MAXREFDES101# Health Sensor Platform 2.0 User Guide

UG6780; Rev 1; 11/18



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
- Different Display Modes 9
- How to Wear the Device 11
  - PPG Measurement 11
  - ECG Measurement 11
  - Body Temperature Measurement 12

Upgrading the Firmware on MAXREFDES101# 13

Installing the PC GUI 15

Using the PC GUI 18

- Start the ECG Measurement 18
- Start Temperature Measurement 20
- Start PPG measurement 22

Installing the Android App 24

- Start ECG Measurement 29
- Start PPG Measurement 37
- Start Temperature Measurement 43

Data Format 49

List of Figures

Figure 1. MAXREFDES101# wearable form factor in detail....5
Figure 2. MAXREFDES101# exploded view....5
Figure 4. Micro USB Type-C cable (left) and Pico adaptor board (right)....8
Figure 5. Time mode....9
Figure 6. PPG mode....9
Figure 7. Maxim logo mode....10
Figure 8. PPG measurement....11
Figure 9. ECG measurement....12
Figure 10. Pico adaptor board connected through micro USB Type-C....13
Figure 11. Pico adaptor board blue status LED....13
Figure 12. DAPLINK drive on the PC....14
Figure 13. Install the .msi file....15
Figure 14. Maxim Device Studio scan options....16
Figure 15. Maxim Device Studio connected devices....16
Figure 16. Upload embedded heart rate algorithm to the MAX32664....17
Figure 17. Start the ECG measurement....18
Figure 18. ECG measurement sample....19
Figure 19. Start temperature measurement....20
Figure 20. Temperature measurement sample....21
Figure 21. Start PPG measurement....22
Figure 22. PPG measurement sample....23
Figure 23. Install the Android app....24
Figure 24. Android app installed....25
Figure 25. Turn on Bluetooth....26
Figure 26. Select the MAXREFDES101# device....27
Figure 27. ECG, PPG, and temp listed under Connected Devices....28
Figure 28. Log to file ECG measurement for Android app....29
Figure 29. Select the Bluetooth icon for ECG measurement....30
Figure 30. ECG measurement connection info....31

Figure 31. Select ECG measurement filter type..... 32
Figure 32. ECG measurement available filter types.....33
Figure 33. Start ECG measurement using the Android app..... 34
Figure 34. Android ECG measurement default settings..... 35
Figure 35. Android app ECG measurement sample..... 36
Figure 36. Start PPG measurement for Android app..... 37
Figure 37. Log to file PPG measurement for Android app..... 38
Figure 38. Check the connection for PPG measurement..... 39
Figure 39. PPG measurement connection info.....40
Figure 40. Start the PPG measurement on the Android app.....41
Figure 41. Android app PPG measurement sample. 42
Figure 42. Start temperature measurement for Android app..... 43
Figure 43. Log to file temperature measurement for Android app.....44
Figure 44. Check the connection for temperature measurement. 45
Figure 45. Temperature measurement connection info.....46
Figure 46. Start the temperature measurement on the Android app..... 47
Figure 47. Android app temperature measurement sample.....48
Figure 48. Log file PPG_.csv for PPG measurement. 49
Figure 49. Log file ECG_.csv for ECG measurement.....50
Figure 50. Log file Temp_.csv for body temperature measurement. 51

List of Tables

Table 1. PPG Raw Data Table Column Definitions (PPG_*.csv) 49
Table 2. ECG Raw Data Table Column Definitions (ECG_*.csv).....50
Table 3. Temperature Raw Data Table Column Definitions (TEMP_*.csv) 51

Detailed Hardware Description

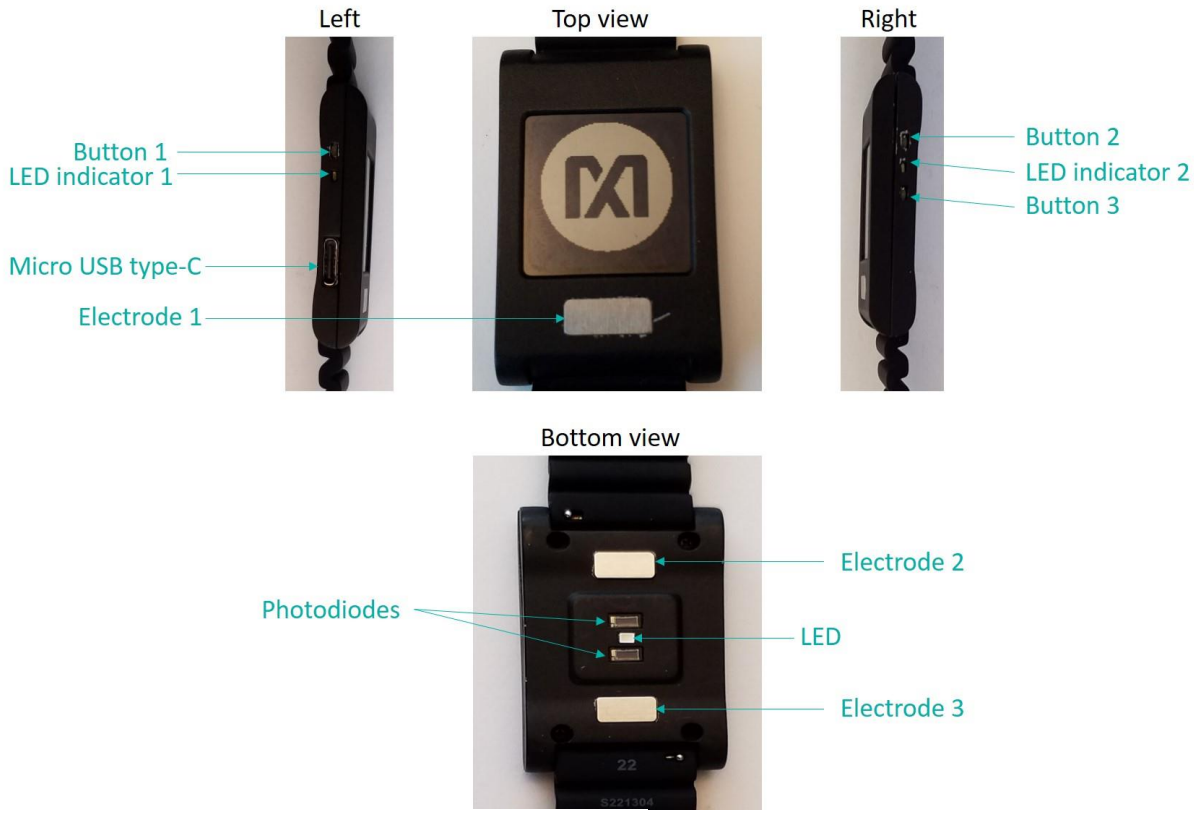


Figure 1. MAXREFDES101# wearable form factor in detail.

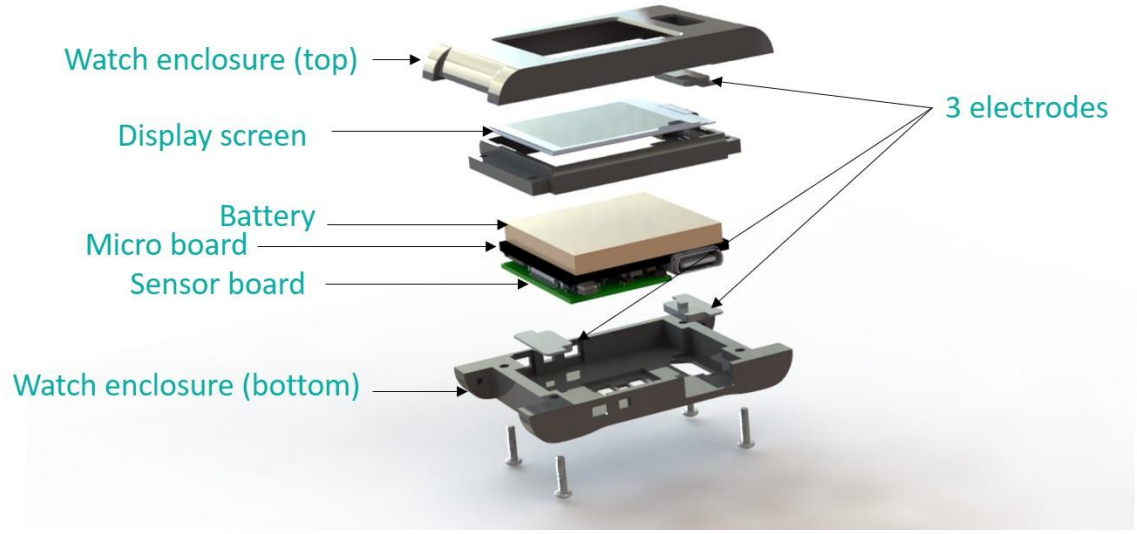


Figure 2. MAXREFDES101# exploded view.

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 two green LEDs and a photodiode
    - MAX30001 ECG sensor
    - MAX30205 human body temperature sensor
    - MAX32664 microcontroller with embedded heart-rate algorithm
- Pico adaptor board to be used during a firmware upgrade for the micro board
- Watch enclosure
- Battery
- 1 micro USB Type-B cable for firmware upgrade of the micro board
- 1 micro 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 logging

Android is a registered trademark of Google Inc.

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.

System Diagram

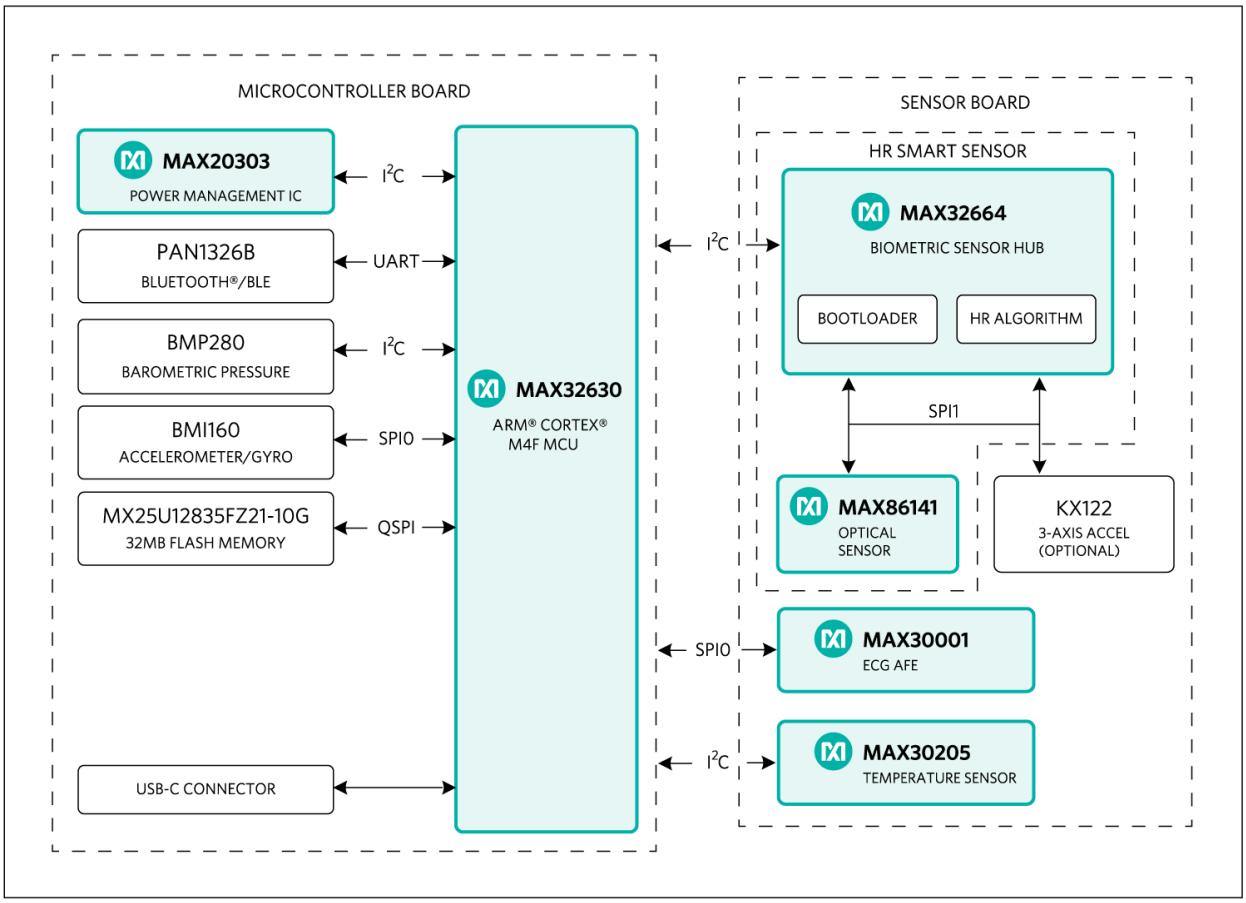


Figure 3. MAXREFDES101# system diagram.

Operating the Watch

Power On/Off

The MAXREDES101# can be powered on by pressing and holding button 1 for at least three seconds. When the device is on, the Maxim® logo is displayed and LED indicator 2 flashes green. The display shows time mode by default.

Alternatively, the device can also be powered on when connected to a PC using a micro USB Type-C cable or when connected to a Pico adaptor board.

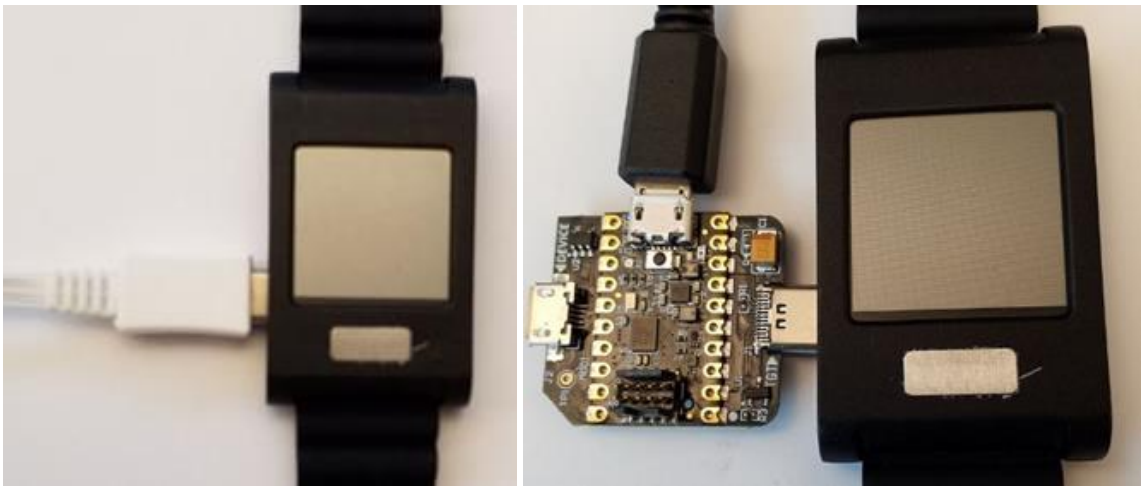


Figure 4. Micro USB Type-C cable (left) and Pico adaptor board (right).

To power off, press and hold button 1 for at least three seconds. LED indicator 1 turns red, at which time button 1 can be let go and the device powers off.

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

Different Display Modes

The display can be toggled between time mode, PPG mode, and Maxim logo mode. To toggle between modes, press and release button 2.



Figure 5. Time mode.



Figure 6. PPG mode.



Figure 7. Maxim logo mode.

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

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 8. 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. Ensure the wrist and the finger are from opposite arms to close the impedance loop. For example, if the watch is worn on the left wrist, use a finger from the right hand.



Figure 9. 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.

Upgrading the Firmware on MAXREFDES101#

The micro board is shipped storing the latest firmware. Subsequent firmware upgrades can also be performed using the Pico adaptor board provided by performing the following steps:

1. Insert the Pico adaptor board into the micro USB Type-C connector of the watch. This establishes a connection with the micro board inside the watch assembly.

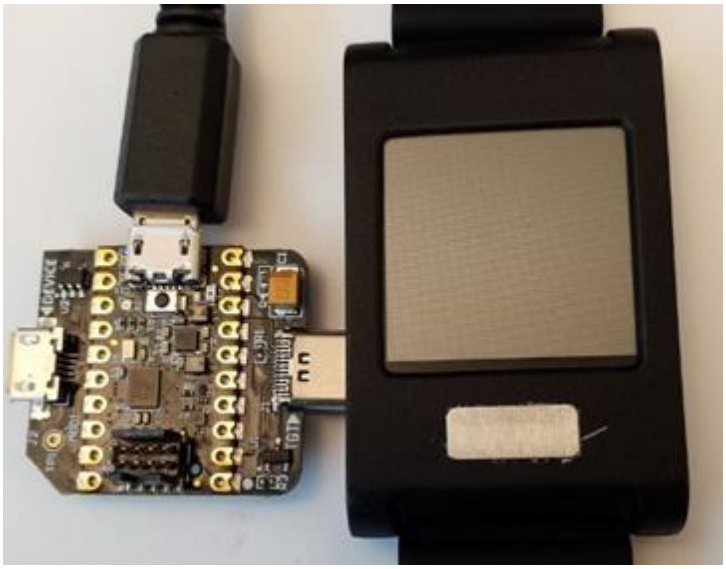


Figure 10. Pico adaptor board connected through micro USB Type-C.

2. Connect the Pico adaptor board to the PC using a micro USB Type-B cable. The micro USB port is next to the button. The blue status LED illuminates and the Pico adaptor board blinks a few times, indicating that it has power.

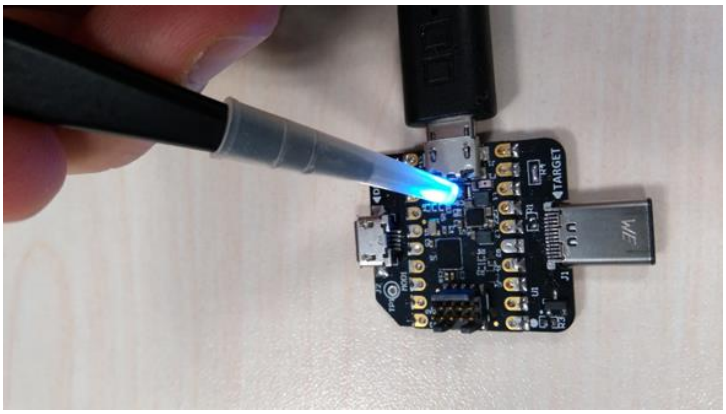


Figure 11. Pico adaptor board blue status LED.

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.

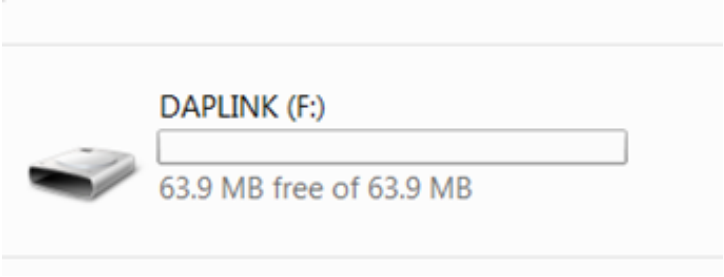


Figure 12. DAPLINK drive on the PC.

3. Download the firmware binary file from MAXREFDES101# Design Resources tab.
4. 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).
5. After flashing the microcontroller board with a new firmware, the board does not automatically reset. To start the software after flashing, press and release the button on the Pico adaptor board or power cycle the board using the micro USB Type-C cable.

Installing the PC GUI

1. Download the following files from the MAXREFDES101# Design Resources tab.
    a. PC GUI for either Windows® 10 or Windows 7 (*.msi)
    b. Embedded heart-rate algorithm (*.msbl)
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."

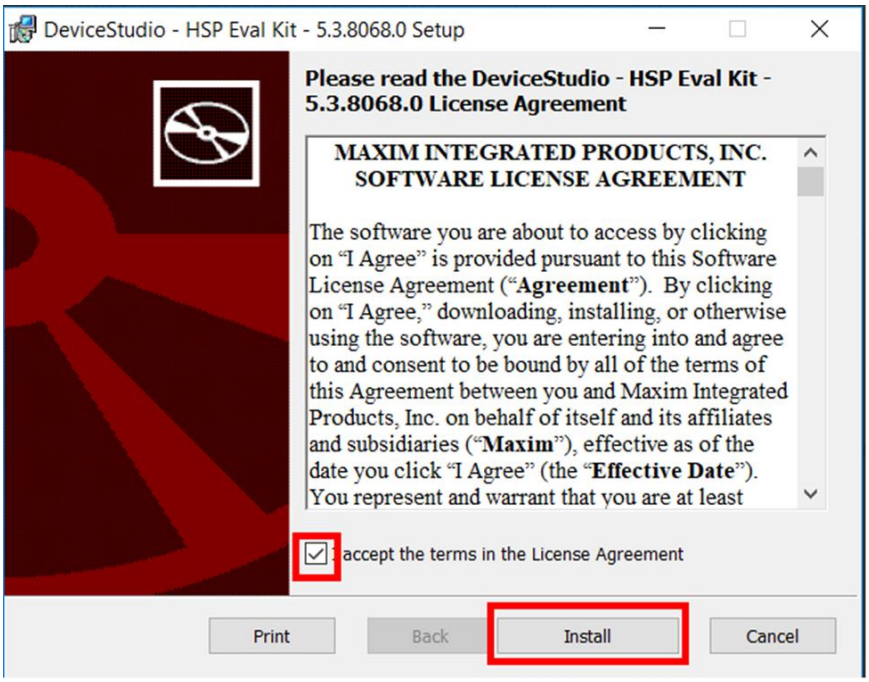


Figure 13. Install the .msi file.

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

3. Check the box for “Serial over USB/Bluetooth”. Click “Scan”.

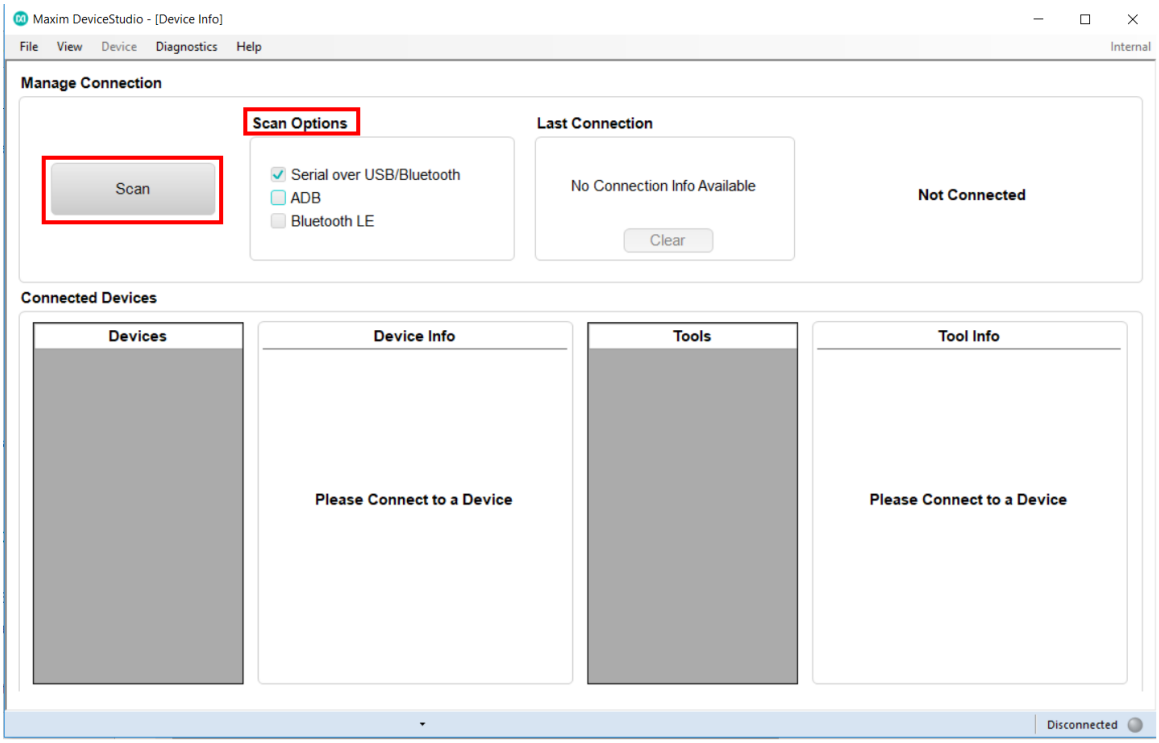


Figure 14. Maxim Device Studio scan options.

4. Verify that the Connected Devices lists ECG, Temp, and PPG.

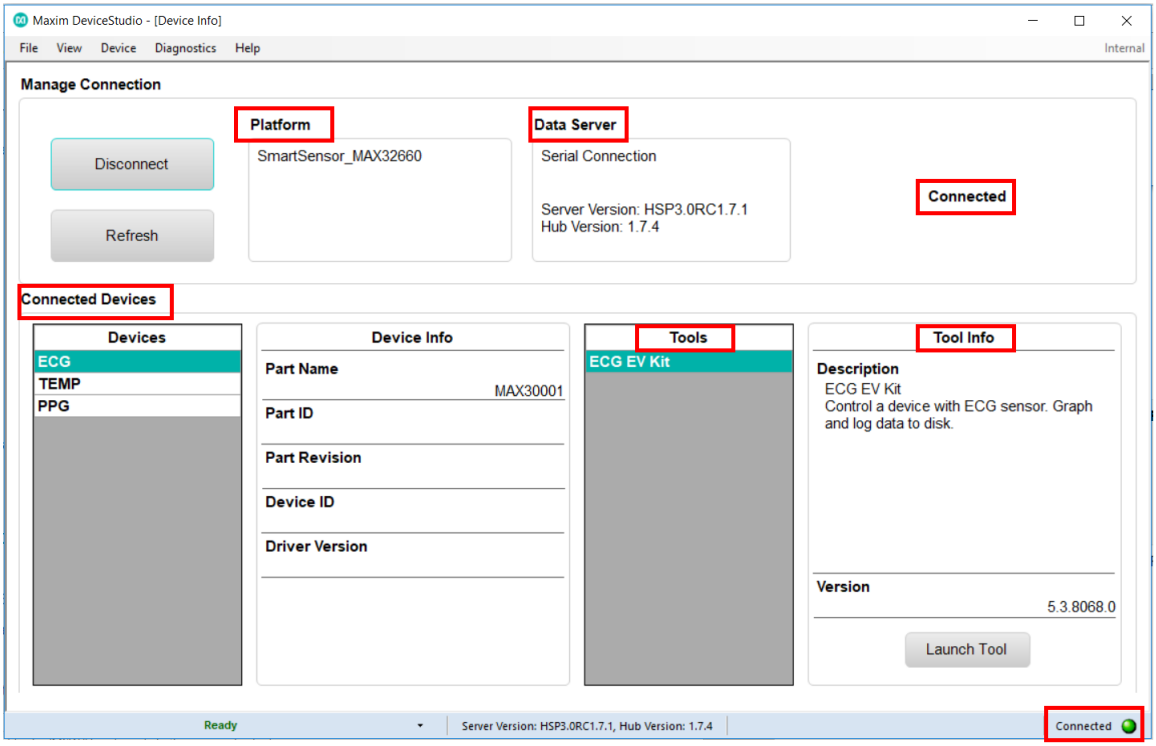


Figure 15. Maxim Device Studio connected devices.

5. Go to Device Tab > Update SmartSensor_MAX32660 Software > Update Firmware and select the *.msbl file.
6. The embedded heart rate algorithm is uploaded to the MAX32664 microcontroller on the sensor board.

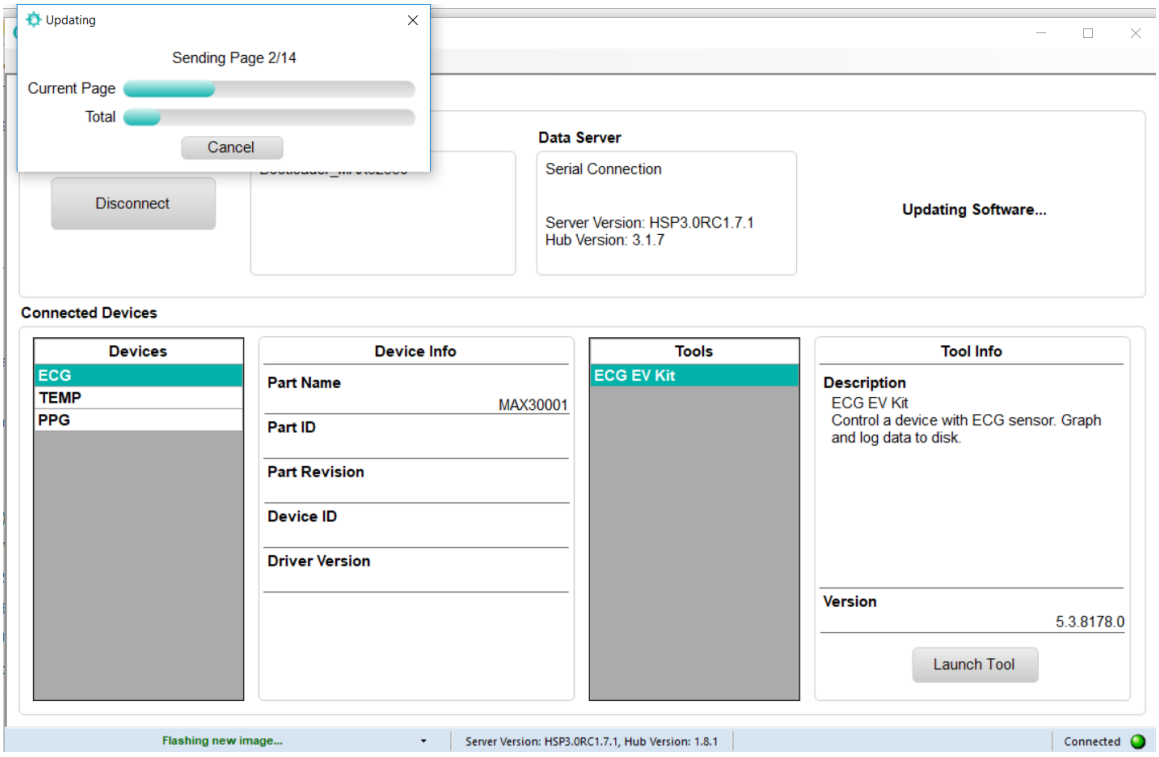


Figure 16. Upload embedded heart rate algorithm to the MAX32664.

Using the PC GUI

Start 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.
3. Select the desired filter.
4. 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.
5. Click on "Start Monitoring."

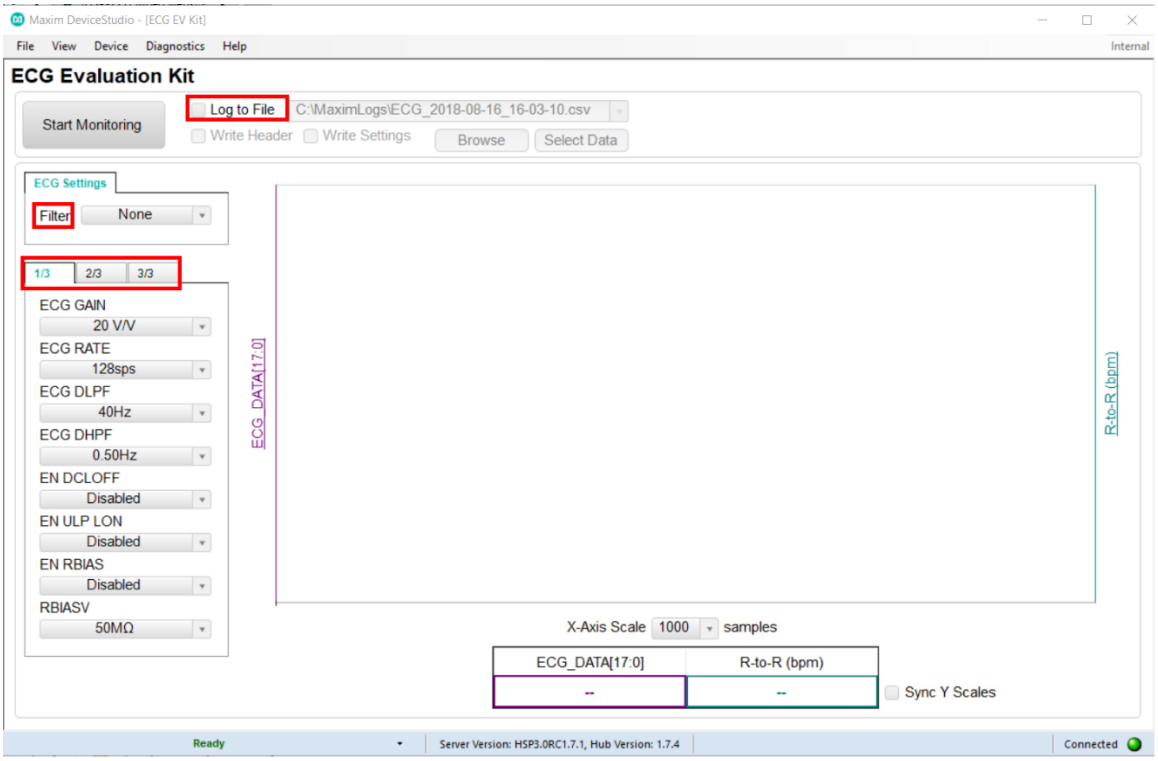


Figure 17. Start the ECG measurement.

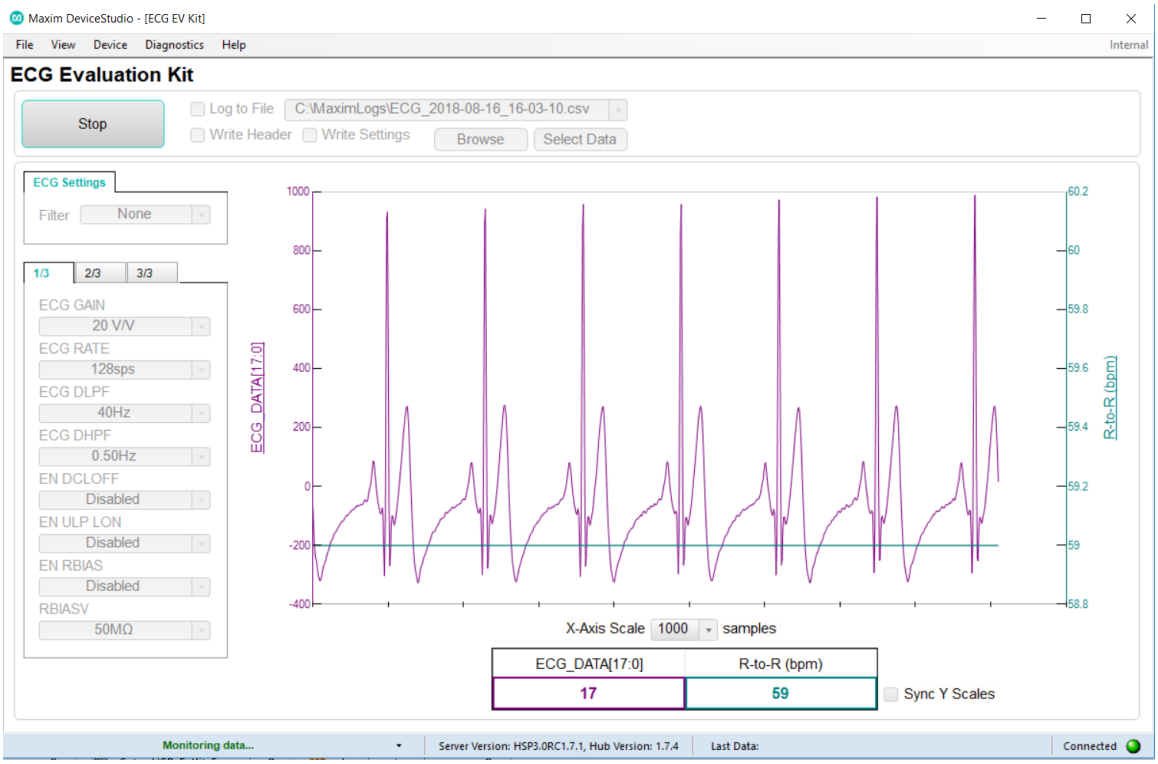


Figure 18. ECG measurement sample.

Start Temperature Measurement

1. Click on View. Select "TEMP EV Kit."
2. Check the box for "Log to File" to save the data.
3. Select the Sample Interval in seconds.
4. Click on "Start Monitoring."

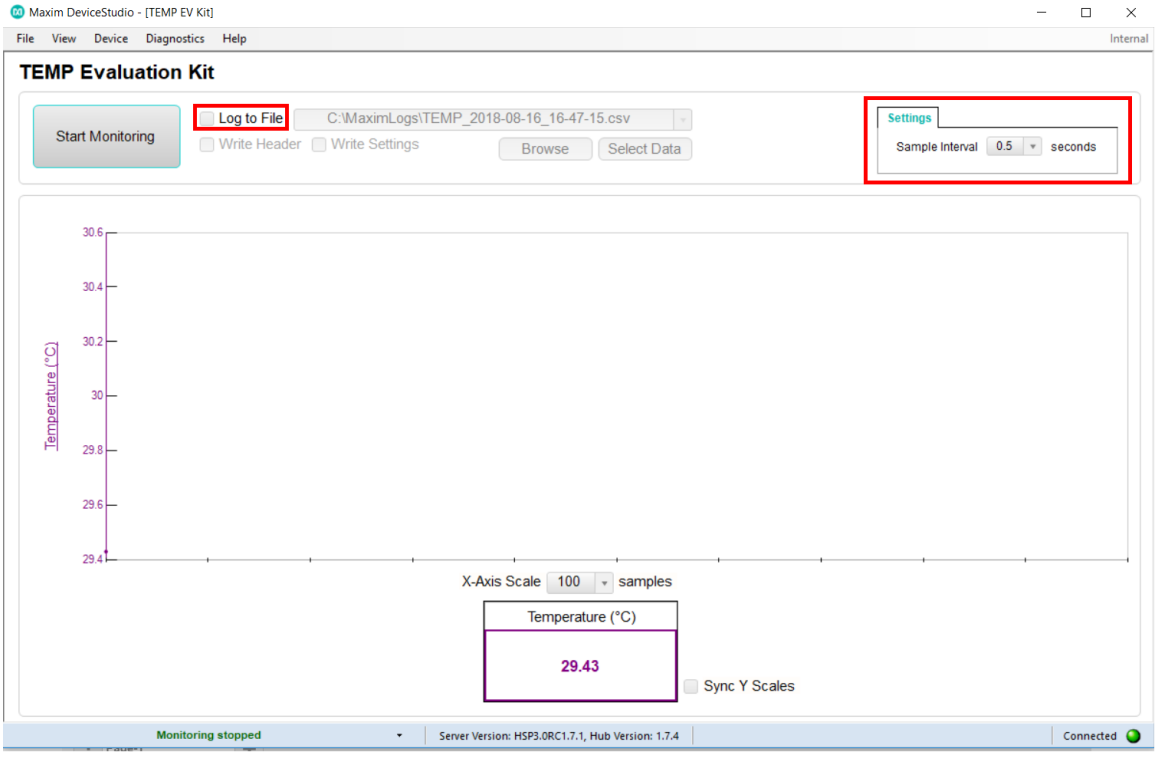


Figure 19. Start temperature measurement.

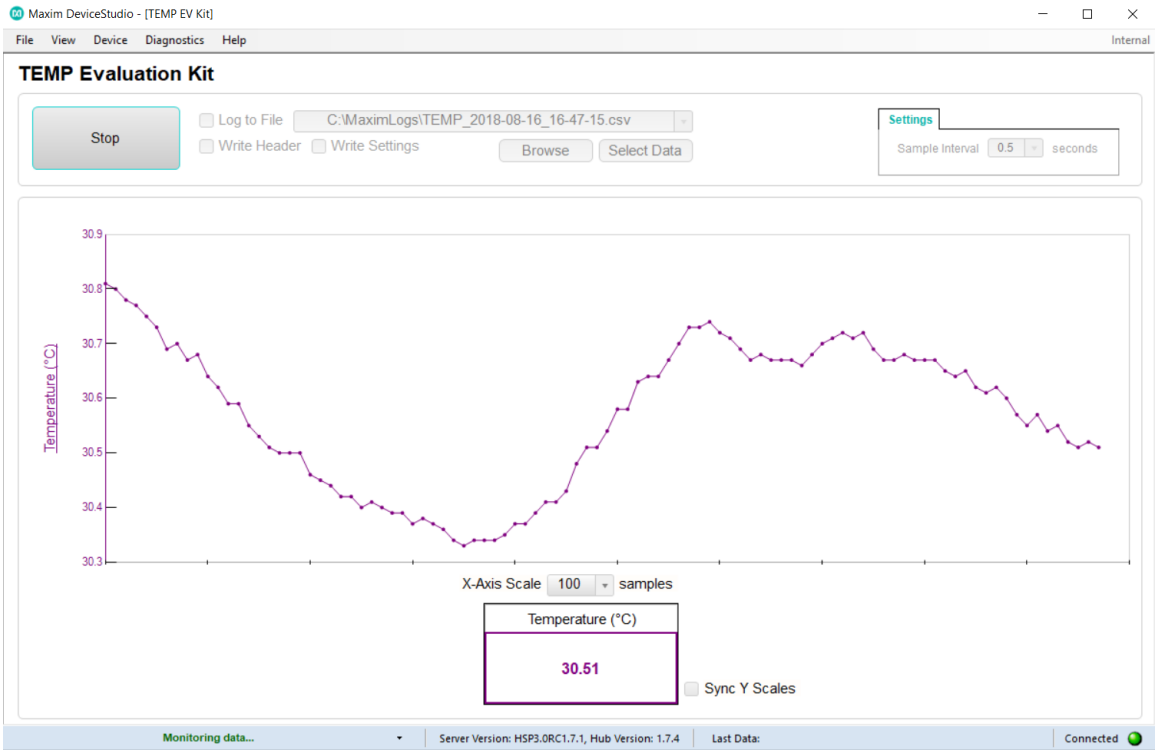


Figure 20. Temperature measurement sample.

Start 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 "Accelerometer Chart" to plot the accelerometer data.
4. Check the box for "Algorithm Data" to see the algorithm data: HR (bpm), HR Confidence (%), Algorithm Status, Algorithm Status Code.
5. Check the box for "AGC" to enable automatic gain control (AGC) in the algorithm.
6. Check the box for "Disable ALC" to disable ambient light cancellation (ALC) in the algorithm.
7. If the box for "Algorithm Data" is not checked, you may modify the remaining settings to suit your application (e.g., LED currents, ADC ranges, sample rate, pulse width).
8. Click on "Start Monitoring."

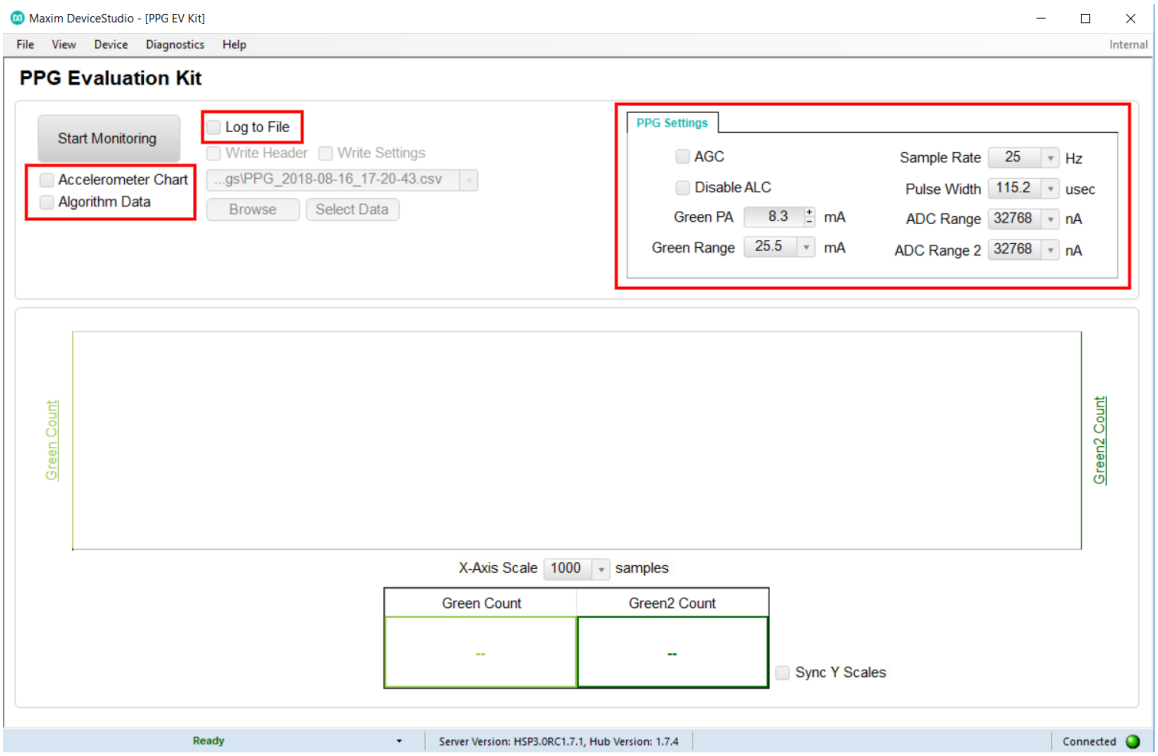


Figure 21. Start PPG measurement.

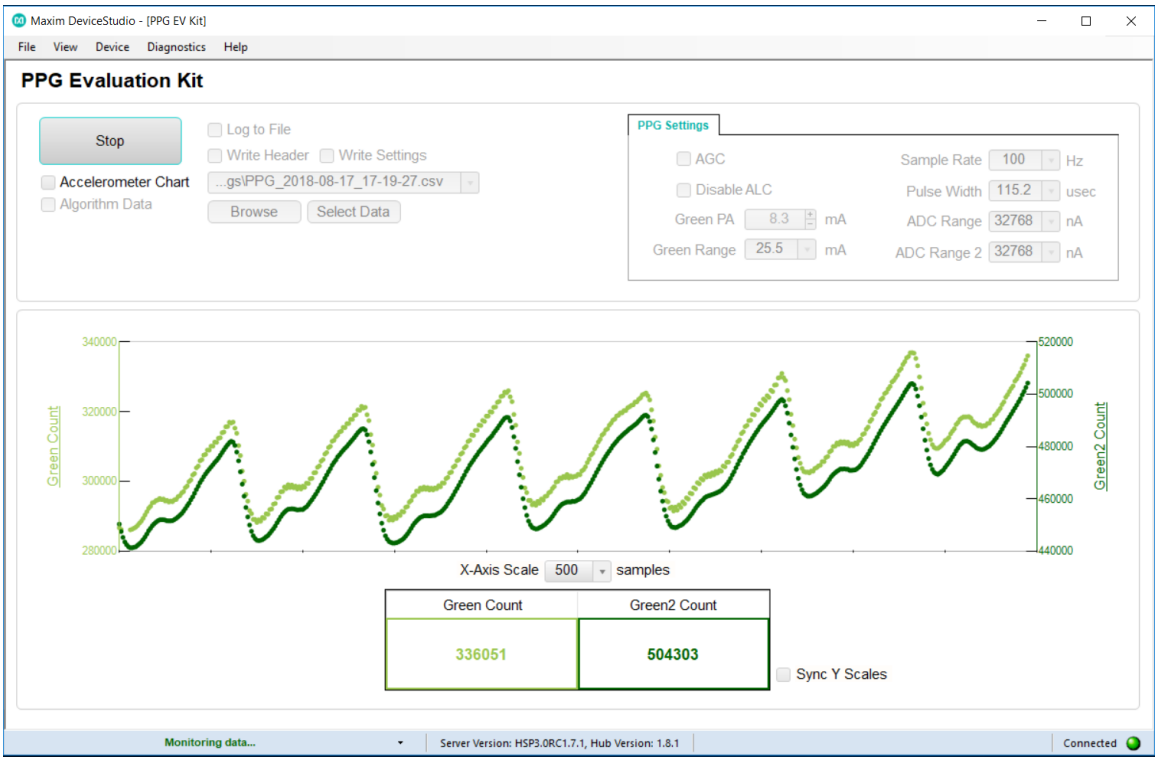


Figure 22. PPG measurement sample.

Installing the Android App

1. Download and install the *.apk file for Android from the MAXREFDES101# Design Resources tab.

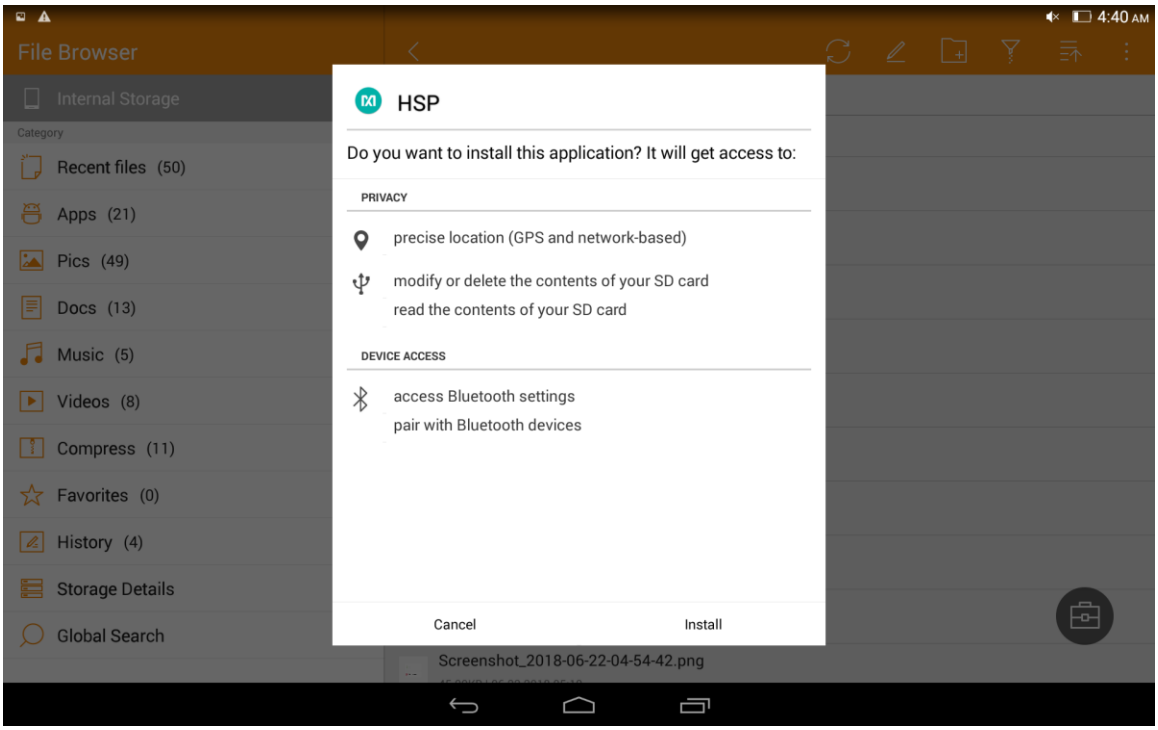


Figure 23. Install the Android app.

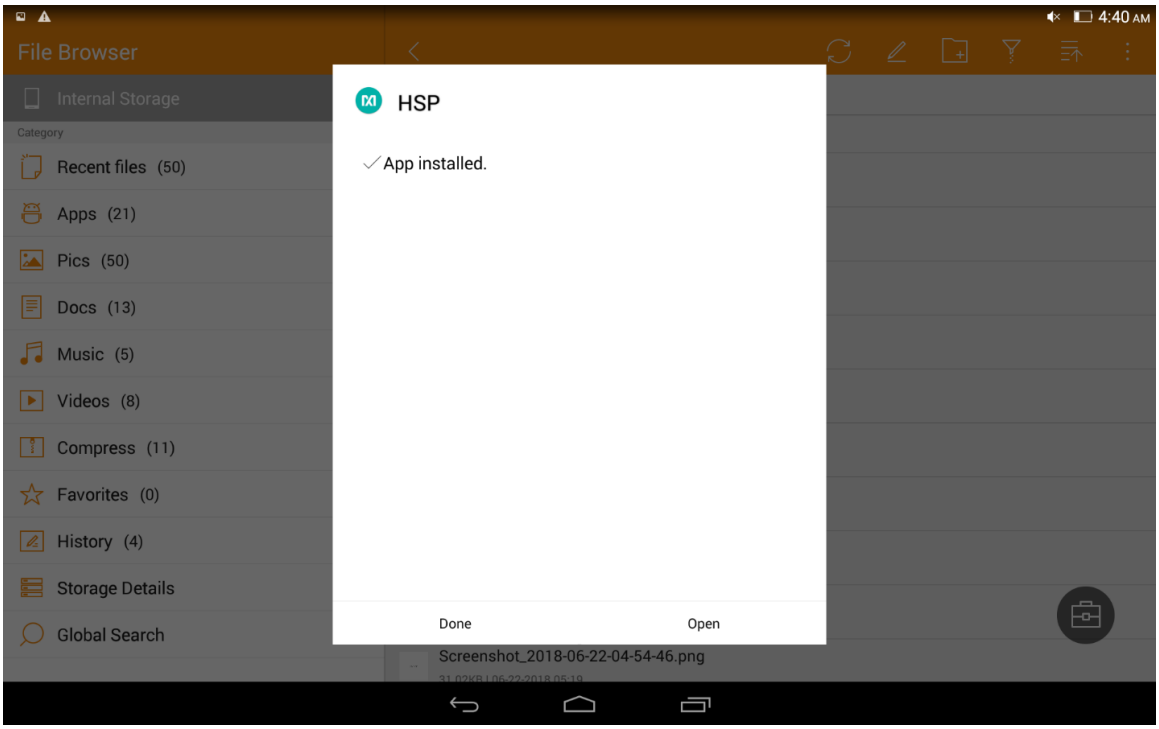


Figure 24. Android app installed.

2. Open the Application and select “TURN ON” to turn on Bluetooth. Select “Scan” to detect nearby devices.

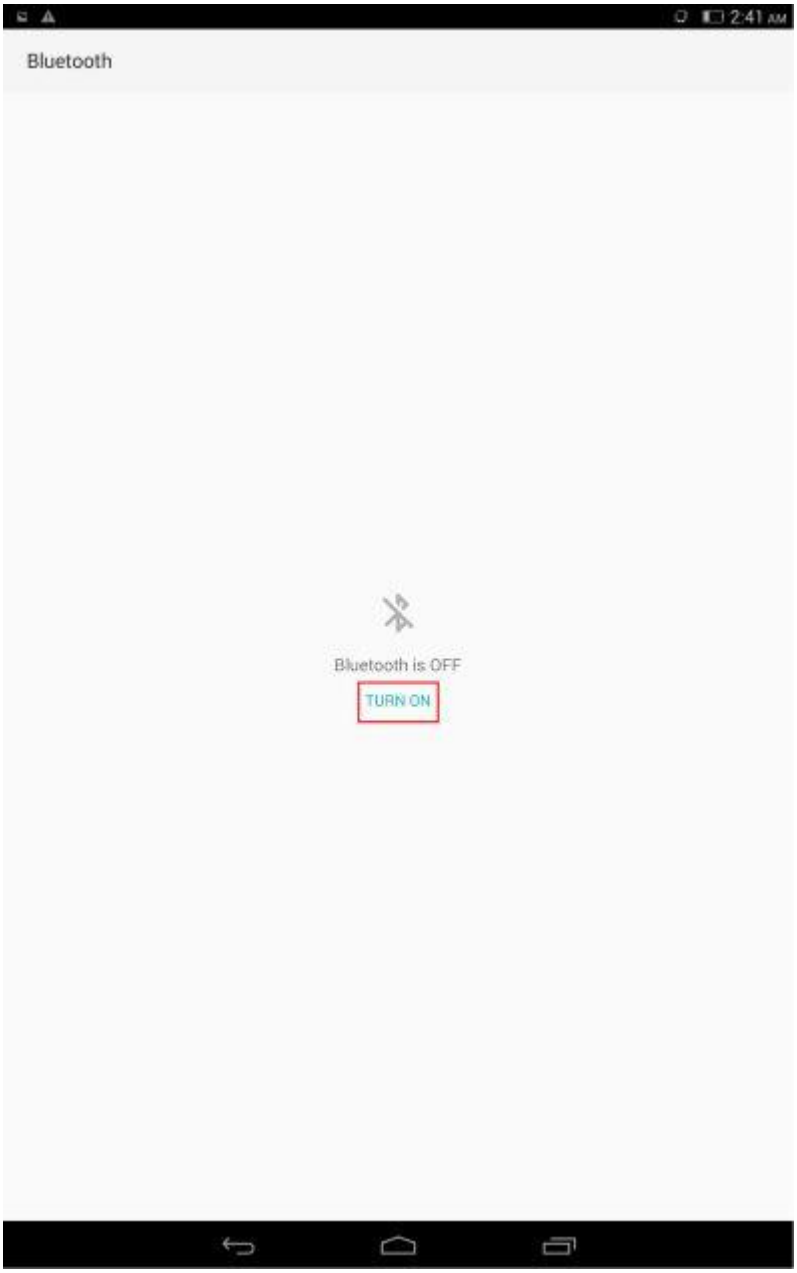


Figure 25. Turn on Bluetooth.

3. Select the MAXREFDES101# device.

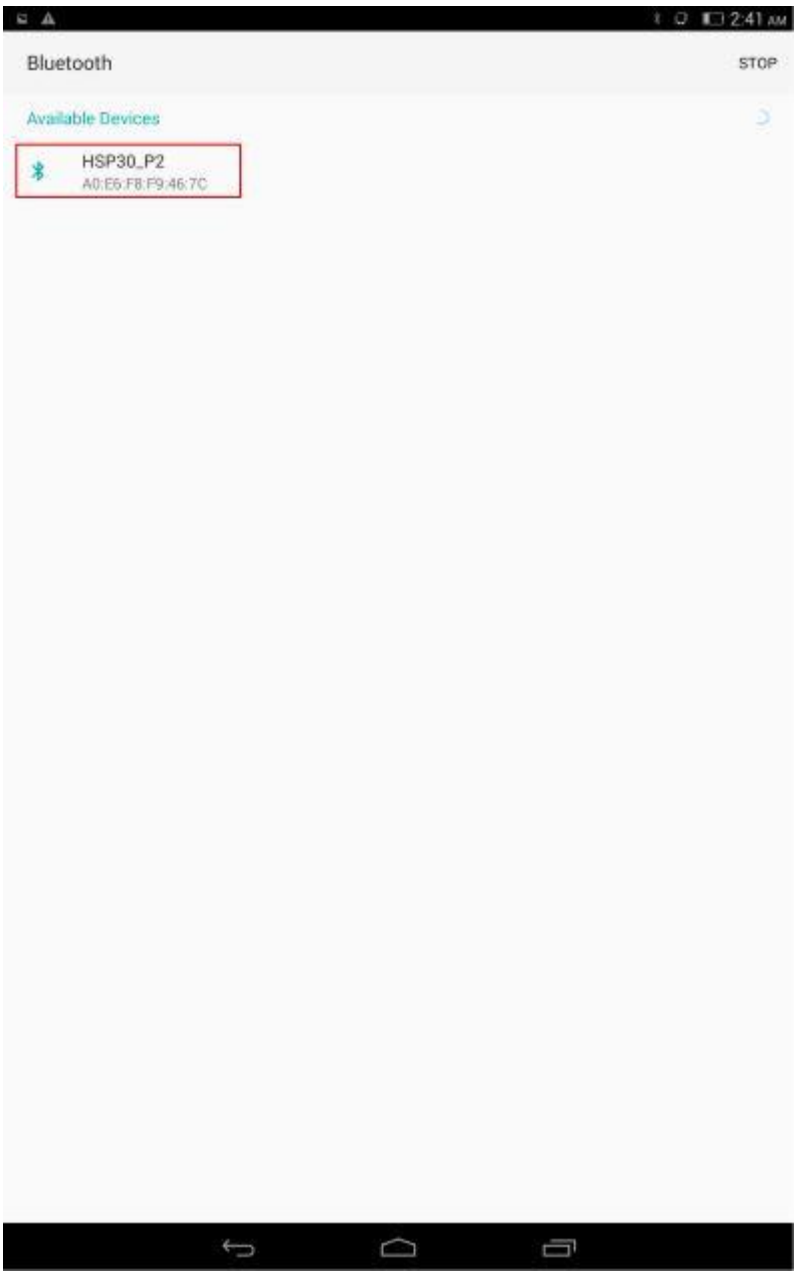


Figure 26. Select the MAXREFDES101# device.

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



Figure 27. ECG, PPG, and temp listed under Connected Devices.

Start ECG Measurement

1. Click on the "…" button on the top right corner and check the box for "Log To File" to save the data.

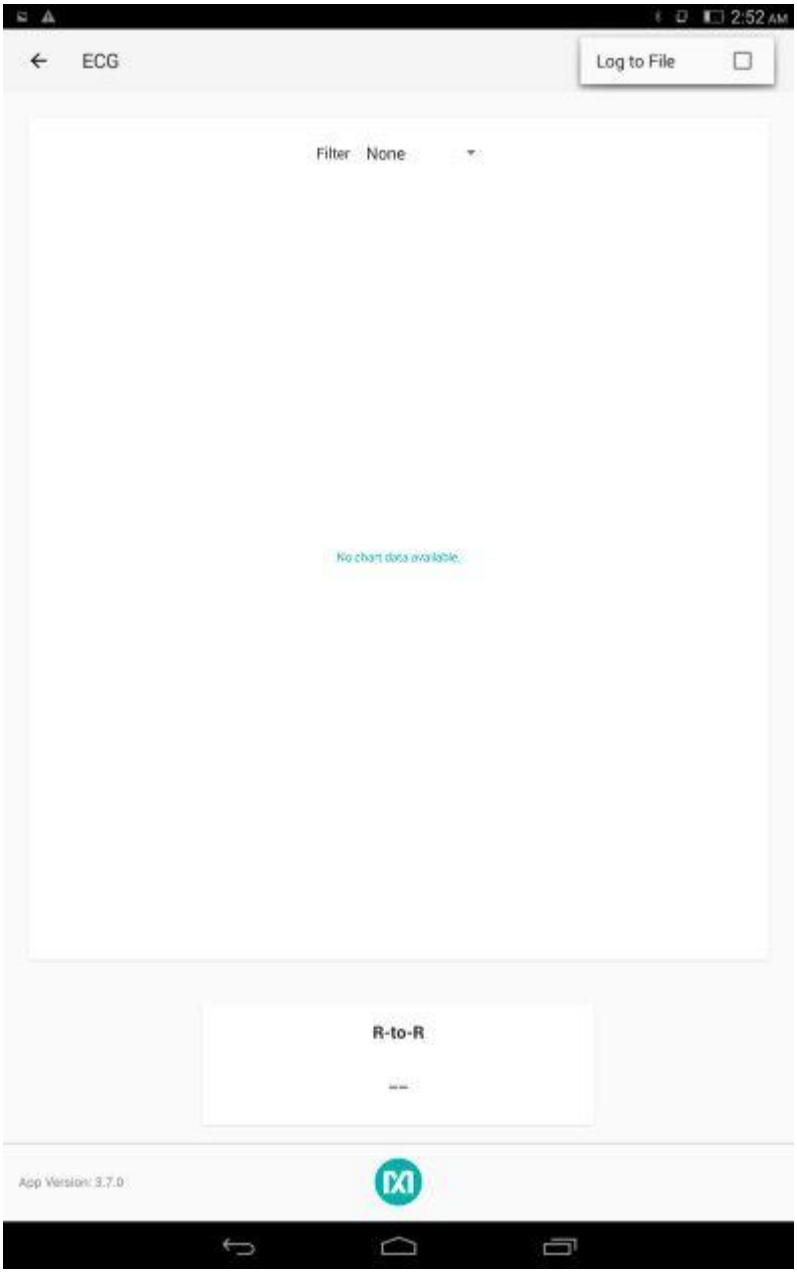


Figure 28. Log to file ECG measurement for Android app.

2. Select the Bluetooth icon to check the status of the connection.



Figure 29. Select the Bluetooth icon for ECG measurement.

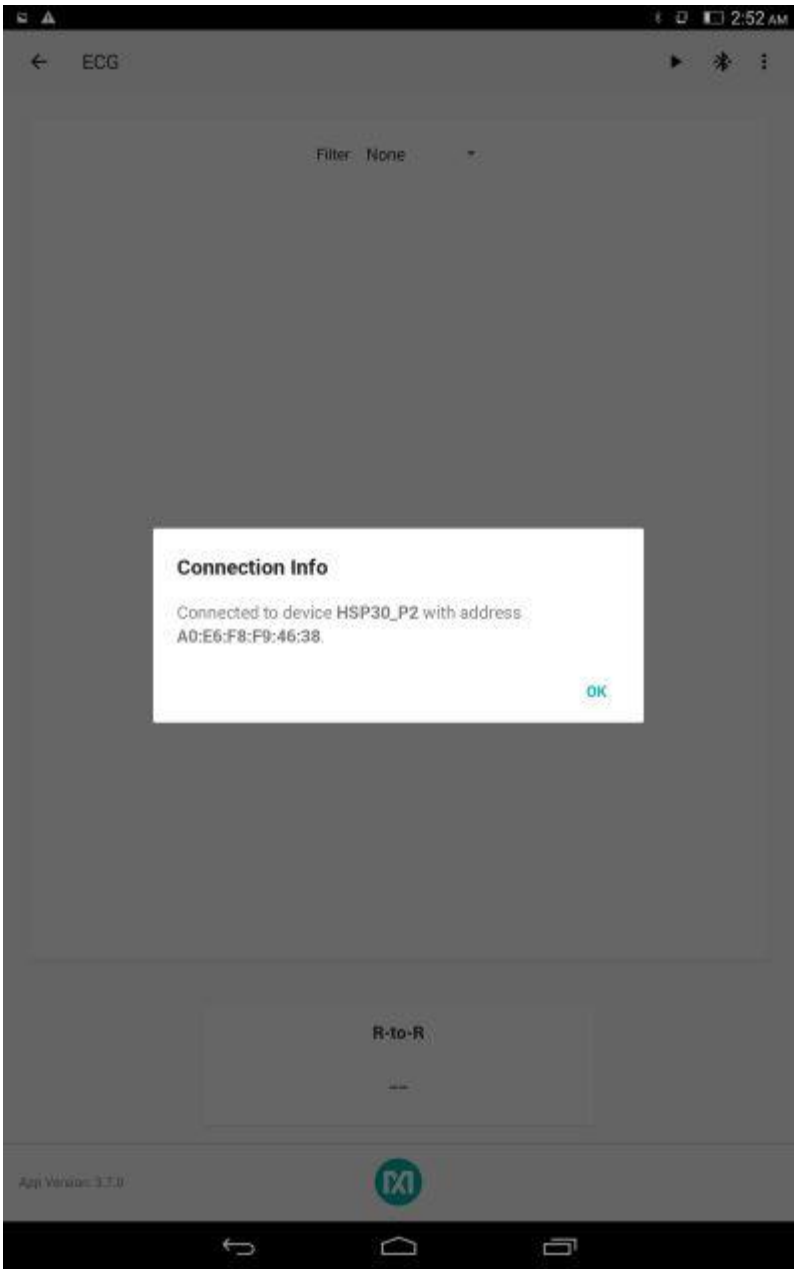


Figure 30. ECG measurement connection info.

3. Choose the filter type to apply.



Figure 31. Select ECG measurement filter type.

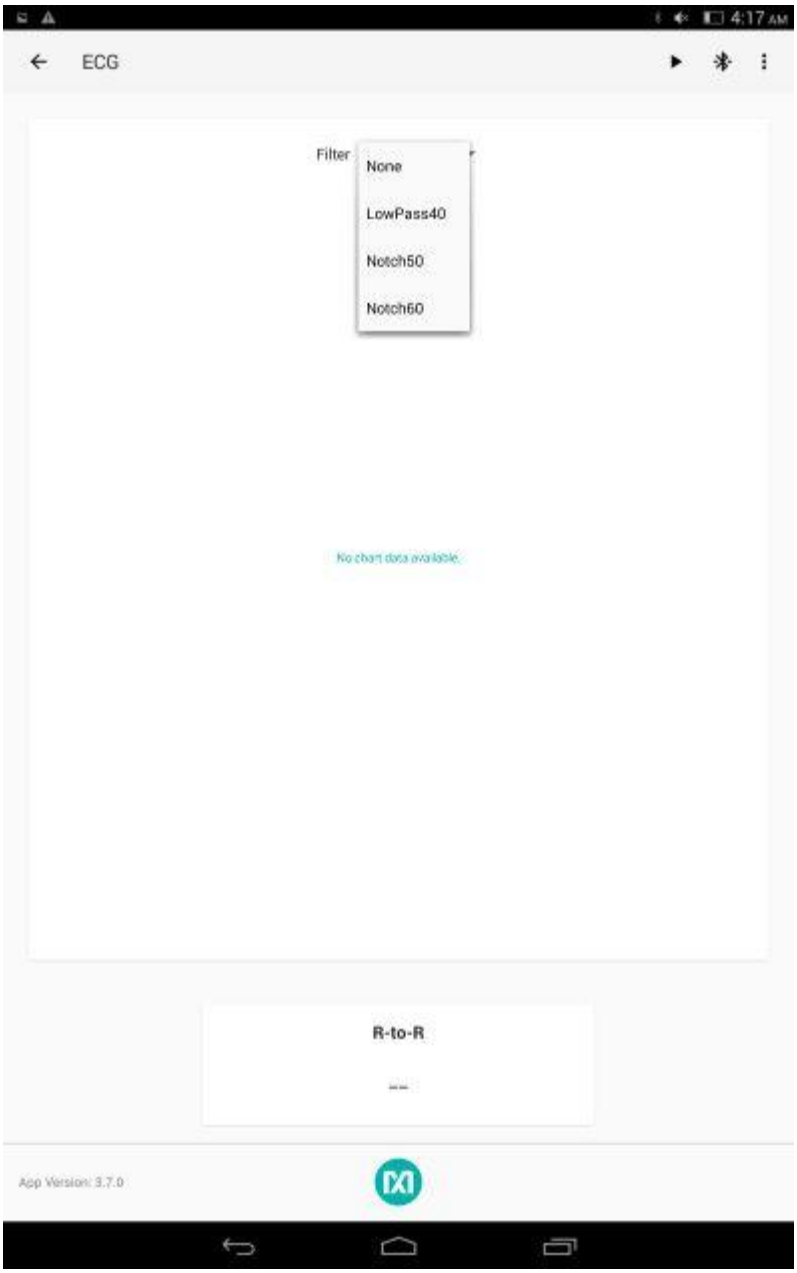


Figure 32. ECG measurement available filter types.

4. Make sure the skin has direct contact with electrode 2 and electrode 3. Then click the start button.



Figure 33. Start ECG measurement using the Android app.

5. A pop-up window appears. Select "NO" to use the last setting, and select "YES" to use the default setting.



Figure 34. Android ECG measurement default settings.

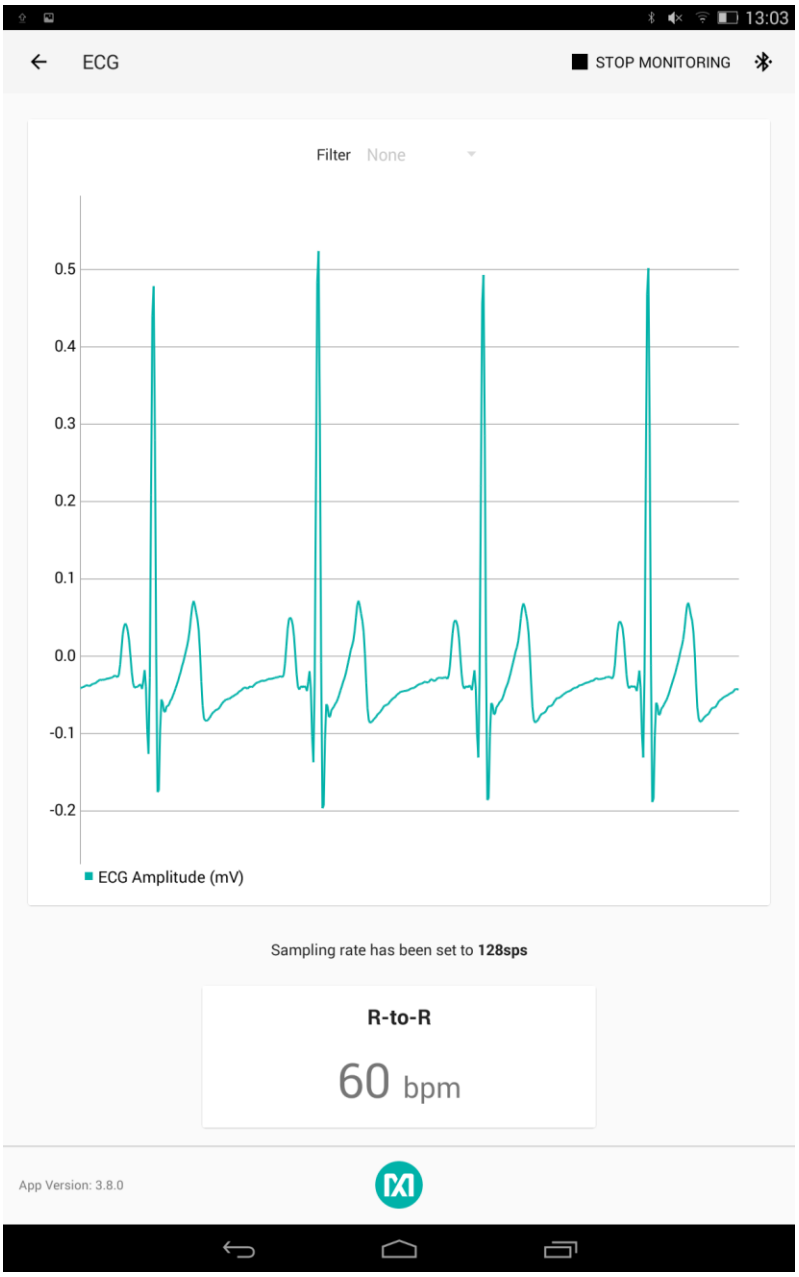


Figure 35. Android app ECG measurement sample.

Start PPG Measurement

1. Select the "…" button at the top right and check the box for "Log to File" to save the data.

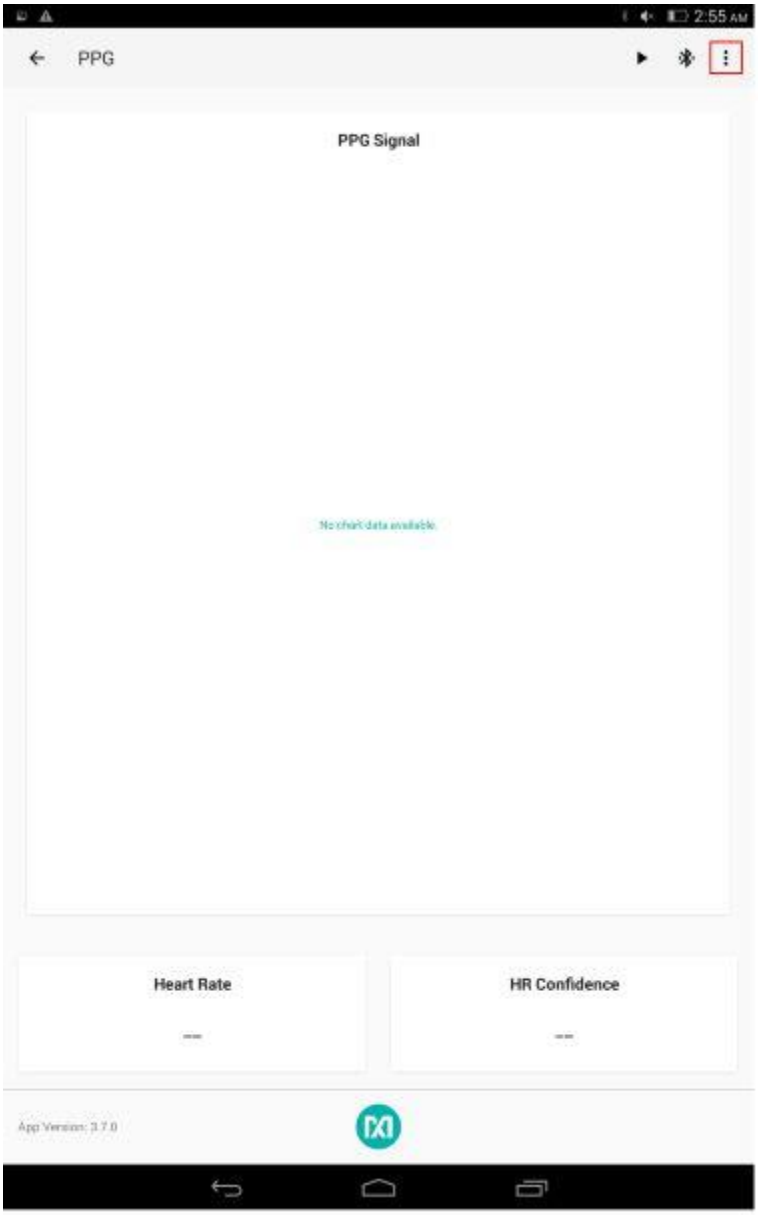


Figure 36. Start PPG measurement for Android app.

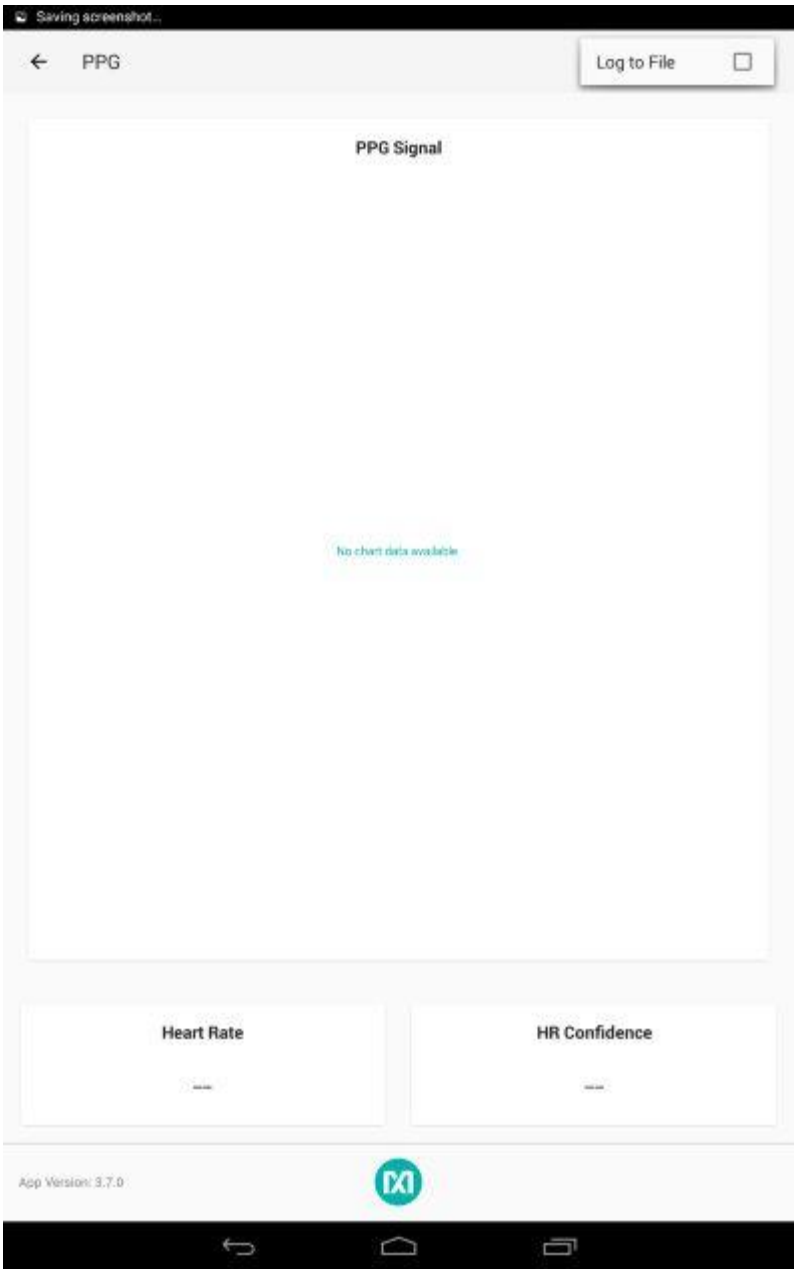


Figure 37. Log to file PPG measurement for Android app.

2. Select the Bluetooth icon to check the status of the connection.

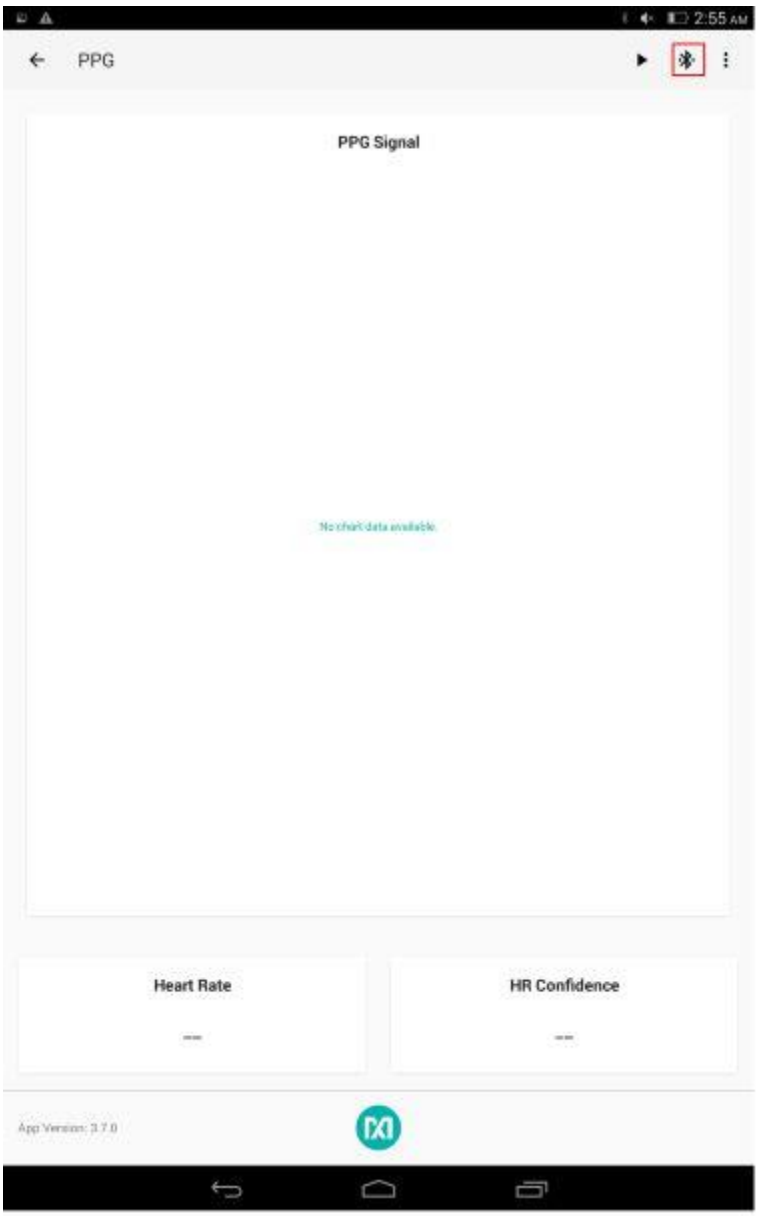


Figure 38. Check the connection for PPG measurement.

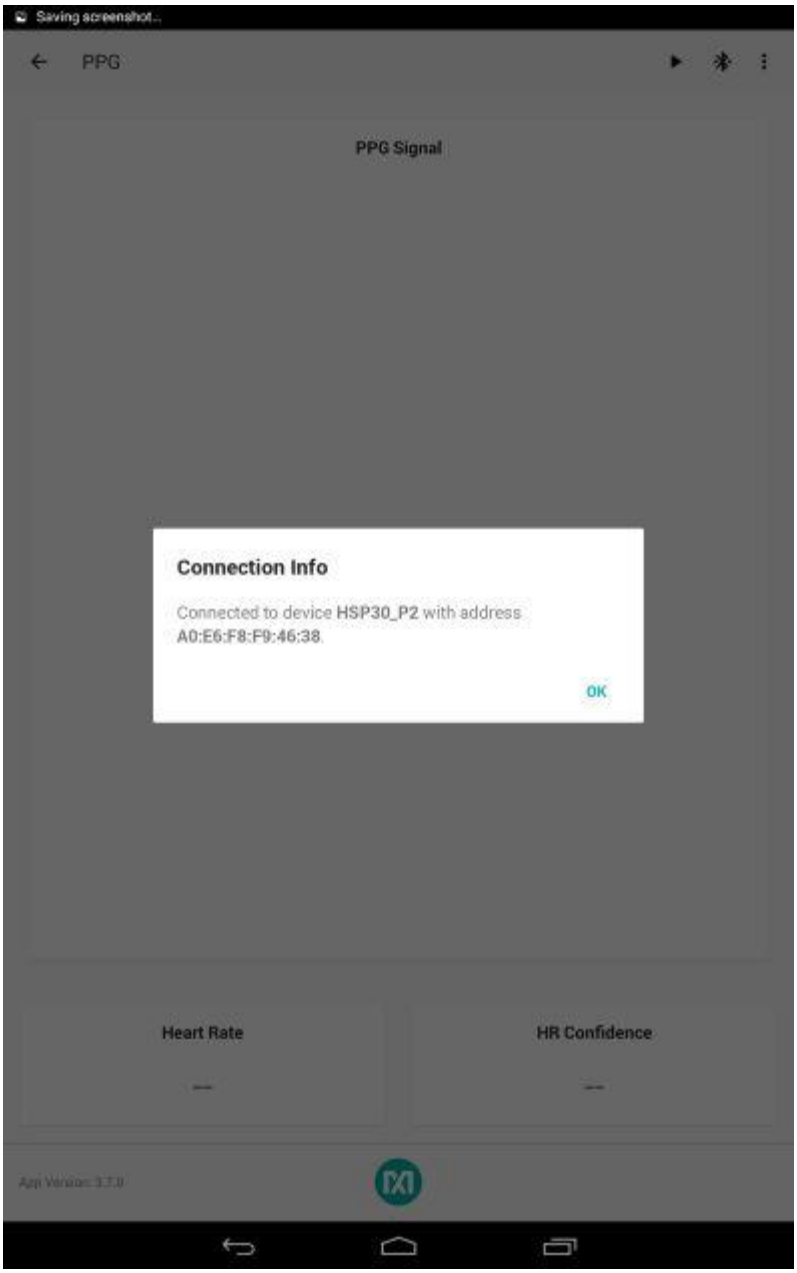


Figure 39. PPG measurement connection info.

3. Make sure the skin has direct contact with the LED/photodiodes on the back of the watch, and click the start button.

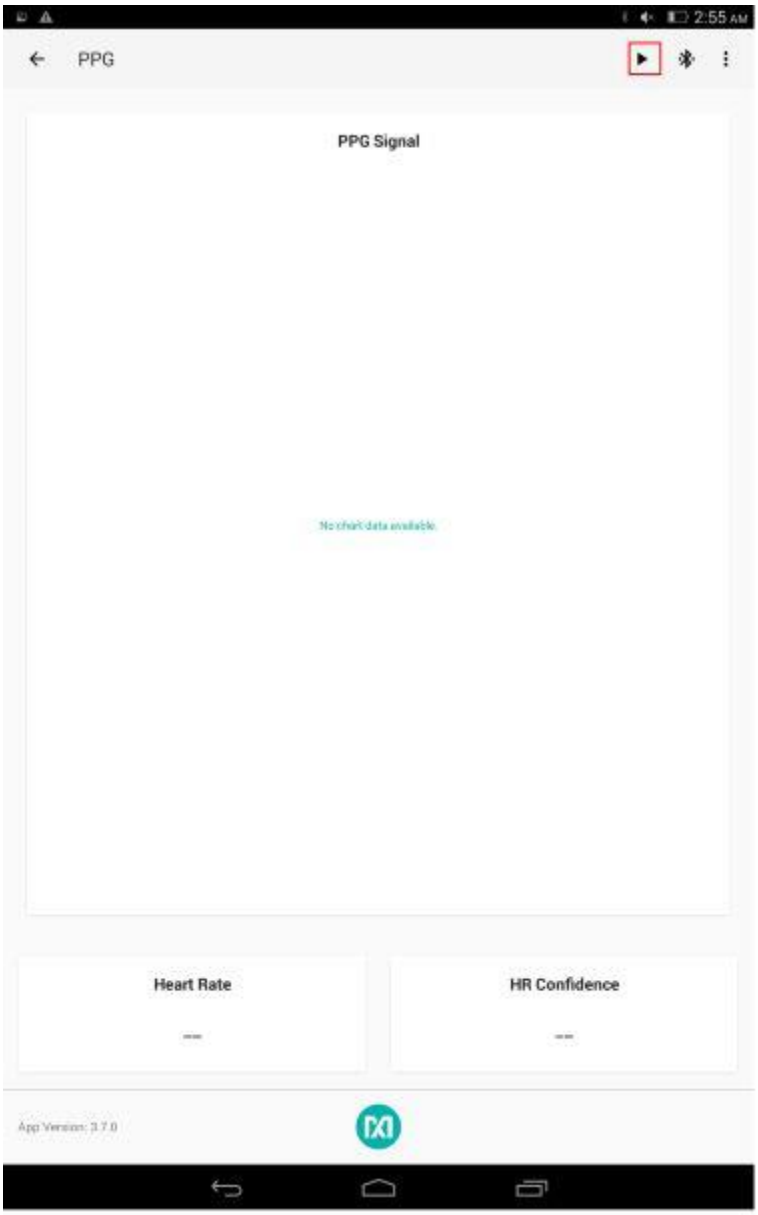


Figure 40. Start the PPG measurement on the Android app.

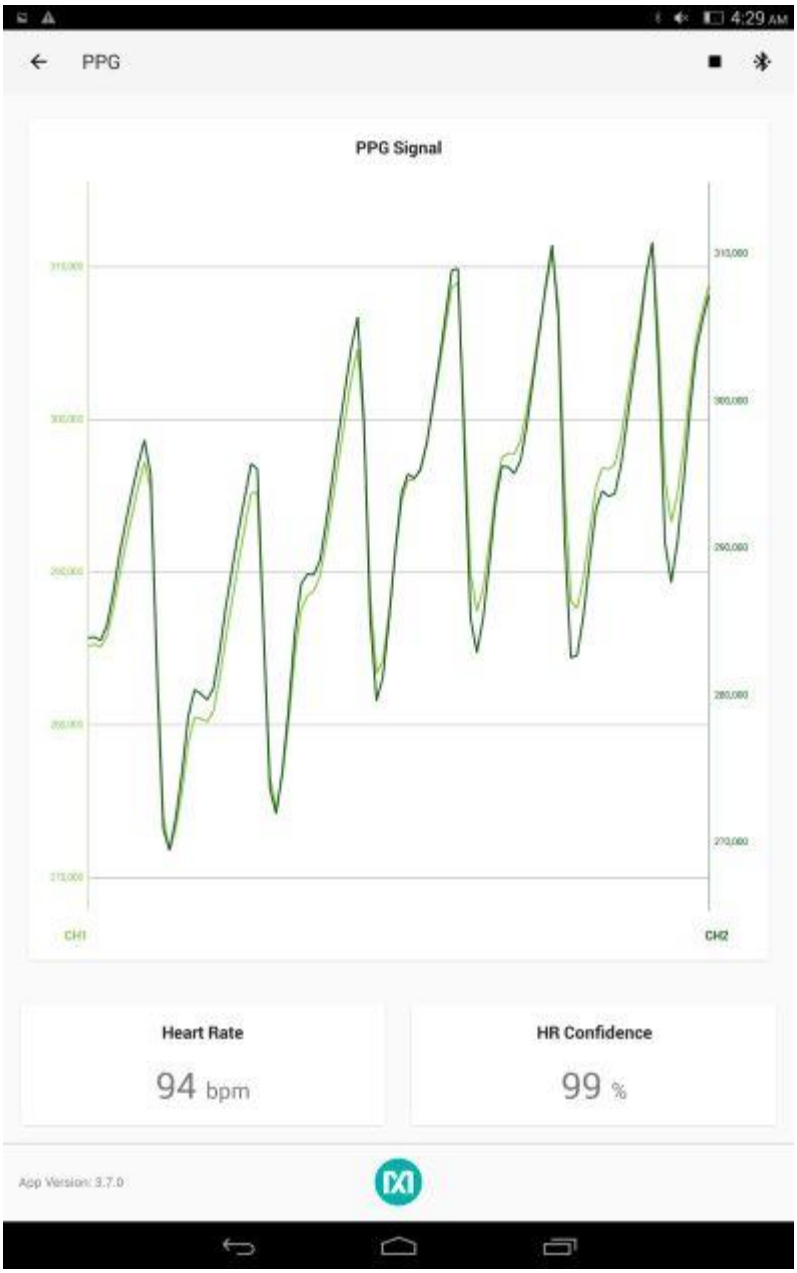


Figure 41. Android app PPG measurement sample.

Start Temperature Measurement

1. Select the "…" button on the top right and check the box for "Log to File" to save the data.



Figure 42. Start temperature measurement for Android app.



Figure 43. Log to file temperature measurement for Android app.

2. Select the Bluetooth icon to check the status of the connection.



Figure 44. Check the connection for temperature measurement.

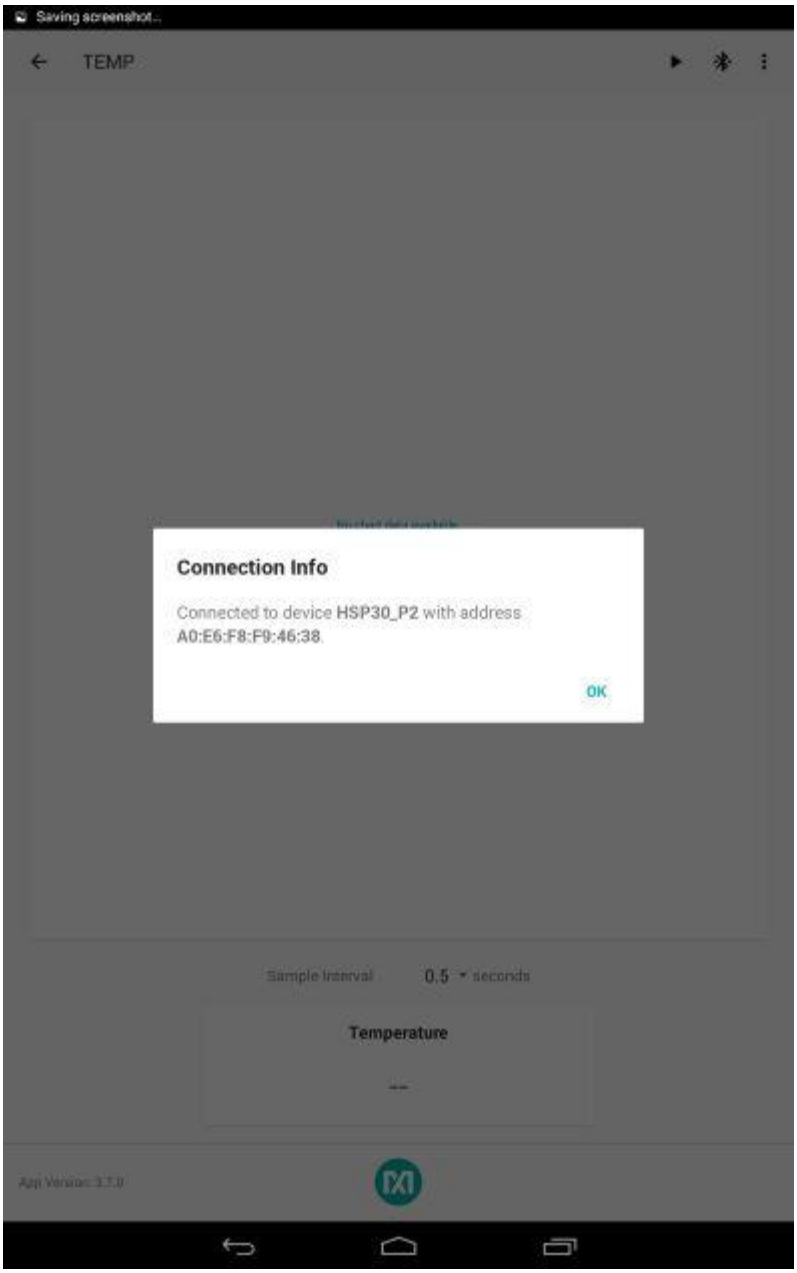


Figure 45. Temperature measurement connection info.

3. Make sure the skin has direct contact with electrode 2 and click on the start button.



Figure 46. Start the temperature measurement on the Android app.

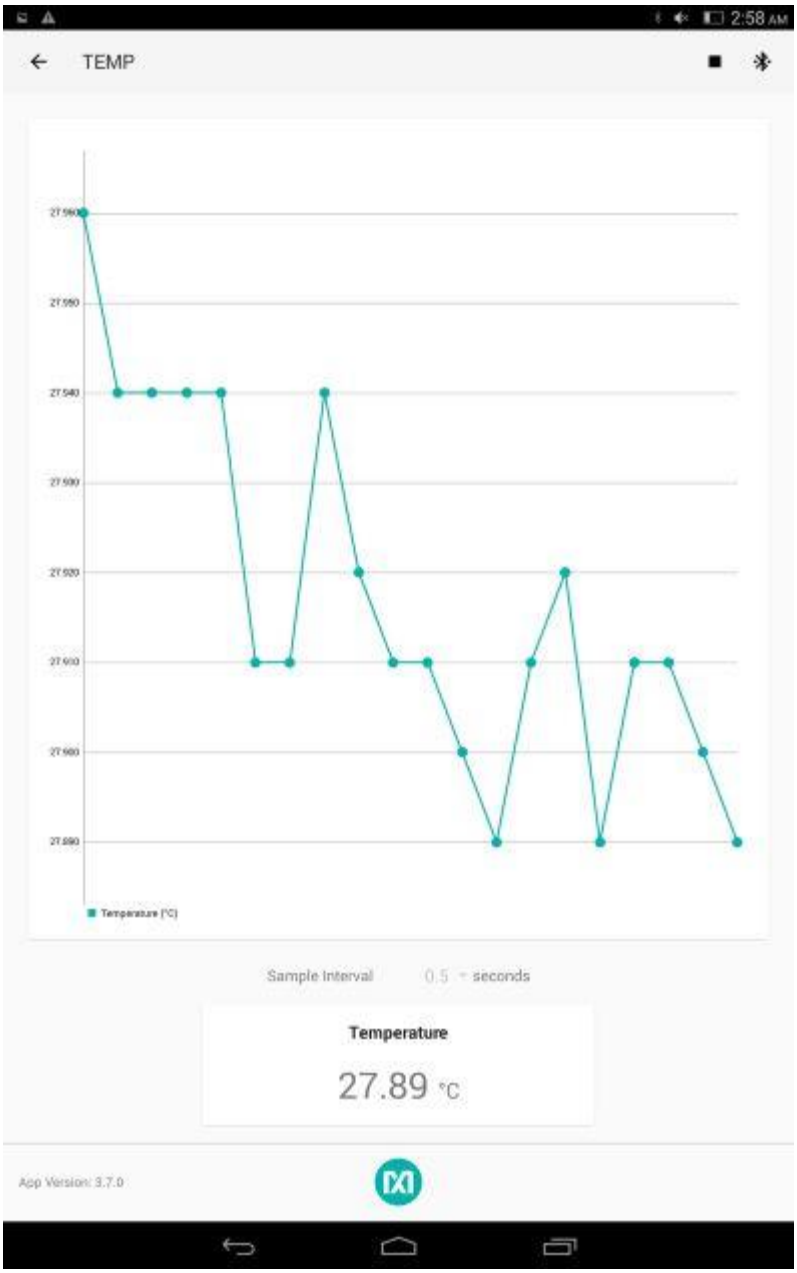


Figure 47. Android app temperature measurement sample.

Data Format

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

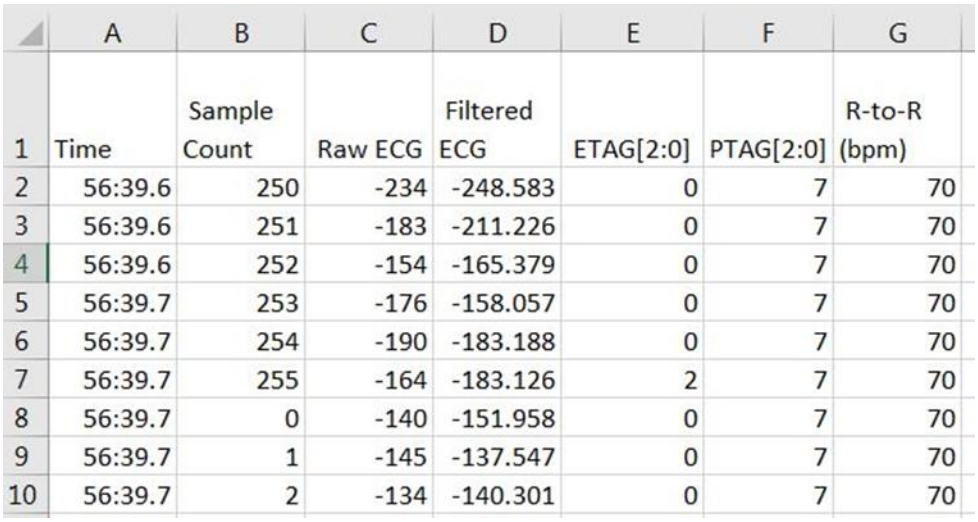
Column	Description
Time	Time stamp
Sample count	Data index ranging from 0 to 255 for monitoring if samples are dropped during Bluetooth transmission
Green count 1	Optical count detected by photodiode 1
Green count 2	Optical count detected by photodiode 2
X Axis Acceleration (g)	Acceleration in x-axis, 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
1	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 48. 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 MAX30001 data sheet for details)
PTAG [2:0]	ECG PACE data tag (see table 49 in MAX30001 data sheet for details)
R-to-R (bpm)	Heart rate (beats per min)



	A	B	C	D	E	F	G
1	Time	Sample Count	Raw ECG	Filtered ECG	ETAG[2:0]	PTAG[2:0]	R-to-R (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 49. 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 50. 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

©2018 by Maxim Integrated Products, Inc. All rights reserved. Information in this publication concerning the devices, applications, or technology described is intended to suggest possible uses and may be superseded. MAXIM INTEGRATED PRODUCTS, INC. DOES NOT ASSUME LIABILITY FOR OR PROVIDE A REPRESENTATION OF ACCURACY OF THE INFORMATION, DEVICES, OR TECHNOLOGY DESCRIBED IN THIS DOCUMENT. MAXIM ALSO DOES NOT ASSUME LIABILITY FOR INTELLECTUAL PROPERTY INFRINGEMENT RELATED IN ANY MANNER TO USE OF INFORMATION, DEVICES, OR TECHNOLOGY DESCRIBED HEREIN OR OTHERWISE. The information contained within this document has been verified according to the general principles of electrical and mechanical engineering or registered trademarks of Maxim Integrated Products, Inc. All other product or service names are the property of their respective owners.