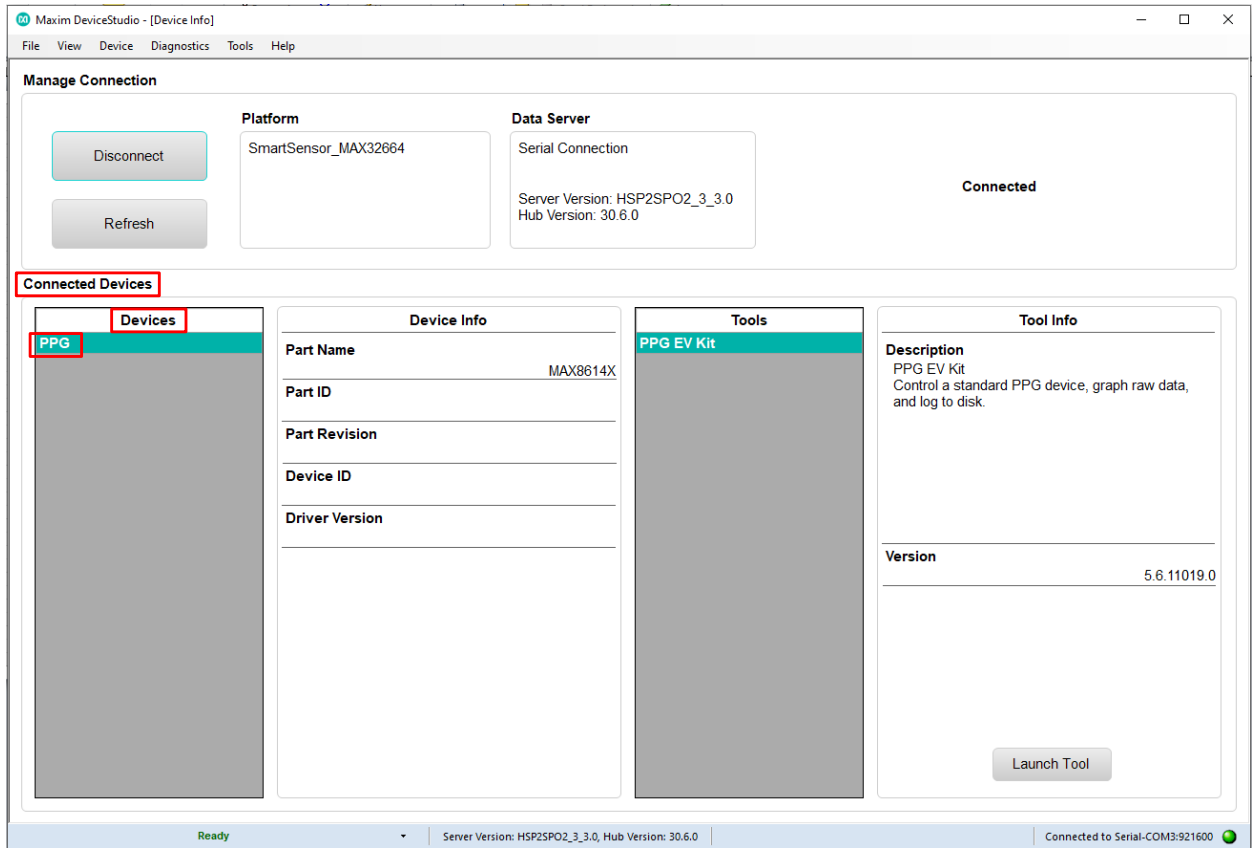


Figure 23. Successful connection over USB.

## Bluetooth LE Connection for Windows 10

1. Select **Windows BLE** under **Scan Mode**. Click **Scan**.

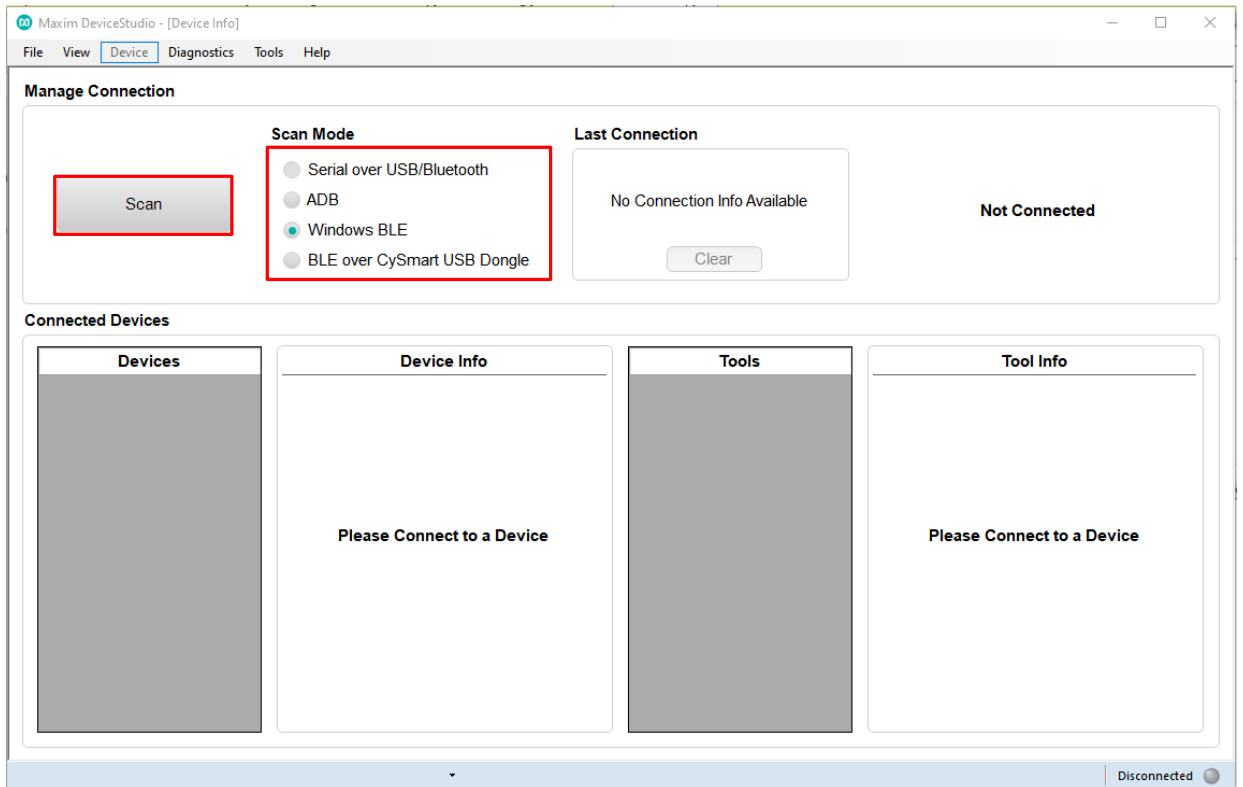


Figure 24. Scan for available Windows BLE devices.

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

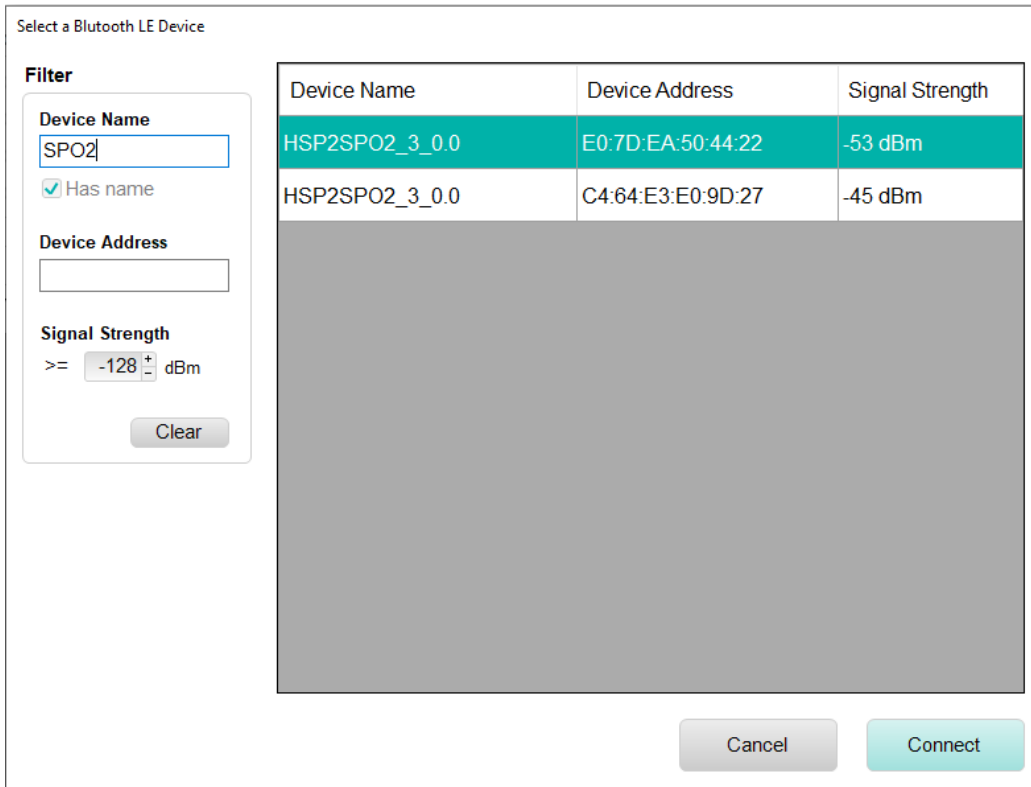


Figure 25. Selecting the Bluetooth LE device.

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

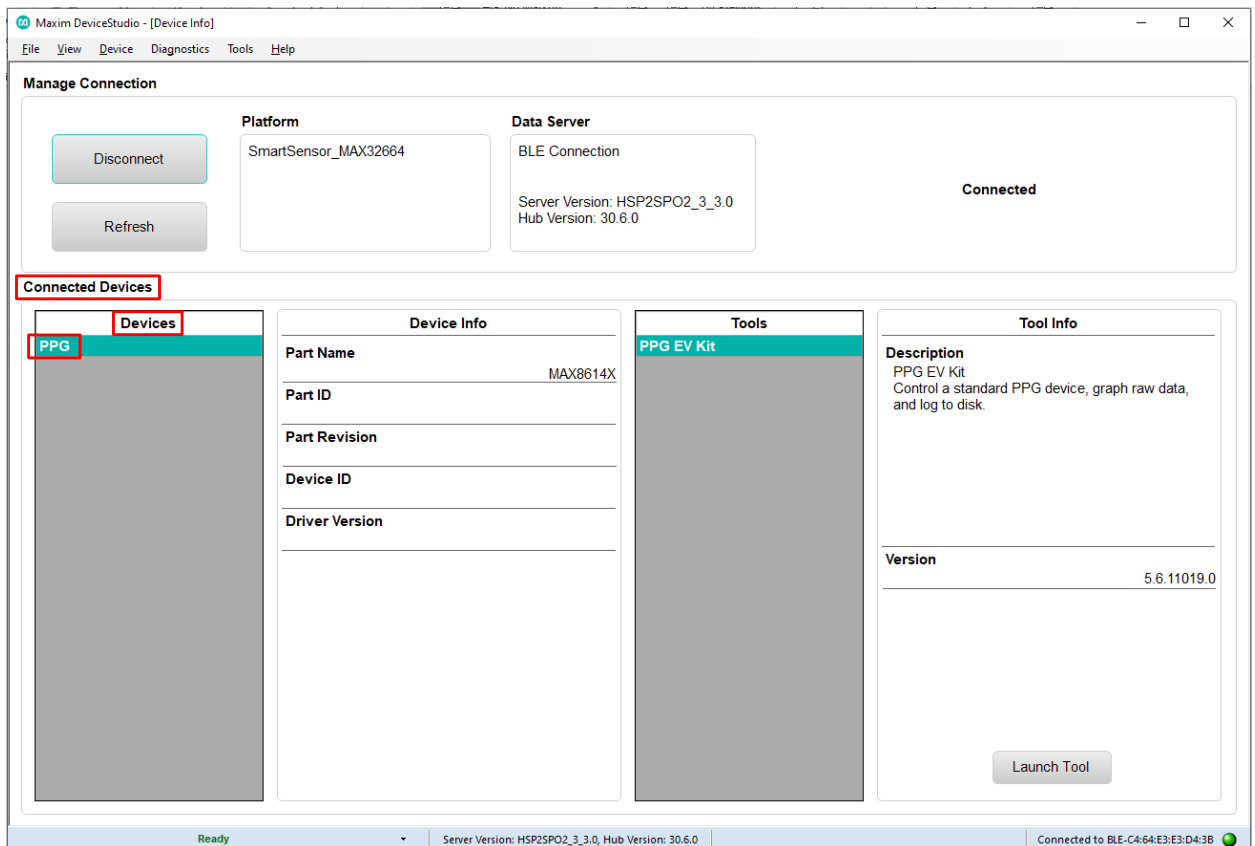


Figure 26. Successful connection over Bluetooth LE.

### 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<sub>2</sub>.
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<sub>2</sub> (%), SpO<sub>2</sub> Confidence (%), R Value, SpO<sub>2</sub> % Completion (for one-shot), Low Signal Flag, Motion Flag, SpO<sub>2</sub> 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.



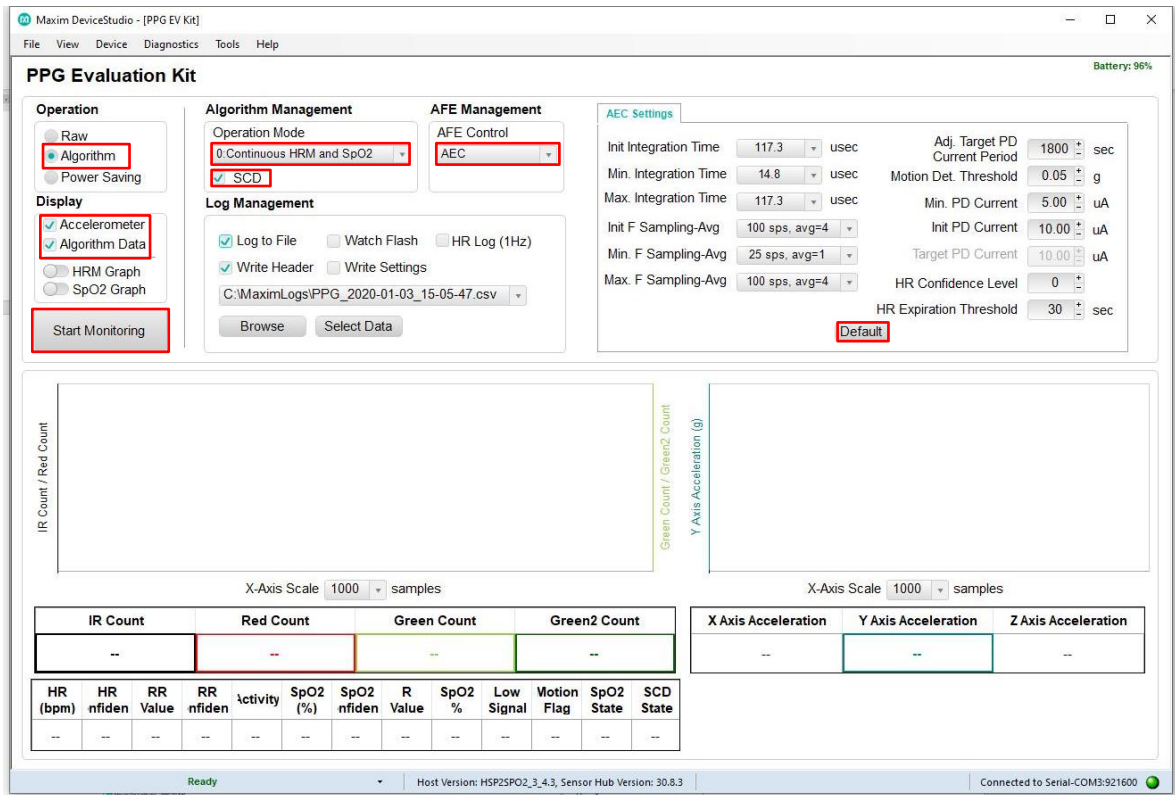


Figure 27. Configure for Algorithm mode.

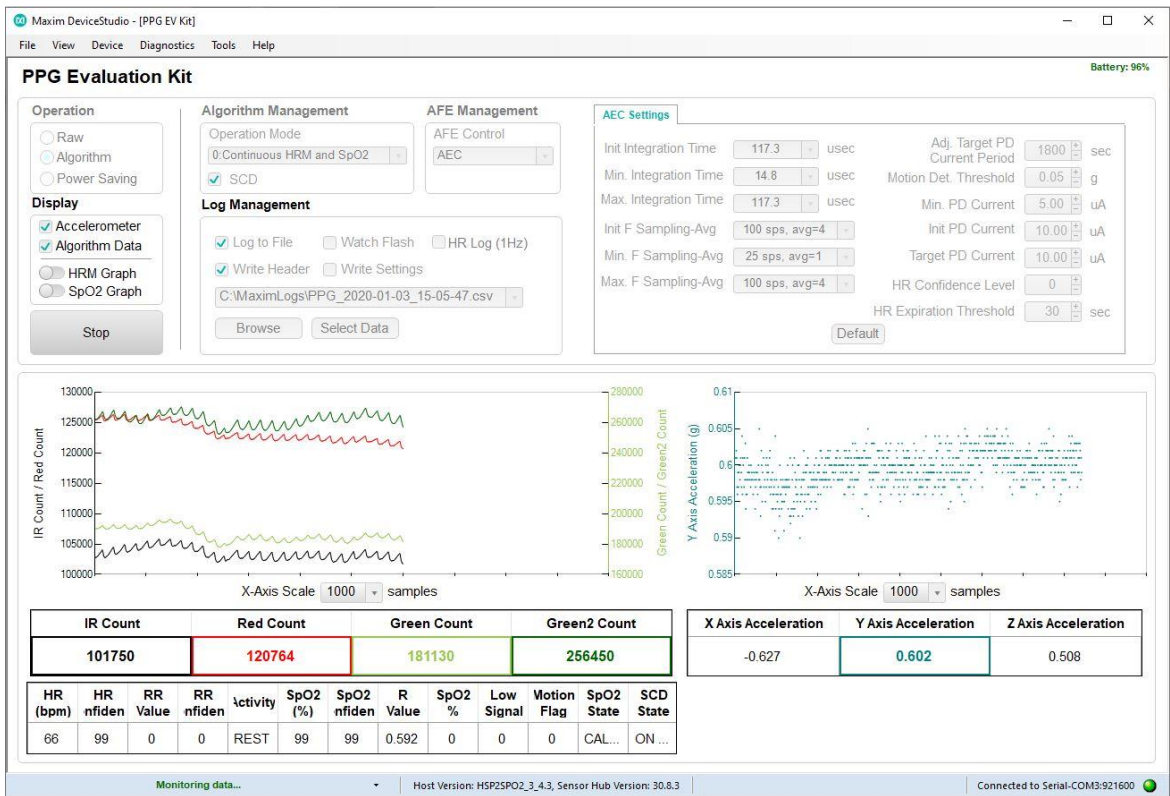


Figure 28. Measurement data displayed.

11. The .csv log file can be viewed on the PC by navigating to the C:\MaximLogs folder and opening it with Excel or a text editor.

**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 <sub>2</sub> 1: Continuous HRM and one-shot SpO <sub>2</sub> 2: Continuous HRM 3: One-shot HRM 4: One-shot HRM and one-shot SpO <sub>2</sub> 5: Activity tracking 6: SpO <sub>2</sub> 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 1: Other 2: Walk 3: Run 4: Bike 5: Rhythmic
R Value	SpO <sub>2</sub> R value (R is defined in Maxim <a href="#">Application Note 6845</a> )
SPO2 Confidence (%)	SpO <sub>2</sub> confidence level; 0 to 100%
SPO2 (%)	SpO <sub>2</sub> value; 0 to 100%
SPO2 Percent Complete	SpO <sub>2</sub> percent complete (only applicable for one-shot mode); 0 to 100%
Low Signal Quality	0: Good SpO <sub>2</sub> signal quality 1: Low SpO <sub>2</sub> signal quality
Motion Flag	0: Little or no motion 1: Excessive motion
WSPO2 Low Pi	0: Normal Perfusion Index 1: Low Perfusion Index
Unreliable R	0: Measurement of SpO <sub>2</sub> R is reliable 1: Measurement of SpO <sub>2</sub> R is not reliable
SPO2 State	0: LED adjustment 1: Computation 2: Success 3: Timeout
SCD State	Skin contact state: 0: No decision

	1: Off skin 2: Contact with object 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
Time	Sample C	Green Co	Green2 C	IR Count	Red Coun	X Axis Acc	Y Axis Acc	Z Axis Acc	Operating	Heart Rat	HR Confi	RR	RR Confi	Activity	R Value	SpO2 Con	SpO2 (%)	SpO2 Peri	Low Sign	Motion	FI	WSPO2 Lc	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	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	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	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	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	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	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	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	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	0	ADJUSTIN ON OBJEC	48646	
11	57:59.1	9	162634	260036	28040	30290	-0.764	0.285	-0.56	0	60	0	0	0	OTHER	0	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	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	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	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	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	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	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	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	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	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	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	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	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	0	ADJUSTIN ON OBJEC	48647	
25	57:59.7	23	164619	266873	28311	30378	-0.8	0.287	-0.572	0	60	0	0	0	OTHER	0	0	0	0	0	0	0	0	0	ADJUSTIN ON OBJEC	48647	
26	57:59.7	24	163651	265226	28272	30370	-0.778	0.29	-0.564	0	60	0	0	0	OTHER	0	0	0	0	0	0	0	0	0	ADJUSTIN ON OBJEC	48647	
27	57:59.8	25	162669	263346	28280	30397	-0.788	0.293	-0.557	0	60	0	0	0	OTHER	0	0	0	0	0	0	0	0	0	ADJUSTIN ON OBJEC	48647	
28	57:59.8	26	161930	261904	28280	30397	-0.789	0.294	-0.56	0	60	0	0	0	OTHER	0	0	0	0	0	0	0	0	0	ADJUSTIN ON OBJEC	48647	
29	57:59.8	27	161310	260786	28280	30397	-0.775	0.277	-0.57	0	60	0	0	0	OTHER	0	0	0	0	0	0	0	0	0	ADJUSTIN ON OBJEC	48647	
30	57:59.9	28	160797	259941	28280	30397	-0.795	0.285	-0.564	0	60	0	0	0	OTHER	0	0	0	0	0	0	0	0	0	ADJUSTIN ON OBJEC	48647	
31	58:00.0	29	160436	259481	28280	30397	-0.787	0.287	-0.555	0	60	0	0	0	OTHER	0	0	0	0	0	0	0	0	0	ADJUSTIN ON OBJEC	48647	
32	58:00.0	30	160237	259271	28280	30397	-0.79	0.286	-0.557	0	60	0	0	0	OTHER	0	0	0	0	0	0	0	0	0	ADJUSTIN ON OBJEC	48647	
33	58:00.0	31	160104	259134	28280	30397	-0.792	0.289	-0.564	0	60	0	0	0	OTHER	0	0	0	0	0	0	0	0	0	ADJUSTIN ON OBJEC	48647	
34	58:00.1	32	159988	259032	28280	30397	-0.771	0.288	-0.561	0	60	0	0	0	OTHER	0	0	0	0	0	0	0	0	0	ADJUSTIN ON OBJEC	48647	

Figure 29. Example log file PPG\_.csv.

### Flash Logging of Data

Perform the following steps to log PPG data to the onboard flash memory:

Start flash logging from the Maxim DeviceStudio PC GUI with the following steps:

1. Set up PPG measurement on the Maxim DeviceStudio PC GUI as instructed in the *Using the Maxim DeviceStudio PC GUI* section and ensure the **Watch Flash** box is checked and the **Log to File** box is unchecked.
2. Click **Start Monitoring**. Data is not streamed to the Maxim DeviceStudio PC GUI or Android app GUI while flash logging is enabled.
3. Only heart rate estimations are transmitted over the standard hearth rate Bluetooth low energy service while the flash logging is enabled and measurement is started. A BLE master device can connect to this service and observe heart rate outputs through a third-party health monitoring BLE application, which supports the standard Heart Rate BLE profile.
4. Disconnect the USB Type-C cable or Bluetooth LE connection at this point to log data while untethered.

Start flash logging from the health band:

1. Press and release Button F.

Start flash logging from the Android app:

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

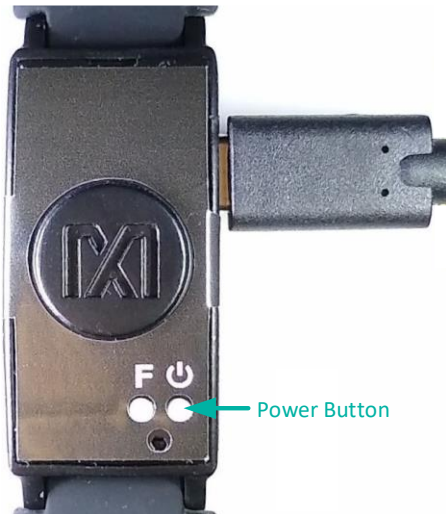
Flash logging can be stopped by pressing the **Stop** button in the Maxim DeviceStudio PC GUI or Android app GUI if the MAXREFDES103# is still tethered to the PC device. Alternatively, press and release Button F to stop flash logging.

Flash logging is not enabled if the battery charge is less than 10%.

### **Downloading the Log File**

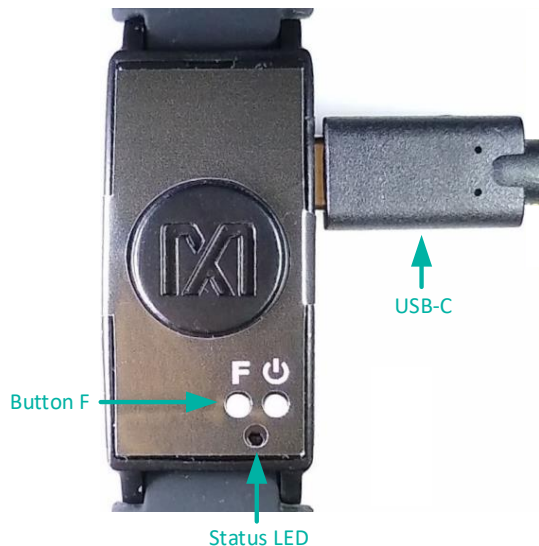
Download and parse the log file using the following steps after flash logging is complete:

1. Ensure the USB Type-C cable is not connected, and power off the MAXREFDES103# by holding the power button down for 15 seconds.



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

The MAXREFDES103# is powered down. Hold Button F on the MAXREFDES103# and insert the USB Type-C cable (or the MAXDAP-TYPE-C Adapter board with a USB Micro-B cable (Figure 31)) into the USB Type-C connector of the MAXREFDES103#. Continue holding Button F until the status LED slowly flashes white.



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

2. The MAXREFDES103# boots into the mass storage device mode if done correctly. The MAXREFDES103# cannot connect to the Maxim DeviceStudio PC GUI or Android app GUI when in the mass storage device mode.

3. The device appears in Windows Explorer as a USB drive. Files can be copied and pasted from the device.
4. Copy the .maximlog file to the PC hard drive.  
Note: The log files are in raw binary format and must be parsed to convert them to a readable .csv format.
5. Open the **Flash Log Parser** from the **Tools** menu in the Maxim DeviceStudio PC GUI.
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.

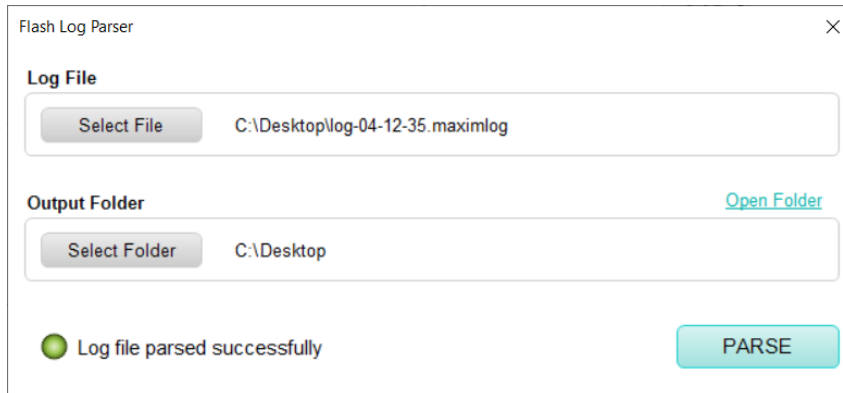


Figure 32. Flash log parser.

## Maxim Health Sensor Platform Android App GUI

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

The following three firmware and software must all be updated using the latest and same software release package.

1. Flash the micro board **.bin** file using drag and drop to the DAPLINK folder,
2. Flash the algorithm **.msbl** file to the MAX32664 using the Maxim DeviceStudio PC GUI.
3. Install the Maxim Health Sensor Platform Android App **.apk**.

### Installing the App

1. Install and run the .apk on the Android device after flashing the .bin, .msbl, and.apk.

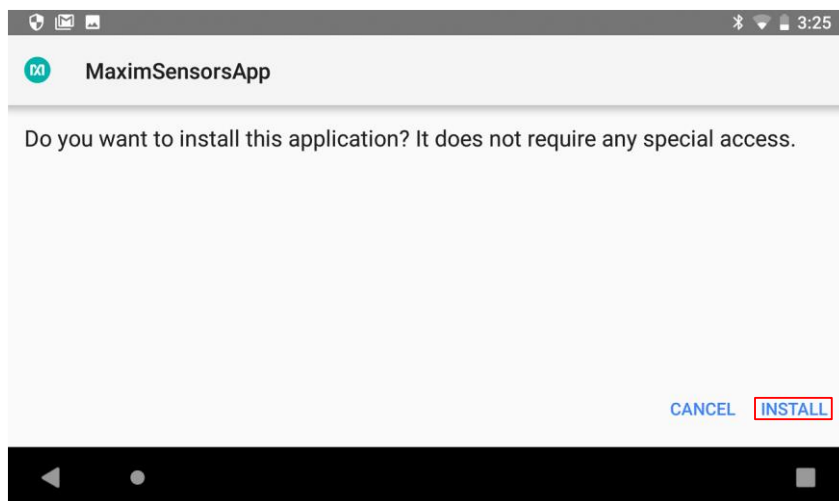


Figure 33. Install the .apk.

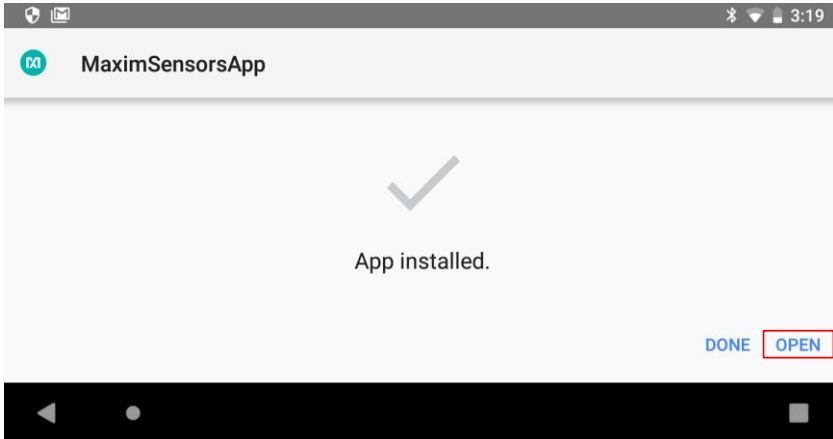


Figure 34. Run the .apk.

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

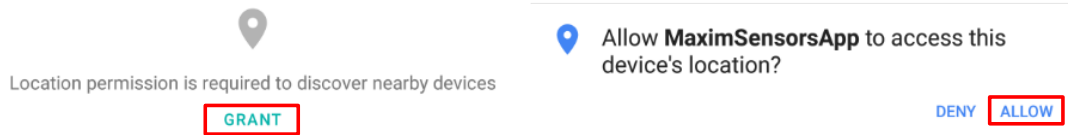


Figure 35. Grant permissions and allow access.

3. Click on the device **HSPSP02...**

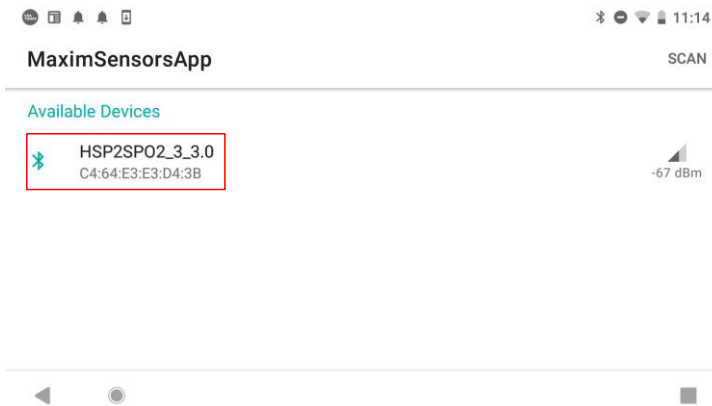


Figure 36. Click on the device HSPSP02...

The main menu displays.

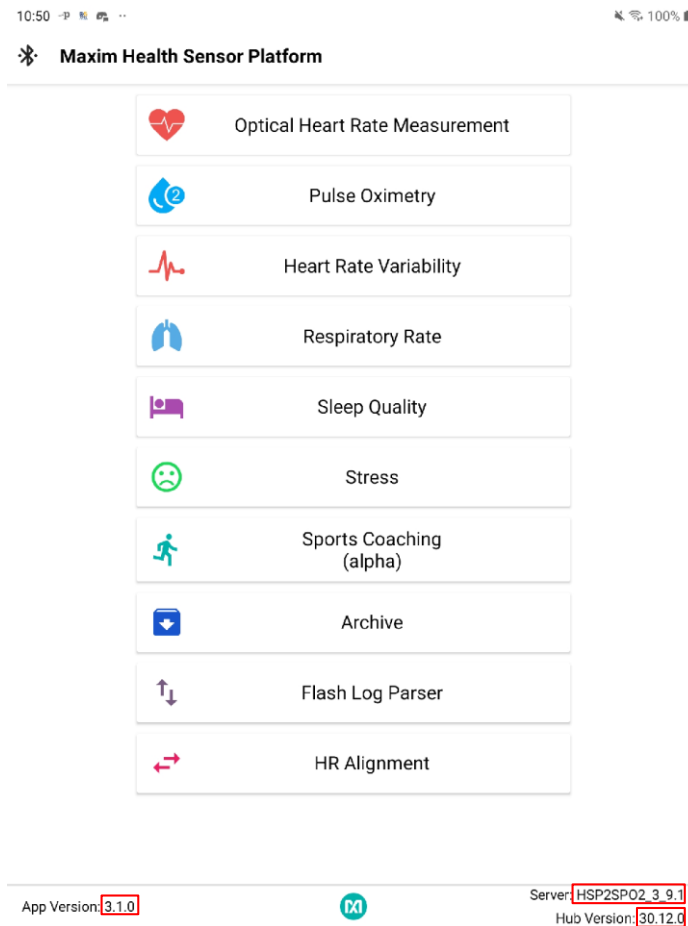


Figure 37. Main menu of the Maxim health sensor platform app.



**IMPORTANT: Verify the version numbers on the App match those in the latest software release package:**

1. Verify the version number in the App Version **x.y.z** matches the version of the latest wellness\_suite\_v**x.y.z**.apk file.
2. Verify the version number for Server **x.y.z** matches the version of the latest mbed-os**XXX\_x.y.z**.bin file.
3. Verify the version number for Hub Version **30.y.z** matches the version of the latest MAX32664C\_XXX\_**30.y.z**.msbl file.

**Optical Heart-Rate Monitoring**

1. Click **Optical HRM** in the main menu. The graphing of the green signal can 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.

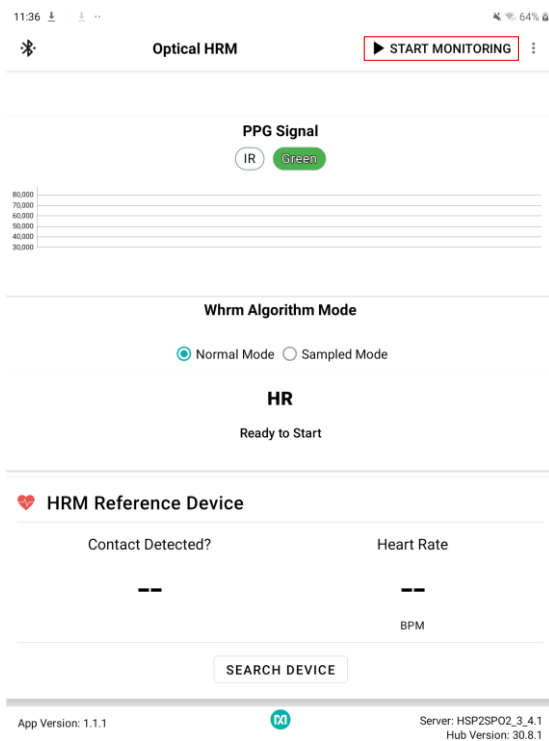


Figure 38. Start heart-rate measurement.

2. The measurement completes after a brief period and the heart-rate measurement displays. Click the stop icon (**STOP MONITORING**) in the upper right corner of the app to stop the measurement.

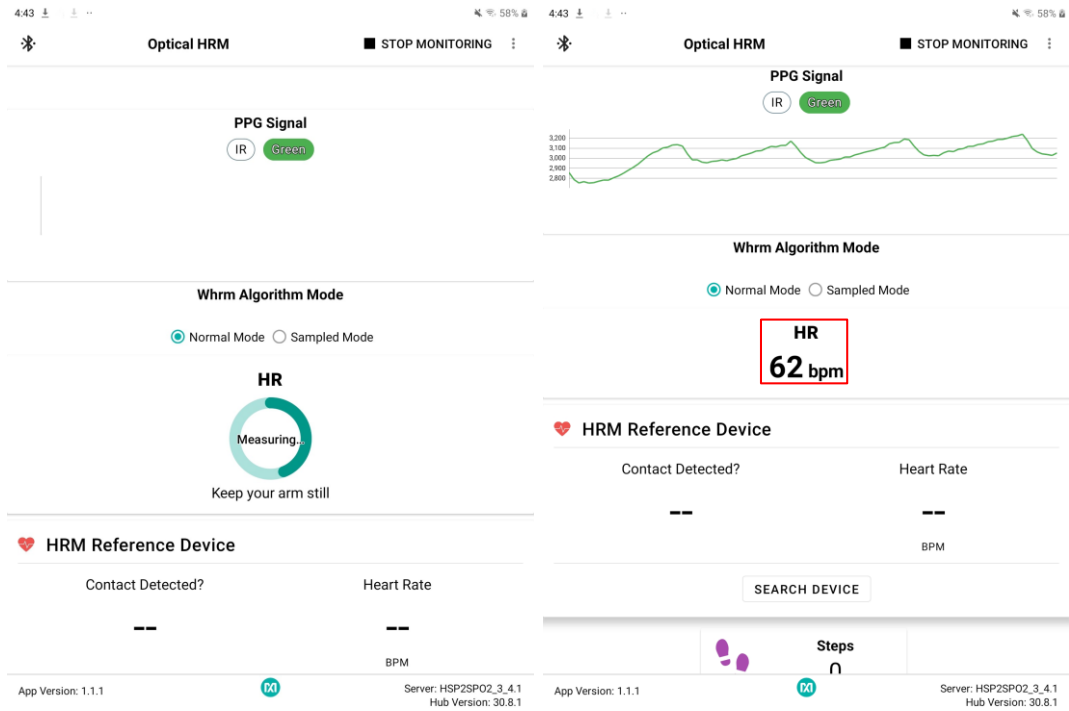


Figure 39. Heart-rate measurement.

## Pulse Oximetry

1. Verify the health sensor band is properly placed about two fingers away from the wrist bone for SpO<sub>2</sub> measurements (Figure 40). Also, the strap tightness is very important (there must be almost no gap between the device and the wrist when the enclosure is lifted slightly).



Figure 40. Positioning the health sensor band.

2. Click the back button of the Android device to go back to the main menu. Click **Pulse Oximetry**. Specify the mode of operation for the algorithm by selecting **Continuous** or **One Shot**. Click the play icon to initiate the SpO<sub>2</sub> measurement. Note the date and time information to recognize the data log files generated by the Android app.

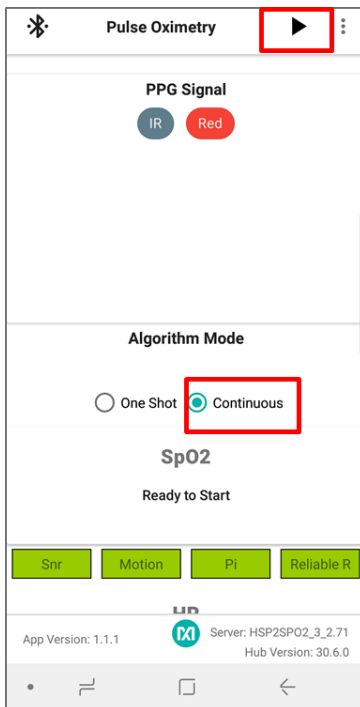


Figure 41. Start SpO<sub>2</sub> measurement.

3. The IR and Red signals are graphed if the **IR** and **Red** buttons are selected. The signals must have peaks and valleys to retrieve a valid SpO<sub>2</sub> reading (Figure 42). Adjust the strap tightness or health sensor enclosure position if the waveform is not correct .

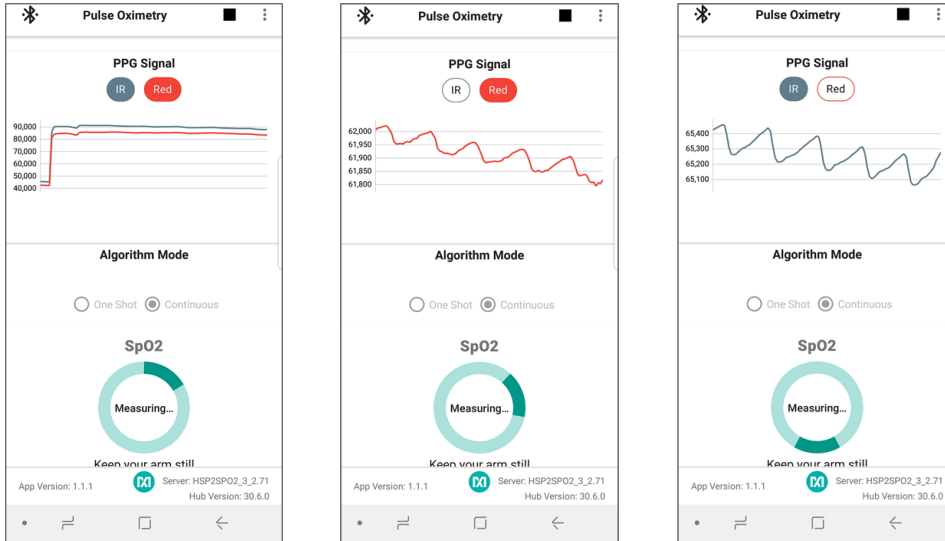


Figure 42. IR and Red signals displayed during the SpO<sub>2</sub> measurement.

The measurement completes after a brief period and the SpO<sub>2</sub> measurement displays.

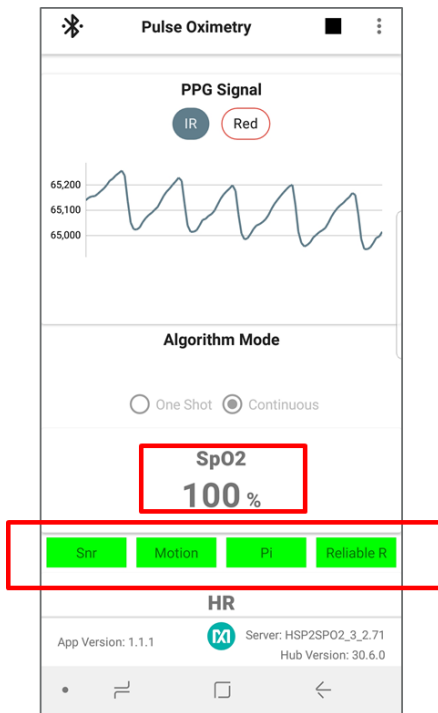


Figure 43. SpO<sub>2</sub> measurement.

4. The 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 the signal has a low signal-to-noise ratio.
  - **Motion** indicates movement on the health sensor band is excessive and wrist movement must be minimized to retrieve proper SpO<sub>2</sub> reading.

- **Pi** indicates if the IR or Red signal's observed perfusion index is too low.
- **Reliable R** indicates the calculated R values are not consistent and so SpO<sub>2</sub> is not being reported.

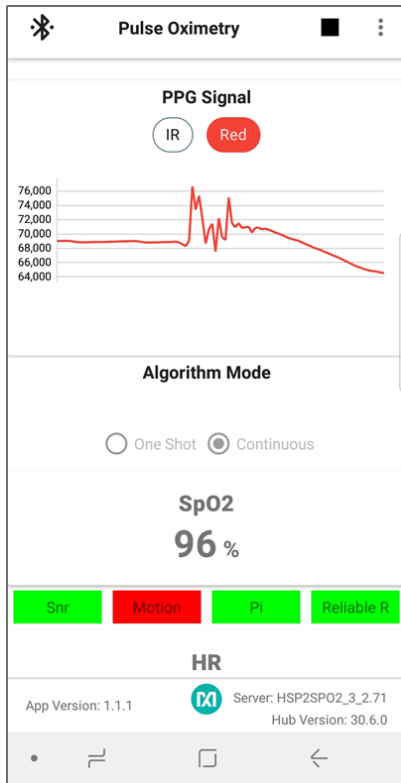


Figure 44. Motion turns red to indicate excessive motion.

5. Click the stop icon to terminate the measurement.

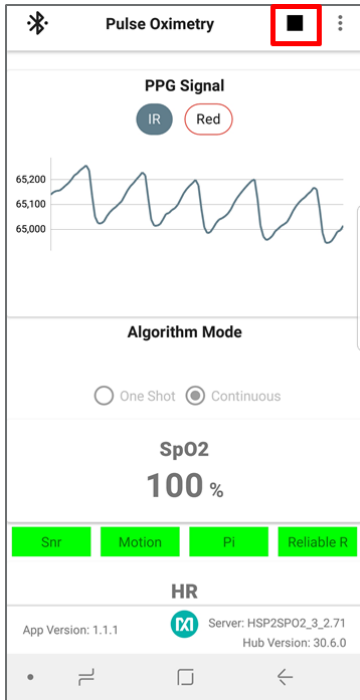


Figure 45. Stop monitoring icon.

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

- Connect an Android device to the 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):

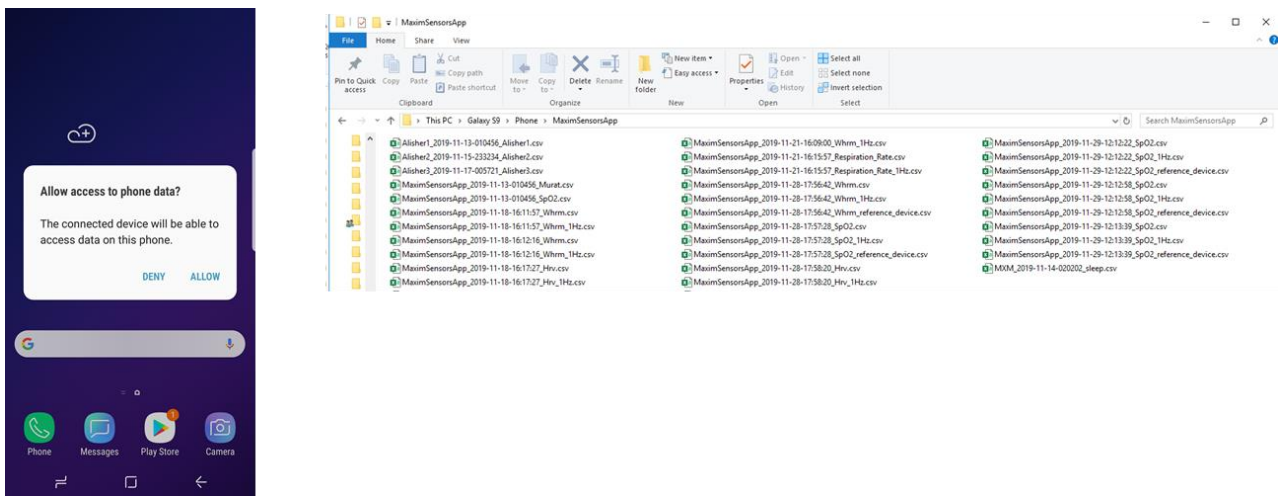


Figure 46. Retrieving the .csv log file from the Android device.

Follow this suggested testing protocol for the most efficient SpO<sub>2</sub> 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 Maxim DeviceStudio PC GUI or Android app GUI as described earlier.
- Verify the proper PPG waveforms for IR/Red are observed without any noise or artifact.
- Reference SpO<sub>2</sub> data is recorded throughout the session. Reference SpO<sub>2</sub> can be recorded visually by reading the reference displayed in the finger clip or using the Android app.
- The number of participants must 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. 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. Click the play icon to start the heart-rate variability monitoring.

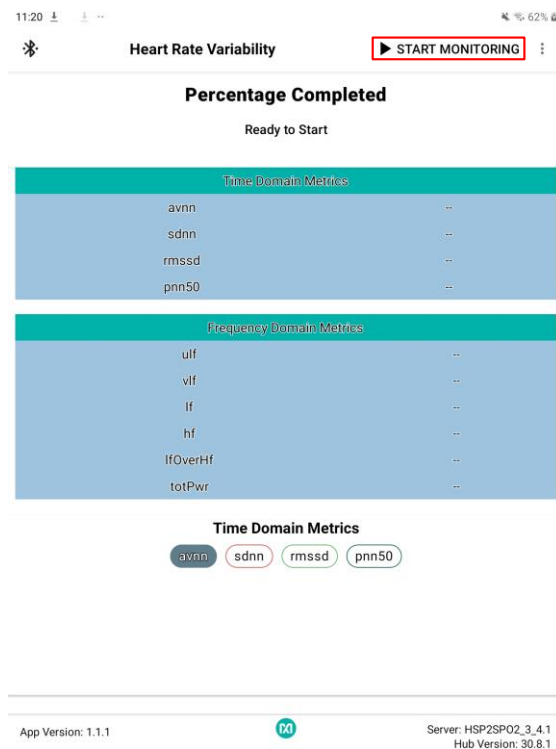


Figure 47. Start heart-rate variability measurement.

2. The measurement completes after a brief period and the data for heart-rate variability displays.

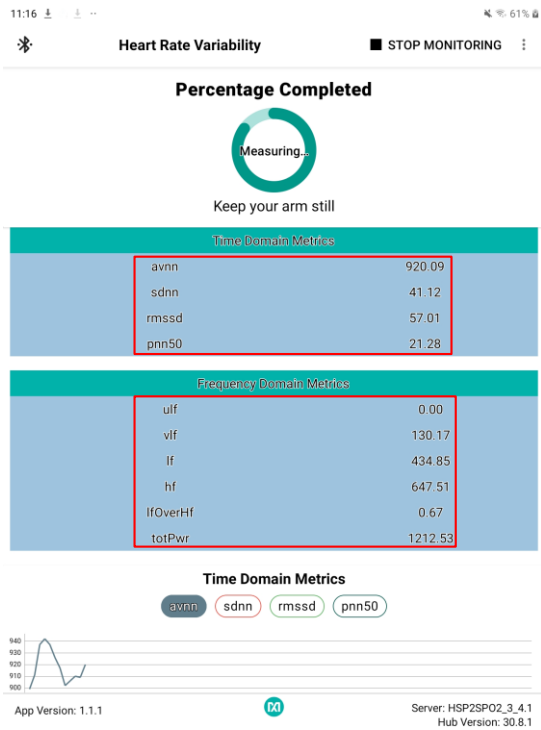


Figure 48. Heart-rate variability measurement.

3. Click 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. Click **Respiration Rate**. Click the play icon to initiate the respiration rate measurement.

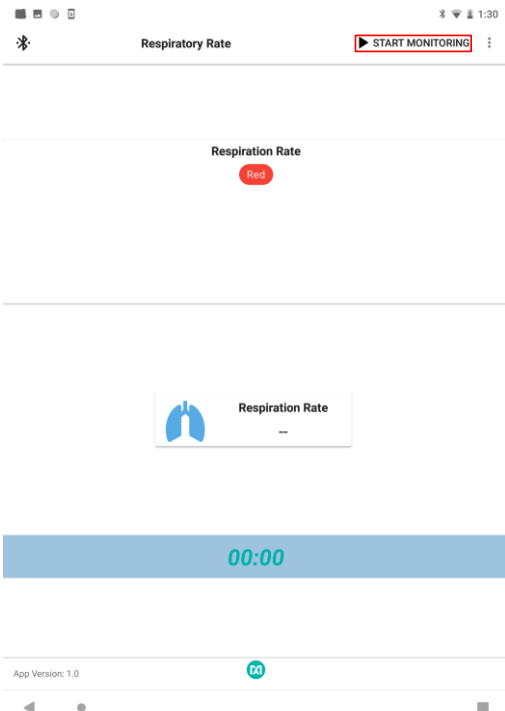




Figure 49. Start the respiration rate measurement.

- The respiration rate displays after a brief period.

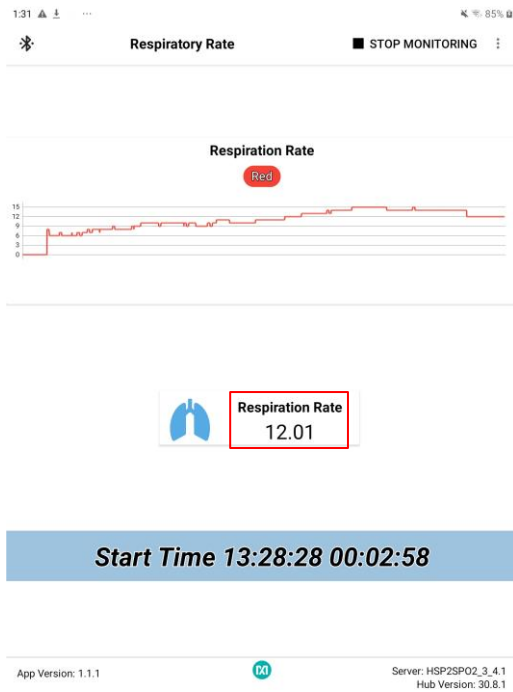


Figure 50. Respiration rate measurement.

- Click the stop icon to terminate the measurement.

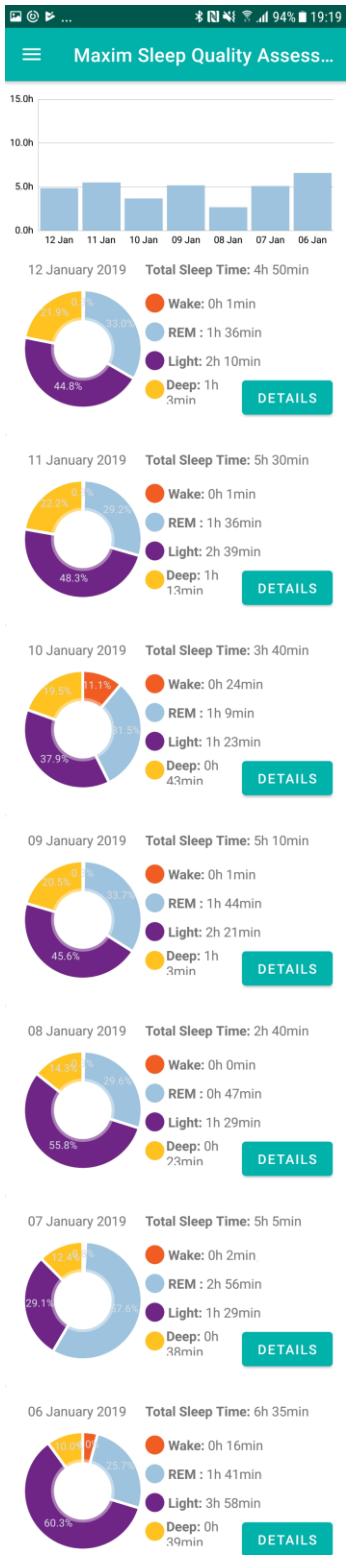


Figure 51. Sleep quality assessment.

## 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 can compromise the tightness of the lid closure. Tape the lid to the sides of the enclosure if this happens.

Do not use solvents such as alcohol to clean the mesa sticker or the cover film as they can damage these items. The cover film on the sensors prevents dirt or sweat from interfering with the optical components.

## Time-Alignment Method to Compare the PPG Data to ECG Data

There can be some time differences between the two data sets when comparing the PPG data from the MAXREFDES103# to the data from an ECG reference device. Consequently, post-process the data to time-align the PPG and ECG data sets, as outlined in the following procedure. (The MAXREFDES103# does not support ECG measurements. This section assists users who want to compare the accuracy to an ECG reference device).

1. Down sample 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.
  - Crop the first `time_difference` seconds from the PPG data set if the `time_difference` is greater than zero.
  - Crop the first `time_difference` seconds from the ECG data set if the `time_difference` is less than zero.
3. Crop the excessive data at the end to make both data sets the same size if one data set is larger than the other.
4. Crop the first 30 seconds of the data sets to remove the data captured during initialization.

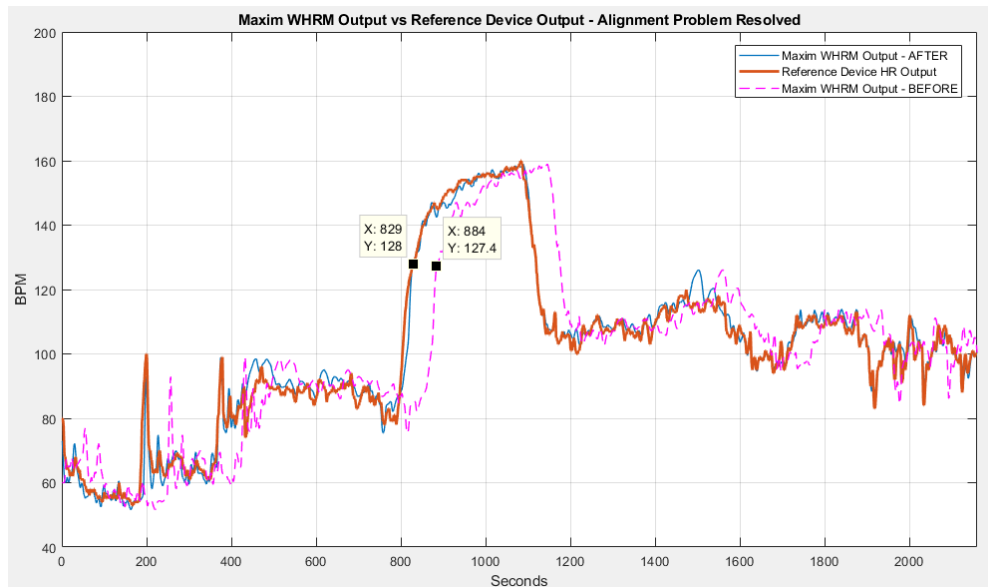


Figure 52. Time-aligned PPG and ECG data sets.

## SpO<sub>2</sub> Calibration

The SpO<sub>2</sub> coefficients must be determined using the final product form factor and product cover lens to obtain accurate SpO<sub>2</sub> measurements. The SpO<sub>2</sub> coefficients are set by sending a message through the I<sup>2</sup>C interface, which is detailed in the [MAX32664 User Guide](#).

Refer to the Maxim Application Note 6845, [Guidelines for SPO2 Measurement Using the Maxim® MAX32664 Sensor Hub](#) for calculations used to determine the SpO<sub>2</sub> value and an explanation of how to calculate the SpO<sub>2</sub> coefficients for the end product.

## Additional Resources

- MAX32664 user guide, application notes, c-keyed .msbl, sample host code: [MAX32664 Ultra-Low Power Biometric Sensor Hub](#)
- [Interface guide for MAX32664 sensor hub-based reference design platforms](#).

## Troubleshooting

- **The MAX32625-TYPE-C does not show up as DAPLINK or the drag and drop into the DAPLINK fails to program the MAX32630FTHR.** Follow the instructions in the given link to program the MAX32625PICO with the file **max32625pico\_max32630hsp.bin** (interface version 243): <https://os.mbed.com/teams/MaximIntegrated/wiki/MAX32625PICO-Firmware-Updates>

## Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	1/20	Initial release	—
1	1/20	Change time for power off to 15s. Update button and LED status description. Change Log to Flash to Watch Flash for PC GUI.	8, 9, 27, 28
2	6/20	Updated Figure 15, 37. Updated Starting the PPG Measurement. Updated Flash Logging of Data. Updated entire document for the names of the Maxim DeviceStudio PC GUI and Android App GUI. Added Additional Resources and Troubleshooting sections. Updated Software Updates and Maxim Health Sensor Platform Android App GUI sections.	All

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