



# MAXREFDES101#: Health Sensor Platform 2.0 User Guide

UG6780; Rev 2; 8/19



## Abstract

This user guide provides information about preparing and running the MAXREFDES101# Health Sensor Platform. This platform uses several biosensors, power-management ICs (PMIC), and microcontrollers from Maxim Integrated® in a wrist worn design that allows the capture of biosignals important to healthcare. The platform also contains algorithms for calculating heart health based on the biosensor measurements.

# Table of Contents

Detailed Hardware Description.....	5
Required Equipment .....	6
System Diagram .....	7
Operating the Watch .....	8
Power On/Off.....	8
Display Modes.....	9
How to Wear the Device .....	10
PPG Measurement .....	10
ECG Measurement .....	10
Body Temperature Measurement.....	10
Installing the PC GUI.....	11
Upgrading the Firmware on MAXREFDES101# .....	12
Updating the Sensor Hub Algorithm .....	13
Using the PC GUI .....	16
USB Connection.....	16
BLE Connection .....	19
Starting the ECG Measurement.....	20
Starting the Temperature Measurement .....	22
Starting the PPG Measurement.....	23
Installing the Android App .....	25
Using the Android App .....	26
BLE Connection for Android .....	26
Starting the ECG Measurement for Android .....	27
Starting the PPG Measurement for Android.....	29
Starting the Temperature Measurement for Android.....	30
Installing the Windows 7 Driver .....	32
Flash Logging .....	34
Downloading the Log File .....	34
Data Format.....	36
Revision History .....	39

## List of Figures

Figure 1. MAXREFDES101# wearable form factor in detail.....	5
Figure 2. MAXREFDES101# exploded view. ....	5
Figure 3. MAXREFDES101# system diagram.....	7
Figure 4. USB Type-C cable (left) and Pico adapter board (right).....	8
Figure 5. Watch display modes.....	9
Figure 6. PPG measurement.....	10
Figure 7. ECG measurement. ....	10
Figure 8. Install the .msi file.....	11
Figure 9. Pico adapter connected to the PC.....	12
Figure 10. DAPLINK drive on the PC. ....	12
Figure 11. Maxim DeviceStudio scan options.....	13
Figure 12. Maxim DeviceStudio connected devices. ....	14
Figure 13. Upload embedded heart-rate algorithm to the MAX32664.....	15
Figure 14. USB connection to PC using a USB Type-C cable (left) and Pico adapter board (right). 16	
Figure 15. Scan for devices.....	17
Figure 16. Successful connection over USB. ....	18
Figure 17. BLE device selection.....	19
Figure 18. Successful connection over BLE.....	19
Figure 19. Start the ECG measurement. ....	20
Figure 20. ECG measurement sample. ....	21
Figure 21. Start the temperature measurement.....	22
Figure 22. Start the PPG measurement. ....	23
Figure 23. PPG measurement sample. ....	24
Figure 24. Install the Android app.....	25
Figure 25. Available Devices list. ....	26
Figure 26. Mode selection view.....	26
Figure 27. Start the ECG measurement for the Android app.....	27
Figure 28. Android app ECG measurement sample. ....	28
Figure 29. Android app PPG measurement sample. ....	29

Figure 30. Start the temperature measurement for the Android app.....	30
Figure 31. Android app temperature measurement sample.....	31
Figure 32. CDC DEVICE in Device Manager. ....	32
Figure 33. Locate and install the driver manually. ....	32
Figure 34. Browse to extracted release package.....	33
Figure 35. Choose Install this driver software anyway.....	33
Figure 36. mbed Serial Port in Device Manager. ....	33
Figure 37. MSD connection to PC using USB Type-C cable (left) and Pico adapter board (right).	34
Figure 38. Flash Log Parser.....	35
Figure 39. Log file PPG_.csv for PPG measurement.....	36
Figure 40. Log file ECG_.csv for ECG measurement. ....	37
Figure 41. Log file Temp_.csv for body temperature measurement.....	38

## List of Tables

Table 1. PPG Raw Data Table Column Definitions (PPG_*.csv) .....	36
Table 2. ECG Raw Data Table Column Definitions (ECG_*.csv).....	37
Table 3. Temperature Raw Data Table Column Definitions (TEMP_*.csv) .....	38

## Detailed Hardware Description



Figure 1. MAXREFDES101# wearable form factor in detail.

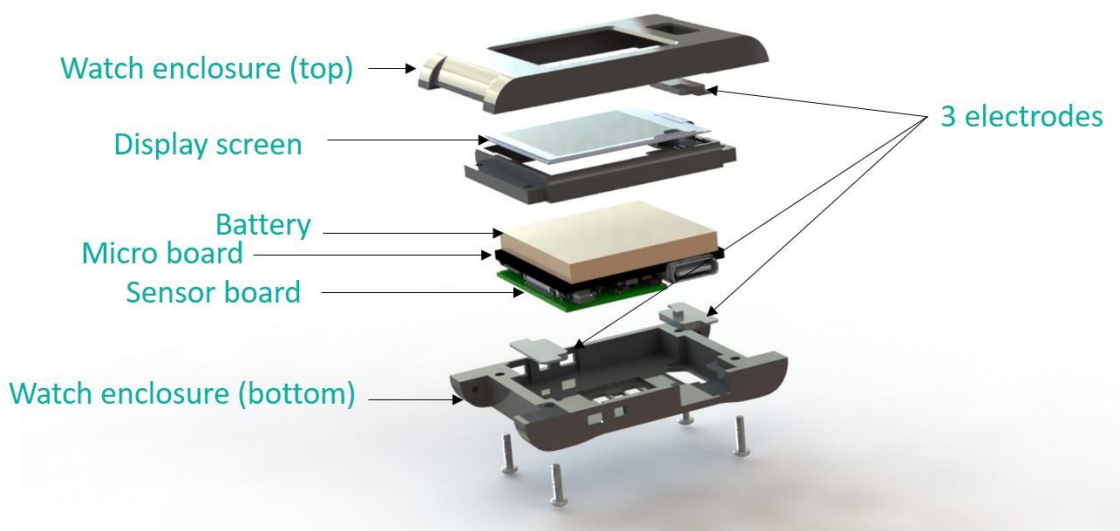


Figure 2. MAXREFDES101# exploded view.

## Required Equipment

The MAXREFDES101# platform includes the following components:

- Micro board that includes:
  - MAX32630 microcontroller
  - MAX20303 power-management IC (PMIC)
  - Dual mode Bluetooth®
  - Six-axis accelerometer and gyroscope
- Sensor board that includes:
  - MAX86141 analog front end and optical heart-rate sensor with one green LED and two photodiodes
  - MAX30001 ECG sensor
  - MAX30205 human body temperature sensor
  - MAX32664 microcontroller with embedded heart-rate algorithm
  - Three-axis accelerometer
- MAXDAP-TYPE-C Pico adapter board to be used during a firmware upgrade for the micro board
- Watch enclosure
- Battery
- 1 USB Micro-B cable for firmware upgrade of the micro board
- 1 USB Type-C™ cable for PC communication with the micro board or charging of the watch

Additional requirements:

- PC or Android® device (e.g., tablet) with Bluetooth connection for data streaming and logging

Note: PC Bluetooth connection is only supported on Windows® 10. A USB connection is required for Windows 7.

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*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.*

*USB Type-C is a trademark of Universal Serial Bus Implementers Forum, Inc.*

*Windows is a registered trademark and registered service mark of Microsoft Corporation.*

# System Diagram

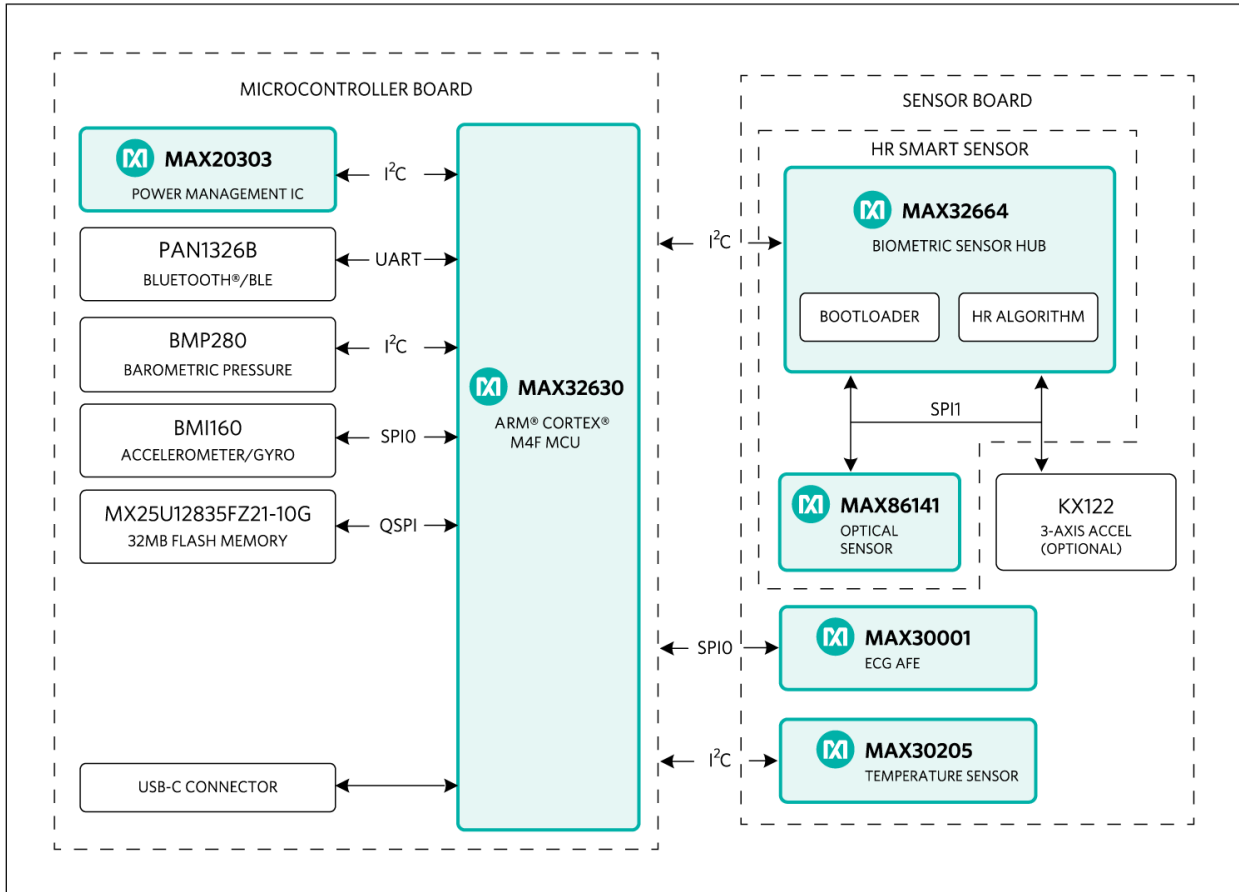


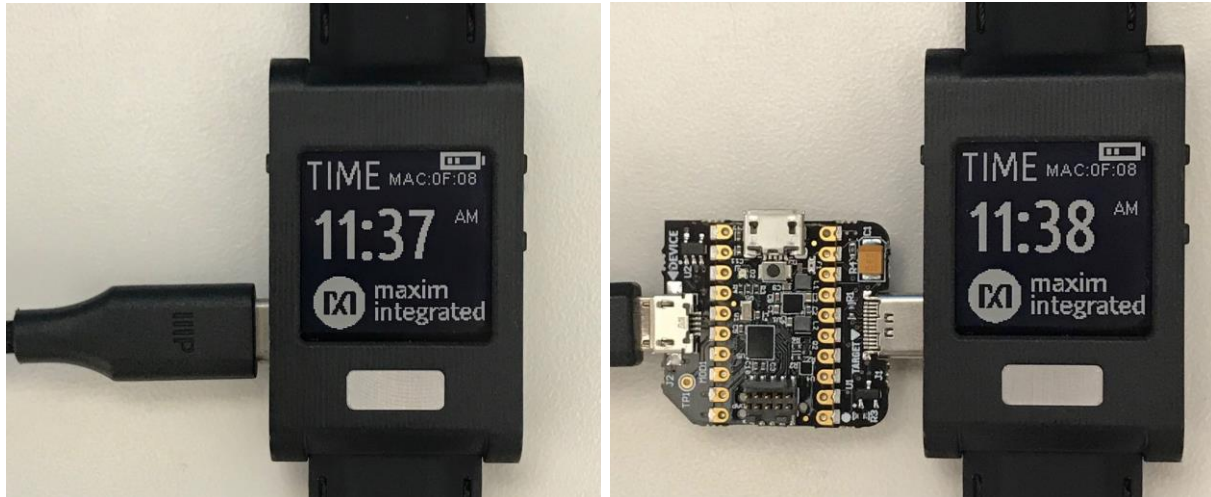
Figure 3. MAXREFDES101# system diagram.

## Operating the Watch

### Power On/Off

The MAXREDES101# can be powered on by pressing and holding button 1 for at least one second. When the device is on, the display shows the time mode by default.

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



*Figure 4. USB Type-C cable (left) and Pico adapter board (right).*

The MAXDAP-TYPE-C Pico adapter board has two USB Micro-B connectors. The top connector next to the push button is used for updating the firmware of the micro board. The left connector next to the “DEVICE” label is used for the serial connection between the MAXREFDES101# and the PC. Both connectors provide power to the MAXREFDES101#.

To power off, press and hold button 1 for at least three seconds. When LED indicator 1 turns red, release button 1, and the device powers off.

Note: If the device fails to power off or becomes unresponsive, press and hold button 1 for at least twelve seconds to perform a hard reset.



## Display Modes

The display can be toggled between time mode, PPG mode, temperature mode, and info mode. To cycle between modes, press and release button 2 or button 3.



*Figure 5. Watch display modes.*

Note: There is no display in ECG mode because the noise from the display interferes with the measurement. To take an ECG measurement, use the PC or Android application.

## How to Wear the Device

Position the watch approximately one finger width up the arm from the wrist bone. If possible, wear the watch on the non-dominant hand, as this improves the quality of the data. The watch should fit tightly but comfortably around the wrist.

### ***PPG Measurement***

To take a PPG measurement, wear the watch on the wrist and make sure the skin has direct contact with the LED/photodiodes at the center of the back of the watch.



*Figure 6. PPG measurement.*

### ***ECG Measurement***

To take an ECG measurement, wear the watch on the wrist and make sure the skin has direct contact with electrodes 2 and 3. Then place a finger from the opposite hand on electrode 1. For example, if the watch is worn on the left wrist, use a finger from the right hand.

Note: For best results on Windows 7, flash logging is recommended to avoid noise over the USB cable.



*Figure 7. ECG measurement.*

### ***Body Temperature Measurement***

To take a body temperature measurement, wear the watch on the wrist and make sure the skin has direct contact with electrode 2.

## Installing the PC GUI

1. Download and extract the Eval Package for either Windows 10 or Windows 7 from the Software section on the [MAXREFDES101# Design Resources tab](#).

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

2. Double click on the .msi file. Check the box for “I accept the terms in the License Agreement”, click on “Install,” and then click on “Finish.”

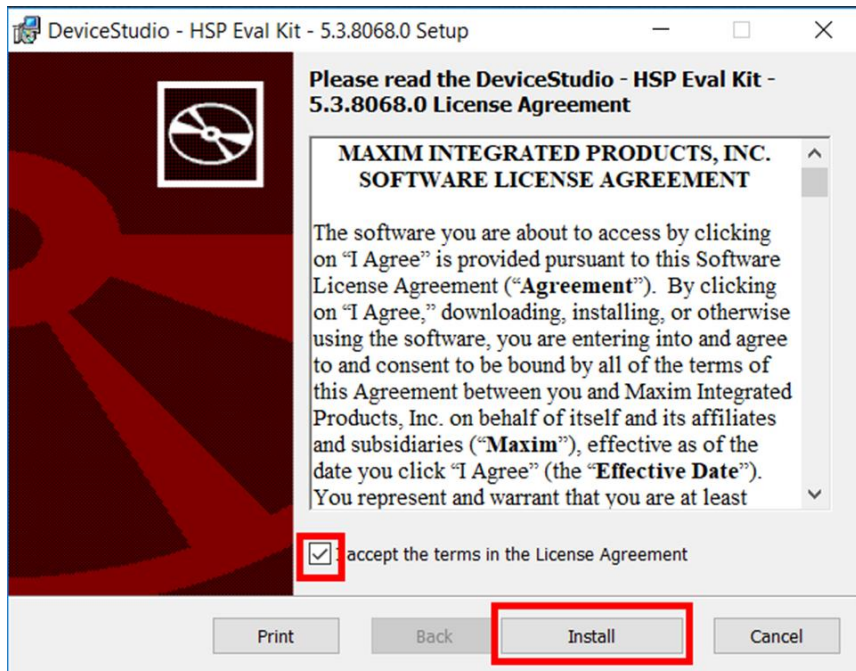


Figure 8. Install the .msi file.

## Upgrading the Firmware on MAXREFDES101#

The micro board might be shipped without the latest firmware. Maxim recommends that you update the firmware whenever new firmware becomes available. Firmware upgrades can be performed using the provided Pico adapter board by performing the following steps:

1. Download and extract the Eval Package from the Software section on the [MAXREFDES101# Design Resources tab](#).

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

2. Insert the Pico adapter board into the USB Type-C connector of the watch. This establishes a connection with the micro board inside the watch assembly.
3. Connect the Pico adapter board to the PC using two USB Micro-B cables.



Figure 9. Pico adapter connected to the PC.

4. 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.

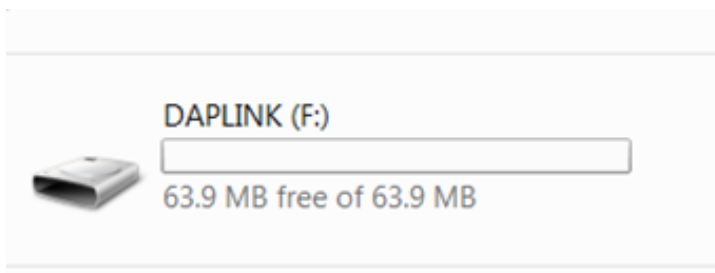


Figure 10. DAPLINK drive on the PC.

5. To flash the program, use the Drag and Drop feature (e.g., drag and drop the binary file into the DAPLINK drive on your PC).

6. After flashing the micro board with the new firmware, the board does not automatically reset. To restart the watch after flashing, press and release the button on the Pico adapter board. The button is located below the top USB Micro-B connector.

## Updating the Sensor Hub Algorithm

After the firmware binary is updated, the Biometric Sensor Hub algorithm can be updated with the PC GUI by performing the following steps:

1. Download and extract the Eval Package from the Software section on the [MAXREFDES101# Design Resources tab](#).

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

2. Open the Maxim<sup>®</sup> DeviceStudio Windows application.
3. Select the “Serial over USB” Scan Option. Click “Scan.”

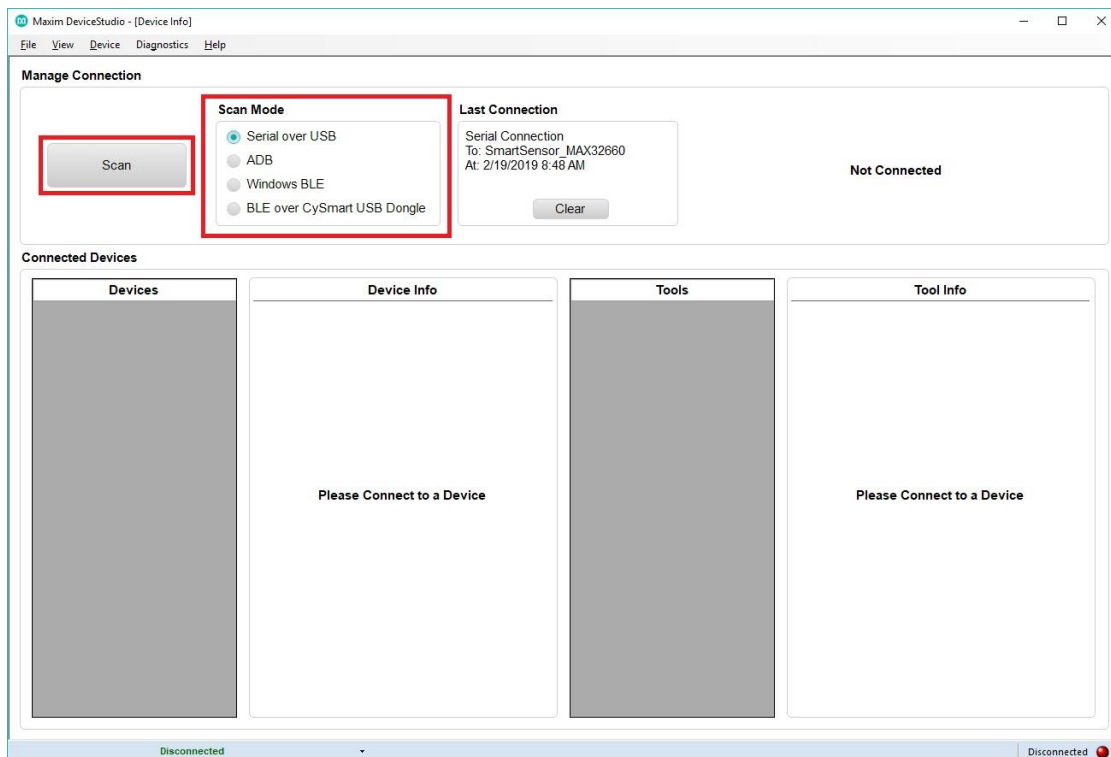


Figure 11. Maxim DeviceStudio scan options.

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- Verify that Connected Devices lists ECG, Temp, and PPG.

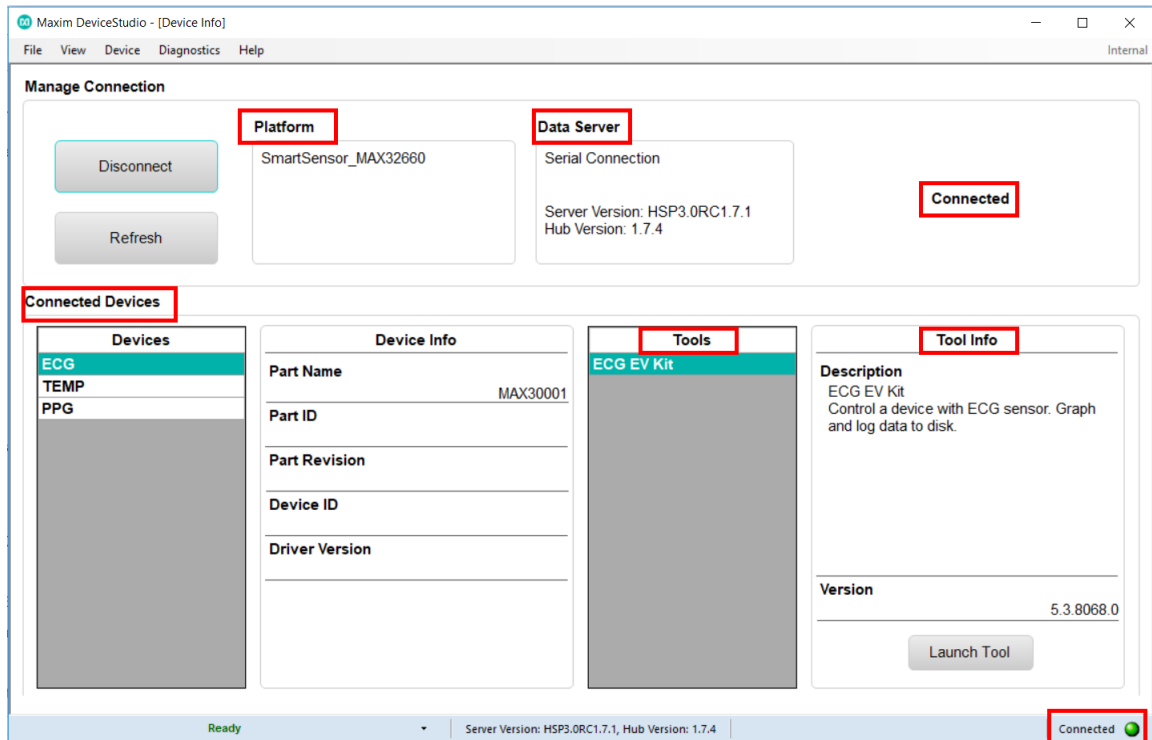


Figure 12. Maxim DeviceStudio connected devices.

- Go to Device Tab > Update SmartSensor\_MAX32660 Software > Update Firmware and select the \*.msbl file from the extracted Eval Package.
- The embedded heart rate algorithm is uploaded to the MAX32664 microcontroller on the sensor board.

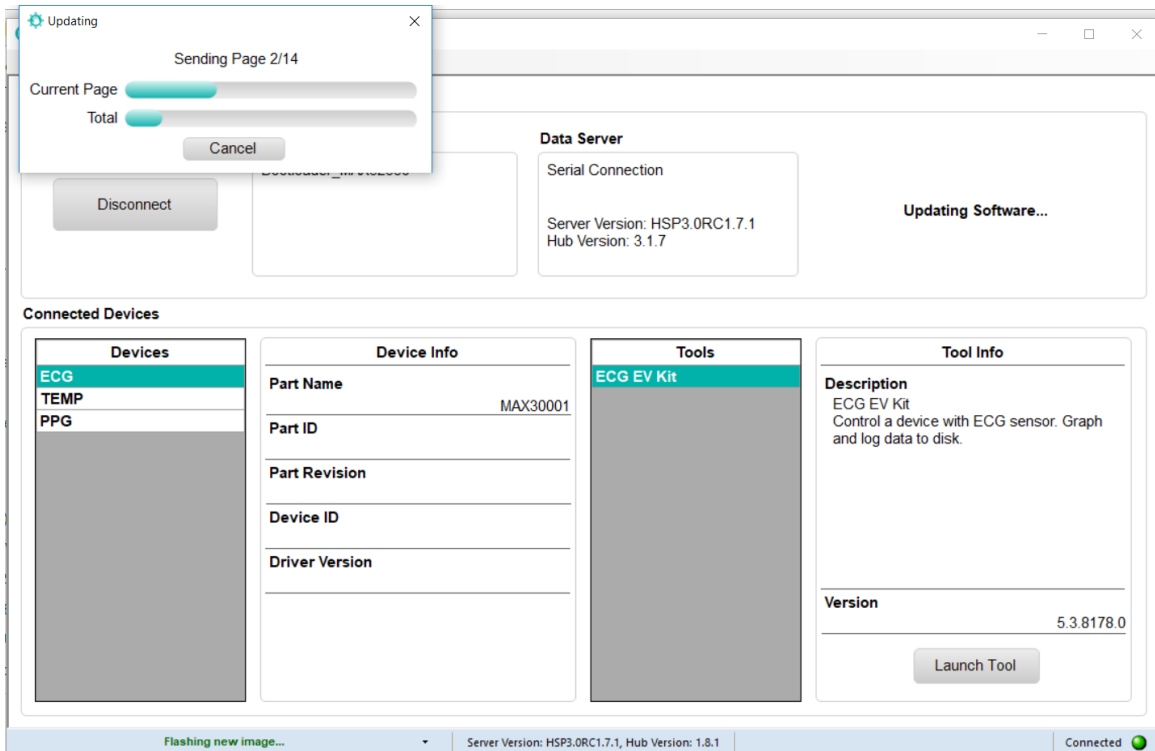


Figure 13. Upload embedded heart-rate algorithm to the MAX32664.

## Using the PC GUI

The Windows 10 PC GUI currently supports connection to the MAXREFDES101# through USB or Bluetooth Low Energy (BLE). The Windows 7 PC GUI only supports connection to the MAXREFDES101# through USB.

### USB Connection

1. Connect the watch to the PC with a USB Type-C cable (or with the Pico adapter board with a USB Micro-B cable).



*Figure 14. USB connection to PC using a USB Type-C cable (left) and Pico adapter board (right).*



2. Under Scan Mode, select “Serial over USB.” Click “Scan.”

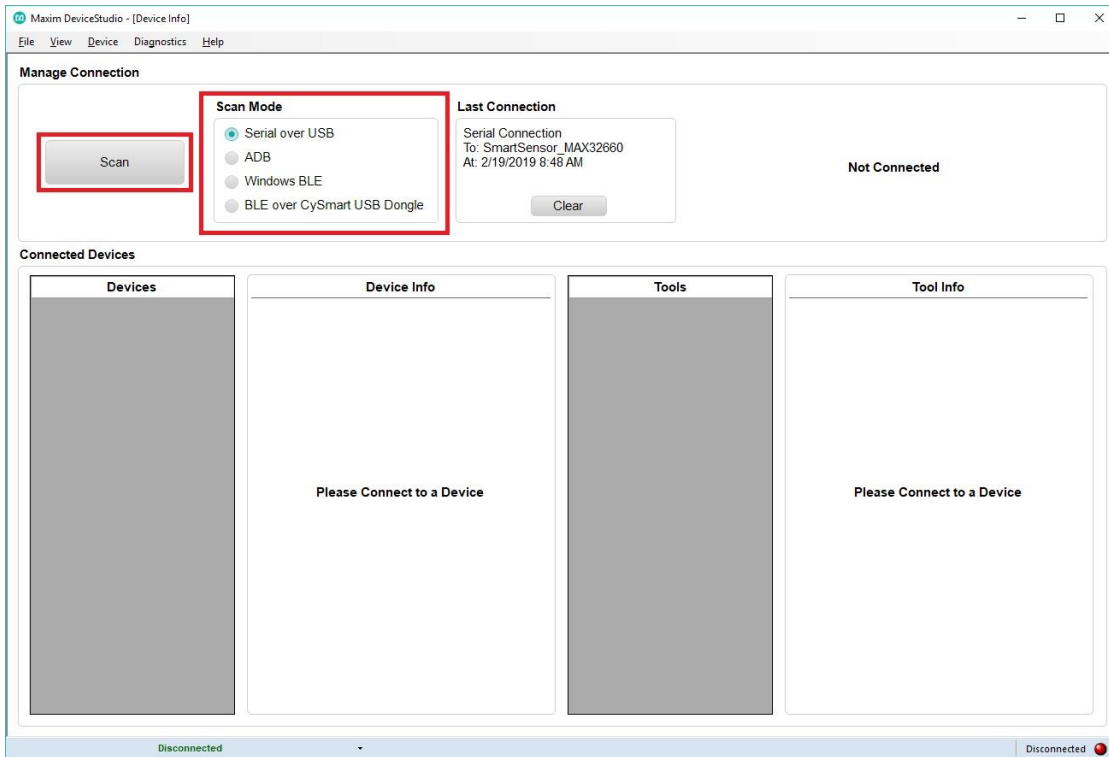


Figure 15. Scan for devices.

3. Verify that Connected Devices lists ECG, TEMP, and PPG.

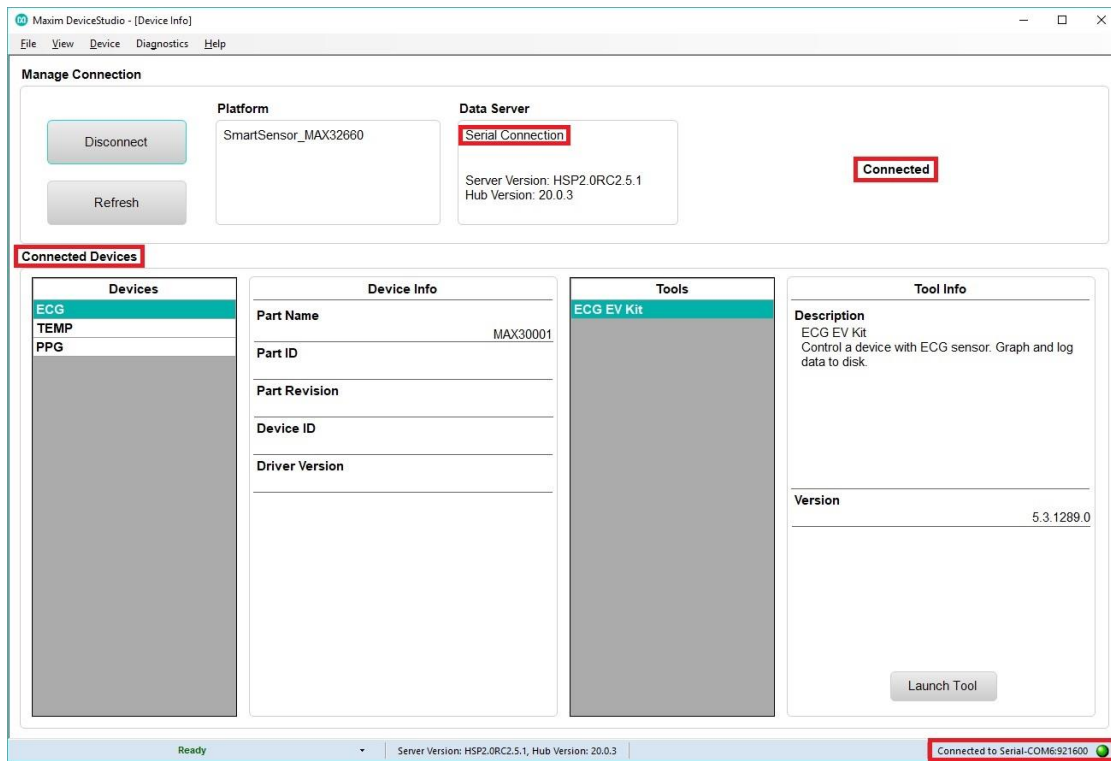


Figure 16. Successful connection over USB.

## BLE Connection

1. Under Scan Mode, select “Windows BLE.” Click “Scan.”
2. Select the device with the MAC address that matches the MAC address listed on the watch info screen. Click “Connect.”

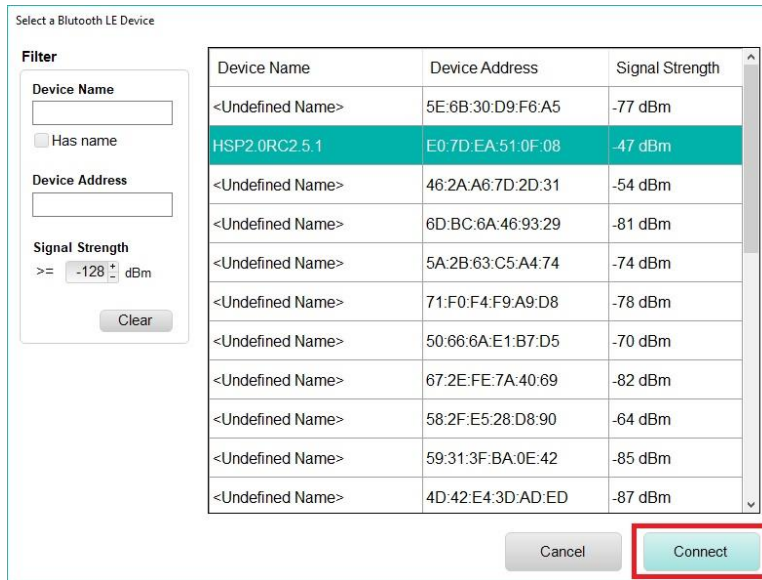


Figure 17. BLE device selection.

3. Verify that Connected Devices lists ECG, TEMP, and PPG.

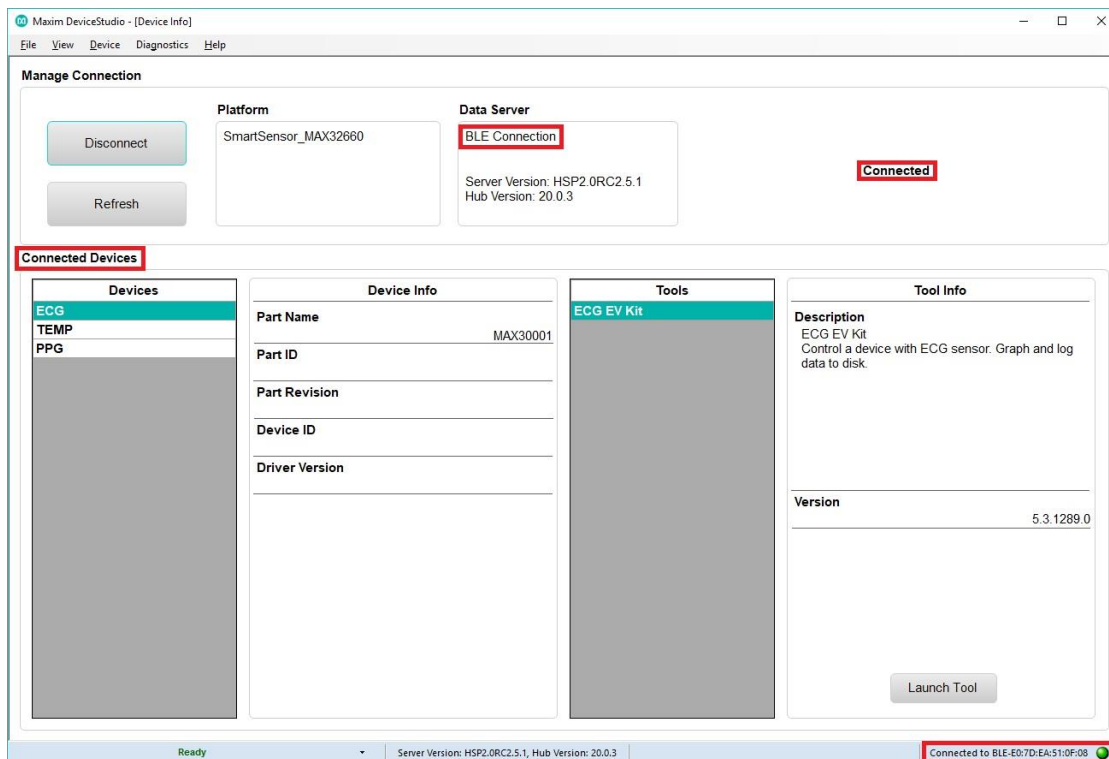


Figure 18. Successful connection over BLE.

## Starting the ECG Measurement

1. Select “ECG” under Connected Devices and click on “Launch Tool.”
2. Check the box for “Log to File” to save the data to a file.
3. Check the box for “Log to Flash” to save the data to the on-board flash. Data is not streamed to the GUI while Flash Logging is enabled.
4. Select the desired filters.
5. Adjust the ECG parameters. The default parameters can be used for the first time. Refer to the MAX30001 data sheet for a detailed explanation of the parameters.
6. Click on “Start Monitoring.”

Note: There is no display in ECG mode because the noise from the display interferes with the measurement.

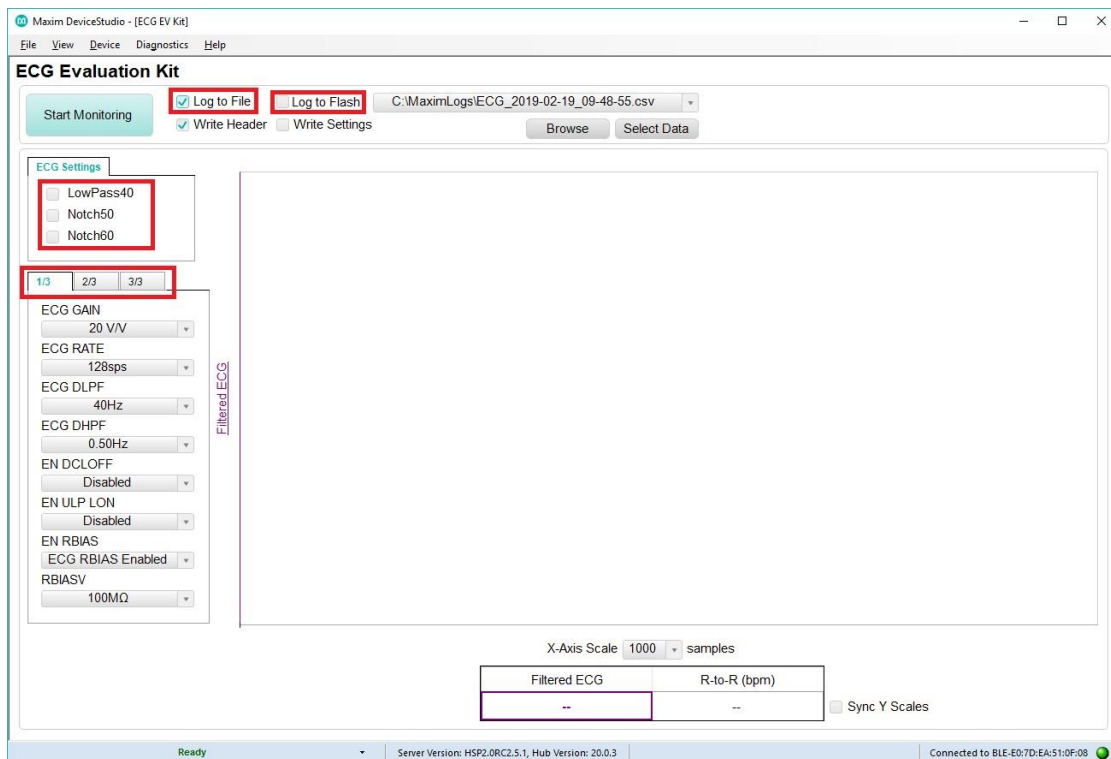


Figure 19. Start the ECG measurement.



Figure 20. ECG measurement sample.

## Starting the Temperature Measurement

1. Click on View. Select “TEMP EV Kit.”
2. Check the box for “Log to File” to save the data.
3. Check the box for “Log to Flash” to save the data to the on-board flash. Data is not streamed to the GUI while Flash Logging is enabled.
4. Select the Sample Interval in seconds.
5. Click on “Start Monitoring.”



Figure 21. Start the temperature measurement.

## Starting the PPG Measurement

1. Click on View and select “PPG EV Kit.”
2. Check the box for “Log to File” to save the data.
3. Check the box for “Log to Flash” to save the data to the on-board flash. Data is not streamed to the GUI while Flash Logging is enabled.
4. Check the box for “Accelerometer Chart” to plot the accelerometer data.
5. Check the box for “Algorithm Data” to see the algorithm data: HR (bpm), HR Confidence (%), and Activity.
6. Select Raw mode to manually set the AFE settings. The default settings can be used for the first time. Refer to the MAX86141 data sheet for a detailed explanation of the AFE settings.
7. Select Algorithm mode to allow the MAX32664 HRM algorithm to dynamically adjust the AFE settings.
8. Click on “Start Monitoring.”

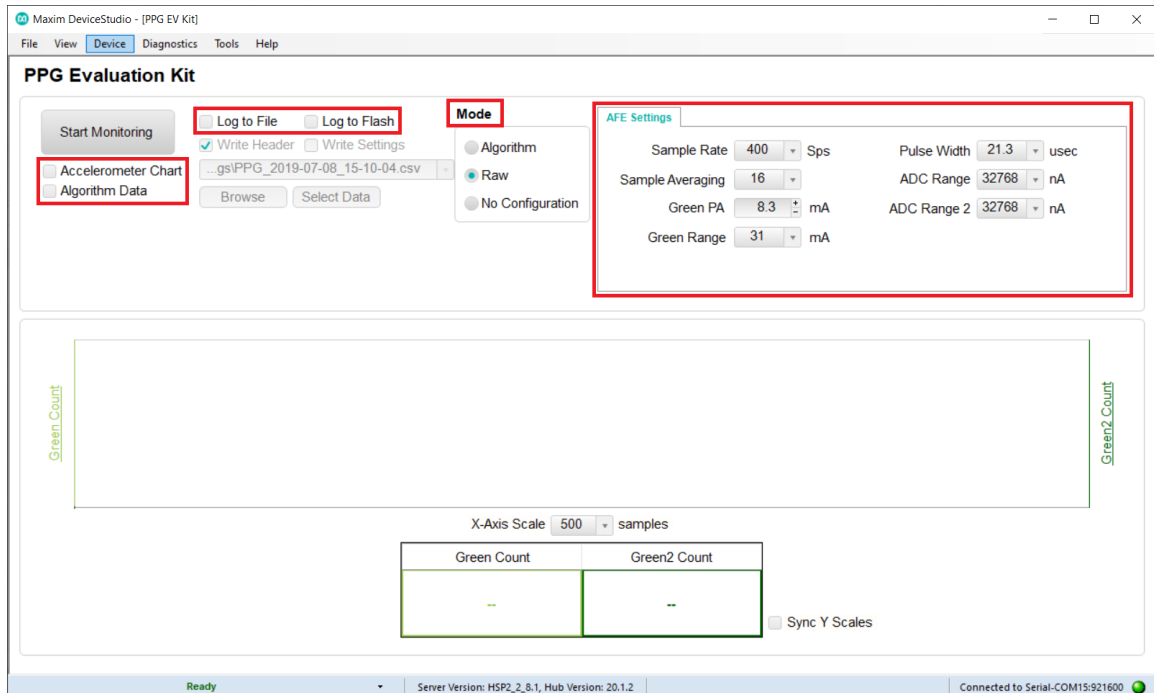


Figure 22. Start the PPG measurement.

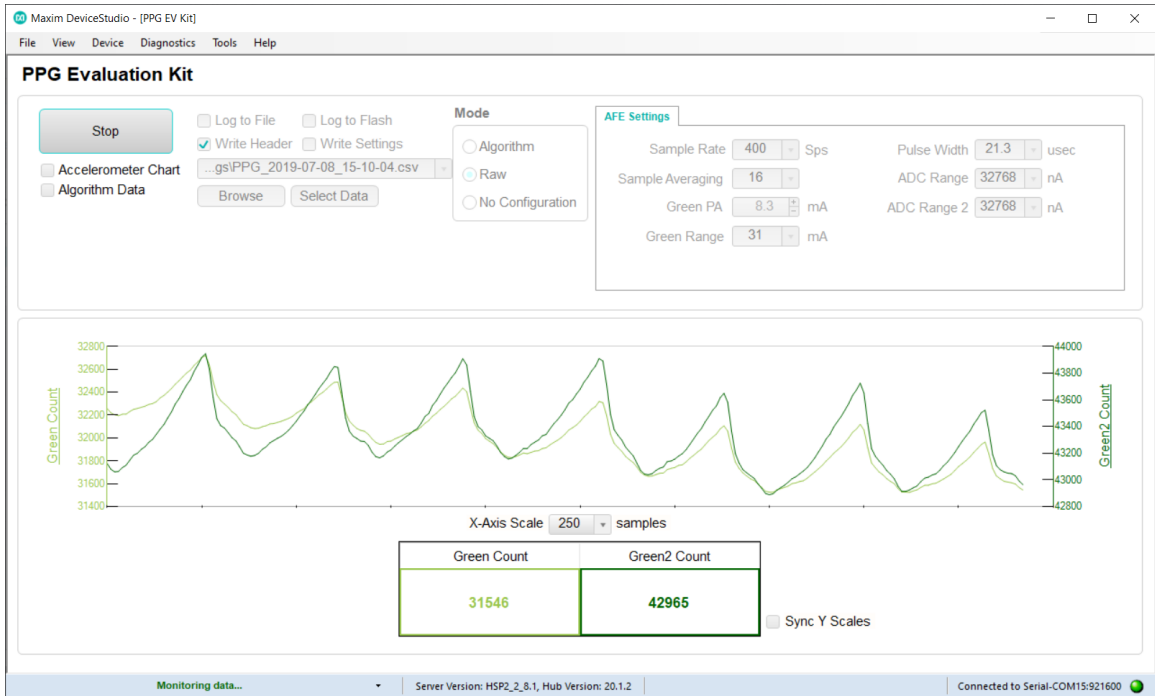


Figure 23. PPG measurement sample.



## Installing the Android App

1. Before installing the Android app, make sure that third-party apps are allowed on the device. Go to **Menu > Settings > Security** and check **Unknown Sources** to allow the device to install apps from sources other than the Google® Play Store.
2. Download the Android Eval Pack using the web browser on the Android device from the Software section on the [MAXREFDES101# Design Resources tab](#).
3. Open Downloads or an Android file browser and unzip the downloaded file. Once extracted, open the AndroidApp\_HSP2 folder.
4. Tap on the .apk file and click Install or Yes when prompted.

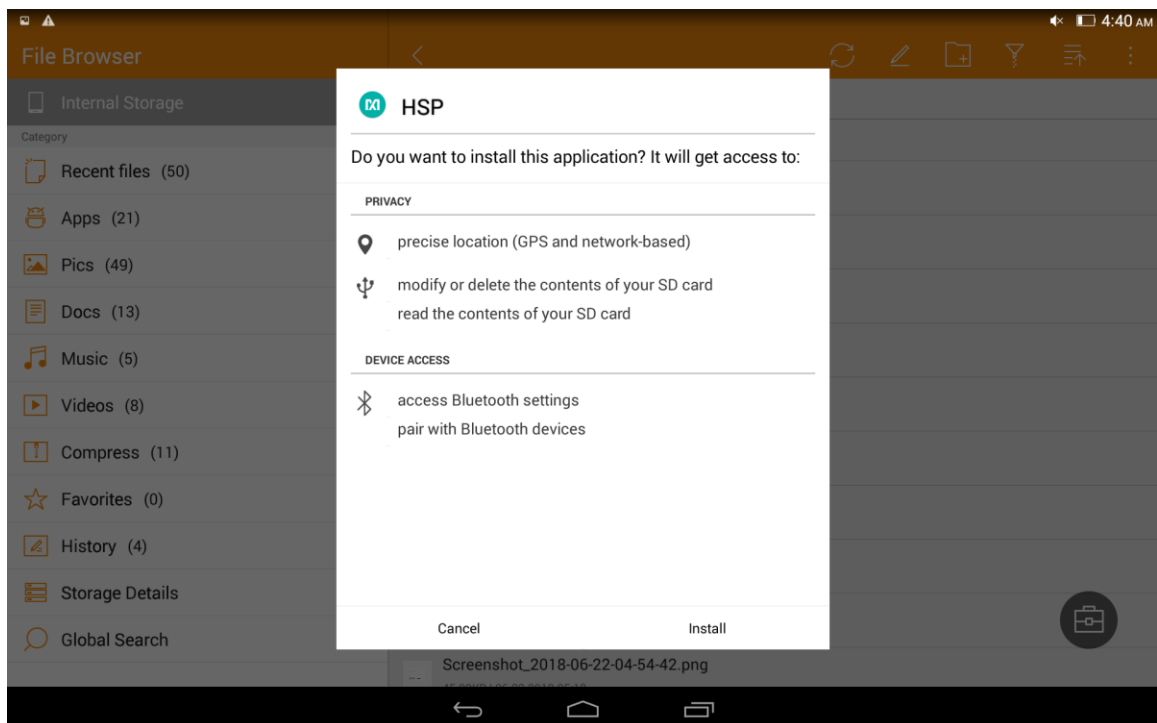


Figure 24. Install the Android app.

Google is a registered trademark of Google, Inc.

## Using the Android App

### BLE Connection for Android

1. Ensure Bluetooth is enabled and open the Android application. Select “Scan” to detect nearby devices.

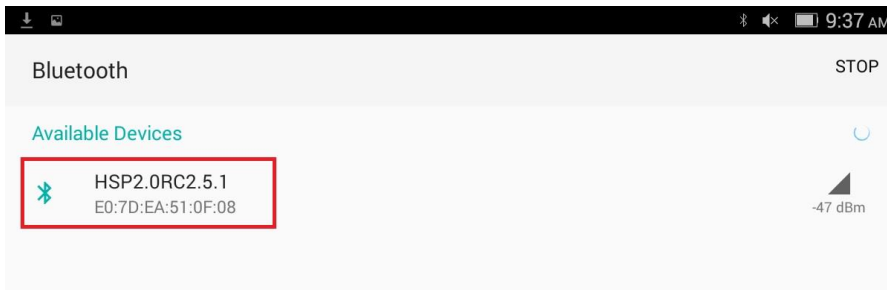


Figure 25. Available Devices list.

2. Tap the device with the MAC address that matches the MAC address listed on the watch info screen.
3. Verify that Electrocardiogram, Optical HRM, and Temperature are displayed.

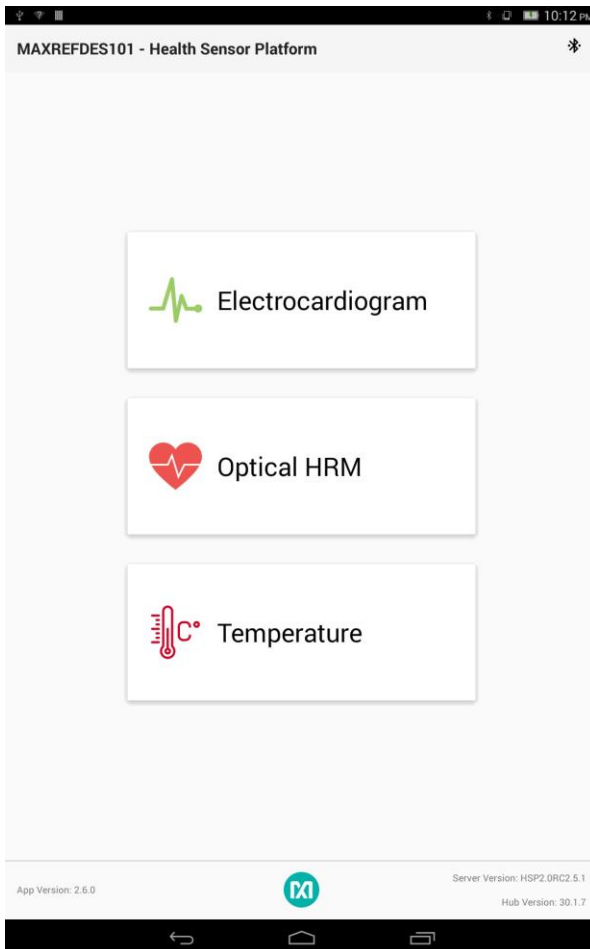


Figure 26. Mode selection view.

## Starting the ECG Measurement for Android

1. Select Electrocardiogram on the mode selection screen.
2. Select the desired filters.
3. Tap the “...” button in the top right corner and check “Log to File” to save data to a file.
4. Tap the “...” button in the top right corner and check “Log to Flash” to save data to the on-board flash. Data is not streamed to the app while Flash Logging is enabled.
5. Tap “Start Monitoring.”

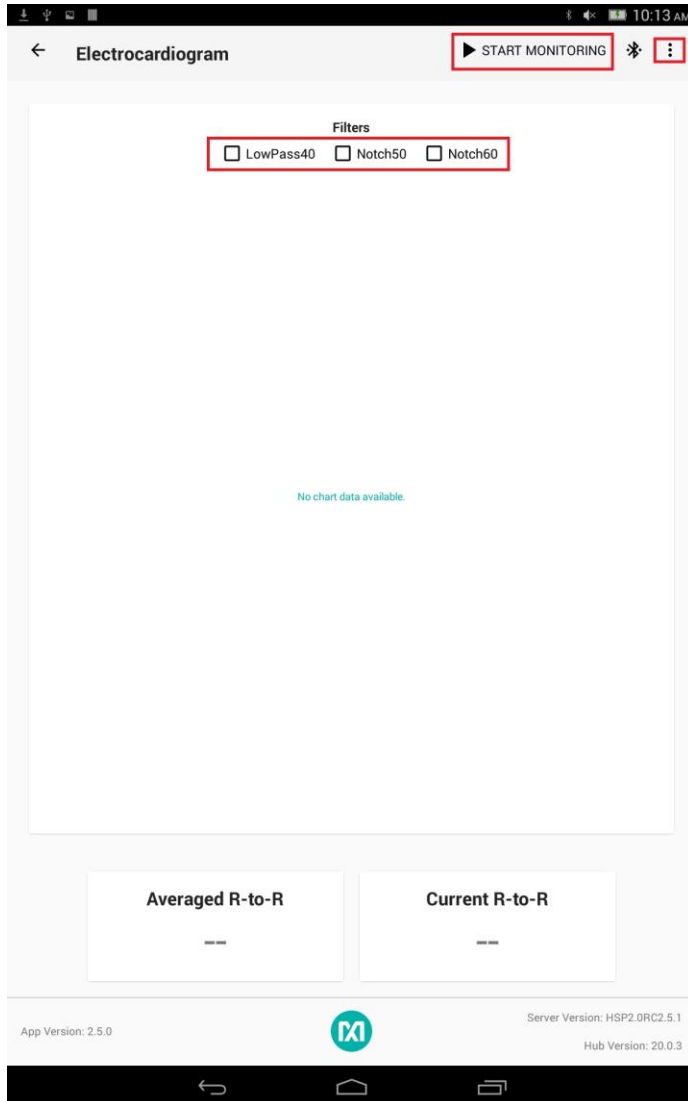


Figure 27. Start the ECG measurement for the Android app.

Note: There is no display in ECG mode because the noise from the display interferes with the measurement.

6. A pop-up window appears. Select “NO” to use the last setting and select “YES” to use the default setting.
7. Wear the watch on the wrist and make sure the skin has direct contact with electrodes 2 and 3. Then place a finger from the opposite hand on electrode 1.
8. Tap “INVERT ECG” to invert the ECG waveform if needed.

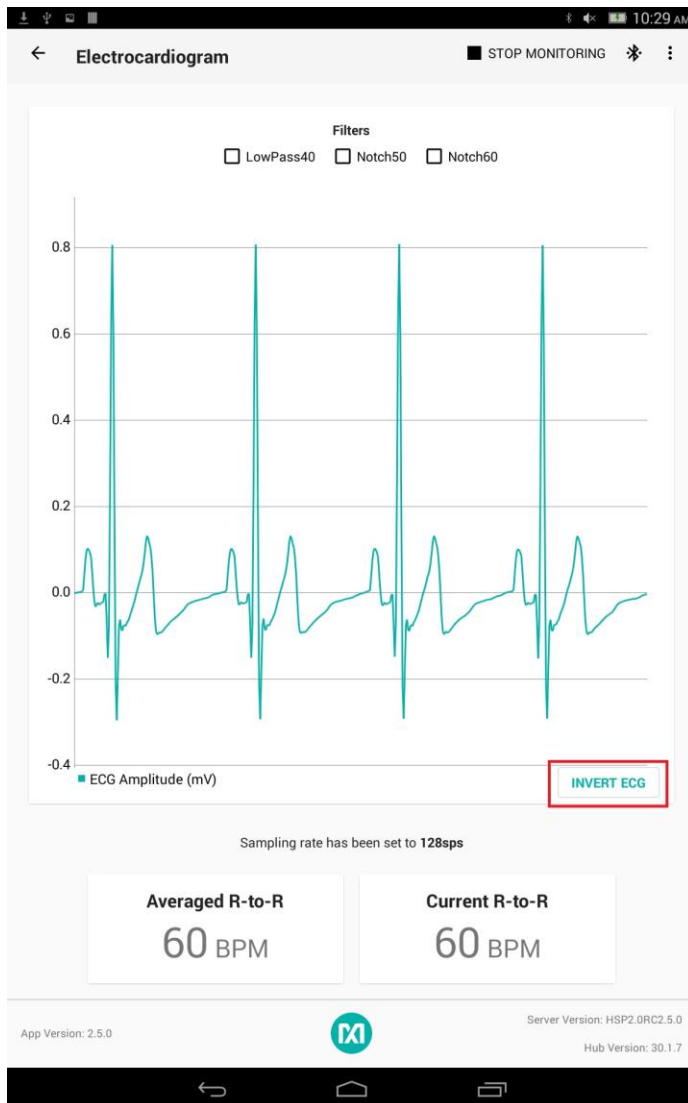


Figure 28. Android app ECG measurement sample.

## Starting the PPG Measurement for Android

1. Select Optical HRM on the mode selection screen.
2. Tap the “...” button in the top right corner and check “Log to File” to save data to a file.
3. Tap the “...” button in the top right corner and check “Log to Flash” to save data to the on-board flash. Data is not streamed to the app while Flash Logging is enabled.
4. Wear the watch on the wrist and make sure the skin has direct contact with the LED/photodiodes at the center of the back of the watch.
5. Tap “Start Monitoring.”

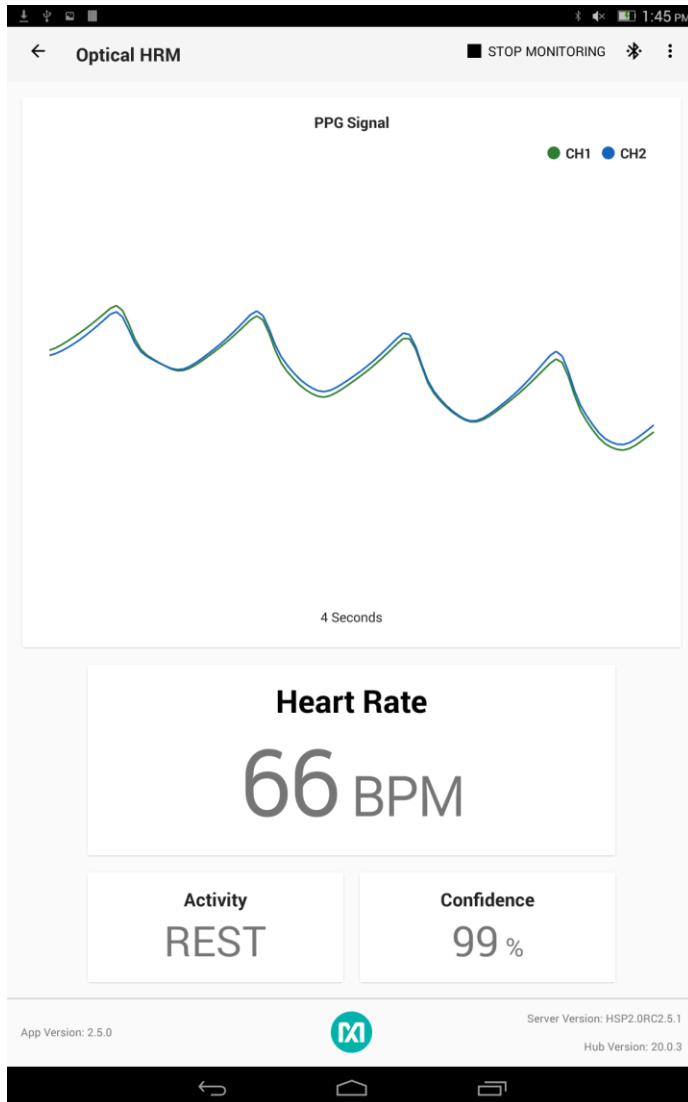


Figure 29. Android app PPG measurement sample.

## Starting the Temperature Measurement for Android

1. Select Temperature on the mode selection screen.
2. Tap the “...” button in the top right corner and check “Log to File” to save data to a file.
3. Tap the “...” button in the top right corner and check “Log to Flash” to save data to the on-board flash. Data is not streamed to the app while Flash Logging is enabled.
4. Tap the Celsius or Fahrenheit radio button to select the units.
5. Tap the Sample Interval dropdown to select the Sample Interval in seconds.
6. Wear the watch on the wrist and make sure the skin has direct contact with electrode 2.
7. Tap “Start Monitoring.”

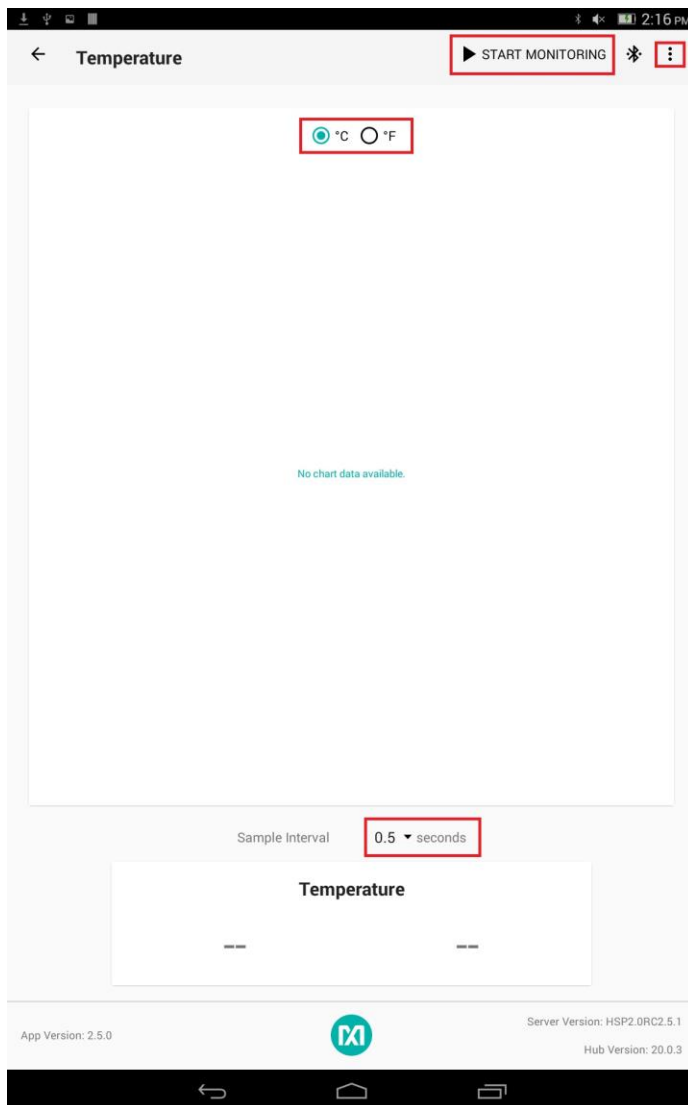


Figure 30. Start the temperature measurement for the Android app.

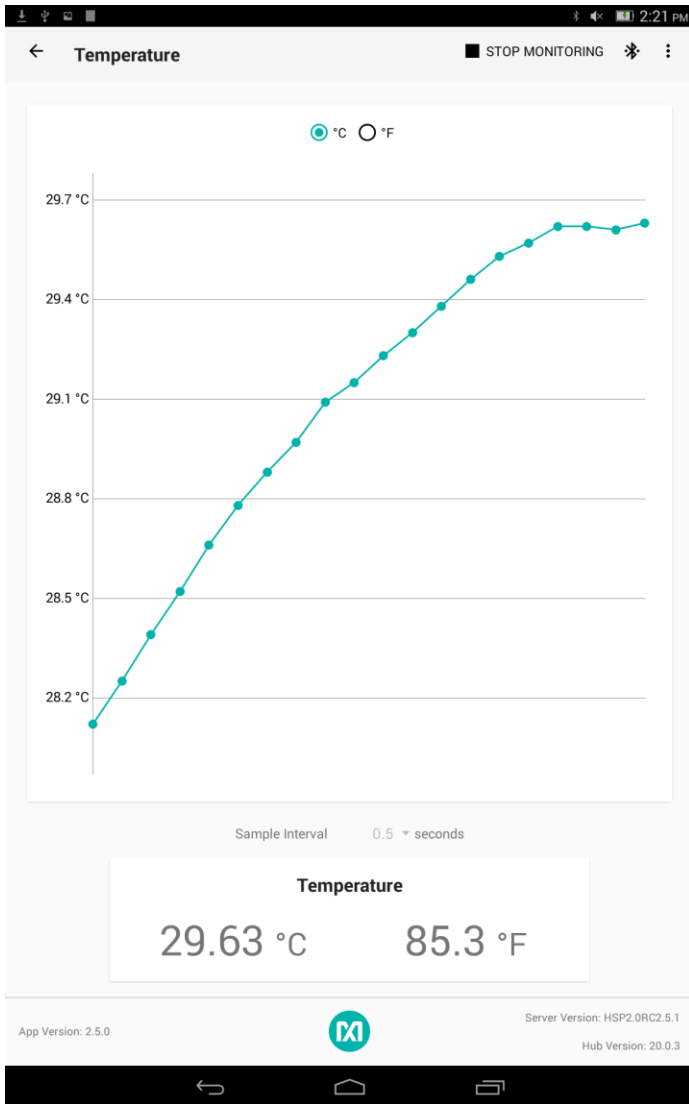


Figure 31. Android app temperature measurement sample.

## Installing the Windows 7 Driver

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. Download the Windows 7 Eval Package from the Software section on the [MAXREFDES101# Design Resources tab](#).
2. Extract the .zip file to a known location.
3. Open Device Manager. Device Manager can be found in the Control Panel.
4. If manual driver installation is needed, the MAXREFDES101# appears under Other devices as “CDC DEVICE.” Right-click “CDC DEVICE” and select Properties.

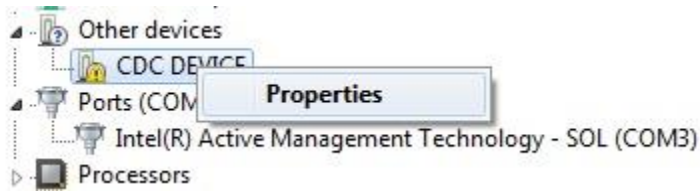


Figure 32. CDC DEVICE in Device Manager.

5. If “Update Driver...” is grayed out, click “Change Settings,” and then click “Update Driver...”
6. Choose “Browse my computer for driver software.”

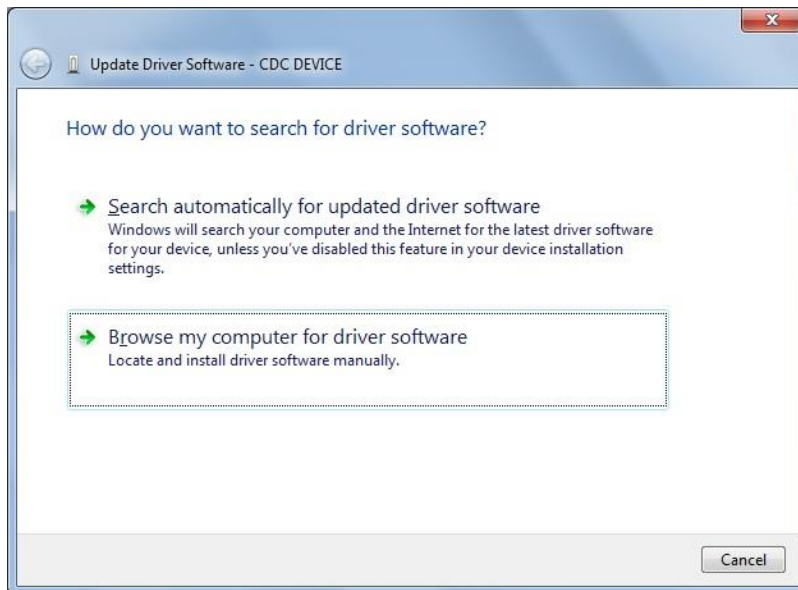


Figure 33. Locate and install the driver manually.



- Click “Browse...” and navigate to the location of the extracted .zip file in step 2. Click “Next.”



Figure 34. Browse to extracted release package.

- When prompted by the Windows Security window, click “Install this driver software anyway.”



Figure 35. Choose Install this driver software anyway.

- After the driver is installed successfully, the MAXREFDES101# appears as an mbed Serial Port.



Figure 36. mbed Serial Port in Device Manager.

## Flash Logging

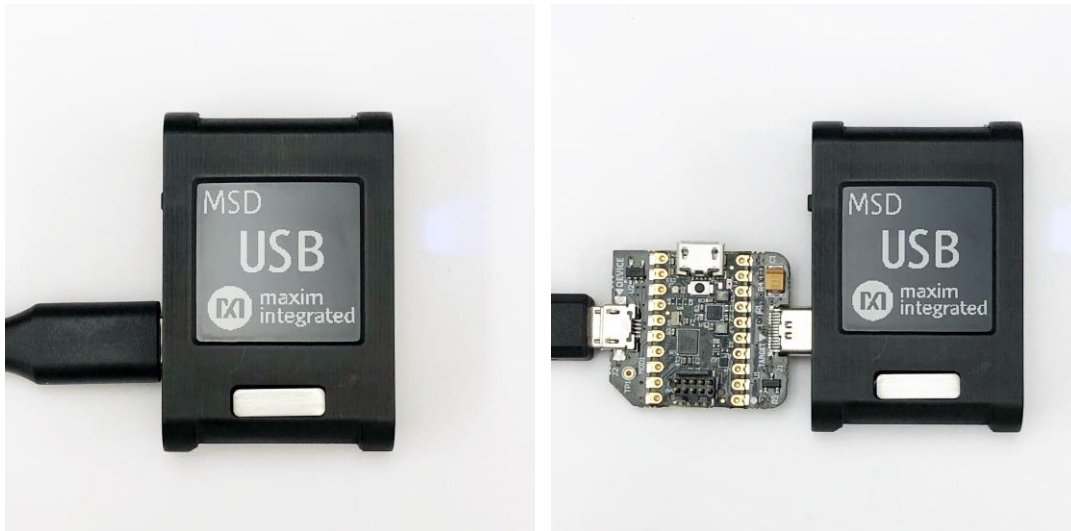
To log ECG, PPG, or temperature data to on-board flash memory, perform the following steps:

1. Set up ECG, PPG, or temperature measurement on the PC GUI or Android app as instructed in the Using the PC GUI section or in the Using the Android App section, and ensure that the box for “Log to Flash” is checked and the box for “Log to File” is unchecked.
2. Click “Start Monitoring.” The device displays “REC” to indicate that data is being logged to flash. 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 or cable or BLE connection to log data while untethered.
4. To stop flash logging while untethered, press the down button on the right side of the watch. The display should return to “USB.” If the watch is still tethered to the PC or Android device, flash logging can be stopped by pressing the “Stop” button in the GUI or app.

## Downloading the Log File

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

1. Ensure the USB Type-C cable is not connected, and power off the watch by holding the power button on the left side of the watch for 3 seconds.
2. While holding the up button on the right side of the watch, insert the USB Type-C cable (or the Pico adapter board with a USB Micro-B cable) into the USB Type-C connector of the watch. Continue holding the up button until the indicator LED on the right side of the watch turns blue.
3. If done correctly, the watch boots into mass storage device mode and displays “MSD.”



*Figure 37. MSD connection to PC using USB Type-C cable (left) and Pico adapter board (right).*

4. The device appears in Windows Explorer as a USB Drive, and you can copy-paste files from the device.
5. 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.

6. In the PC GUI, open the Flash Log Parser from the Tools menu.
7. 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 38. Flash Log Parser.

## Data Format

**Table 1. PPG Raw Data Table Column Definitions (PPG\_\*.csv)**

COLUMN	DESCRIPTION
Time	Time stamp
Sample count	Data index ranging from 0 to 255 for monitoring if samples are dropped during Bluetooth transmission
Green count 1	Optical count detected by photodiode 1
Green count 2	Optical count detected by photodiode 2
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
Heart Rate (bpm)	Heart rate, in unit of beats per min
HR confidence (%)	Heart rate algorithm extraction confidence, a threshold confidence >85% is recommended
Algorithm status	0: Rest (no or very light activity). HR confidence threshold: 50%. 1: Non-rhythmic activities that cannot be classified in the other categories. HR confidence threshold 30%. 2: Walking activity. HR confidence threshold: 30%. 3: Running activity. HR confidence threshold: 30%. 4: Biking activity. HR confidence threshold: 30%. 5: Rhythmic activities that cannot be classified in the other categories. HR confidence threshold: 30%.

	A	B	C	D	E	F	G	H	I	J	K
	Time	Sample Count	Green Count	Green2 Count	X Axis Acceleration (g)	Y Axis Acceleration (g)	Z Axis Acceleration (g)	Heart Rate (bpm)	HR Confidence (%)	Algorithm Status	
2	46:48.4	261	295283	384957	0.004	0	-1.036	58	97	0	
3	46:48.4	262	295248	385222	0.004	0	-1.037	58	97	0	
4	46:48.5	263	295189	385469	0.004	0	-1.037	58	97	0	
5	46:48.5	264	294781	385658	0.004	0	-1.036	58	98	0	
6	46:48.5	265	296470	385885	0.004	0	-1.037	59	98	0	
7	46:48.6	266	295779	385073	0.004	0	-1.038	59	98	0	
8	46:48.6	267	293601	383225	0.003	0	-1.036	59	98	0	
9	46:48.6	268	293751	382358	0.003	0	-1.037	60	98	0	
10	46:48.7	269	293101	382500	0.003	0	-1.038	60	98	0	
11	46:48.7	270	292714	382585	0.003	0	-1.038	60	98	0	
12	46:48.8	271	292847	382983	0.003	0	-1.038	61	98	0	

Figure 39. Log file PPG\_\*.csv for PPG measurement.

**Table 2. ECG Raw Data Table Column Definitions (ECG\_\*.csv)**

COLUMN	DESCRIPTION
Time	Time stamp
Sample count	Data index ranging from 0 to 255 for monitoring if samples are dropped during Bluetooth transmission
Raw ECG	ECG data count
Filtered ECG	Filtered ECG data count (defined by user's choice of filter setting)
ETAG [2:0]	ECG FIFO data tag (see table 48 in <a href="#">MAX30001</a> data sheet for details)
PTAG [2:0]	ECG PACE data tag (see table 49 in <a href="#">MAX30001</a> data sheet for details)
R-to-R (bpm)	Heart rate (beats per min)

	A	B	C	D	E	F	G
		Sample		Filtered			R-to-R
1	Time	Count	Raw ECG	ECG	ETAG[2:0]	PTAG[2:0]	(bpm)
2	56:39.6	250	-234	-248.583	0	7	70
3	56:39.6	251	-183	-211.226	0	7	70
4	56:39.6	252	-154	-165.379	0	7	70
5	56:39.7	253	-176	-158.057	0	7	70
6	56:39.7	254	-190	-183.188	0	7	70
7	56:39.7	255	-164	-183.126	2	7	70
8	56:39.7	0	-140	-151.958	0	7	70
9	56:39.7	1	-145	-137.547	0	7	70
10	56:39.7	2	-134	-140.301	0	7	70

Figure 40. Log file ECG\_\*.csv for ECG measurement.

**Table 3. Temperature Raw Data Table Column Definitions  
(TEMP\_\*.csv)**

COLUMN	DESCRIPTION
Time	Time stamp
Sample count	Data index ranging from 0 to 255 for monitoring if samples are dropped during Bluetooth transmission
Temperature (°C)	Temperature in units of Celsius

	A	B	C
1	Time	Sample Count	Temperature (°C)
2	32:21.1	1	26.31
3	32:21.5	2	26.3
4	32:22.0	3	26.32
5	32:22.5	4	26.34
6	32:23.0	5	26.35
7	32:23.5	6	26.34
8	32:24.0	7	26.36
9	32:24.6	8	26.36
10	32:25.1	9	26.36

*Figure 41. Log file Temp\_.csv for body temperature measurement.*

## Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	9/18	Initial release	—
1	11/18	Updated the description in the Power On/Off section to pressing and holding button 1 for powering on and off the device.	8
2	8/19	Updated procedures and figures to match with the latest firmware and software and added the Flash Logging section.	1-37

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