



MAX-HEALTH-BAND (hBAND) User Guide

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Abstract

This user guide provides an introduction to and overview of the MAX-HEALTH-BAND (hBAND) fitness watch. The document details the major functions of the watch, its most useful features, and how to use it in conjunction with an Android device and the Health Map app.

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Introduction

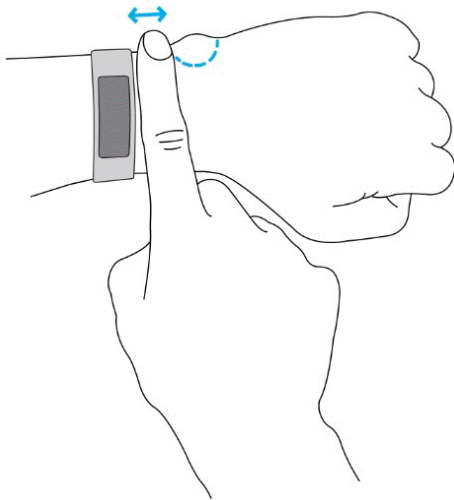
The MAX-HEALTH-BAND, or hBAND, is a fitness watch that utilizes a Maxim analog front-end (AFE), optical components, accelerometer, and an internal algorithm. The watch showcases an integrated solution for a wide audience, ranging from casual users interested in obtaining health/fitness metrics to software developers interested in using the raw optical and accelerometer data that the watch can provide. When used as a standalone watch, the device can monitor heart rate, calories burned, and steps taken. When used in conjunction with an Android® app, users can stream raw optical and accelerometer data to develop their own custom algorithms and invent new fitness applications.

Operating the Watch

Power On/Off and Wearing

During the first few seconds after powering on the watch, the watch sensor (the surface that normally faces the wrist when worn) should be off the wrist and exposed to ambient air. This is required for proximity detection and for the algorithm to work properly.

1. To turn on the watch, hold the watch with the sensor surface exposed to ambient air and press the button down for two seconds. The watch vibrates and an hBAND logo appears after a few seconds. The watch is ready to be worn on the wrist as soon as the logo appears.
2. Position the device approximately one finger width up the arm from the wrist bone (see figure below). 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.



3. To turn off or reboot the watch, press the button down for 10 seconds. A power-off warning sign (⏻!) is displayed before the watch powers off. Hold the button until the warning sign disappears to ensure that the watch is powered off.

! After powering up and placing the watch on the wrist, it can take up to one minute for the algorithm to initially report a heart rate value. In the interim, the display shows a short line ("—"), indicating the heart rate is being computed.

! If the watch is powered on or power-cycled while being worn on the wrist, lift the watch one inch away from the wrist surface for more than one second; this updates the proximity setting without needing to completely take off the watch. This can be done at any time (e.g., during any operation mode, and even during data logging). During the process, be sure not to insert fingers in the one-inch clearance space between the watch and the skin. Make sure the strap is tightly fitted around the wrist afterwards.

Low Battery/Charging

The hBAND has a screen showing battery status. It does not have a warning for low battery.

The watch can be recharged using a micro-USB Type-B cable (included). When connecting the hBAND to a charger, the watch vibrates and displays a recharging screen. Removing the watch from the charger also causes it to vibrate.

Modes

The watch has the following modes: sampled mode and continuous mode. The operating mode can be changed from the watch by pressing the button down for one second. The watch vibrates as an indicator of mode change.

Different screens can be cycled through by pressing the button for one second within each usage mode. This section provides an overview of the displays for each screen.

Sampled Mode

The watch is in sampled mode by default. This mode is recommended for resting, when fitness metrics are not expected to change much. During sampled mode, the watch measures the heart rate every five minutes or whenever the button is pressed. This can extend battery life.

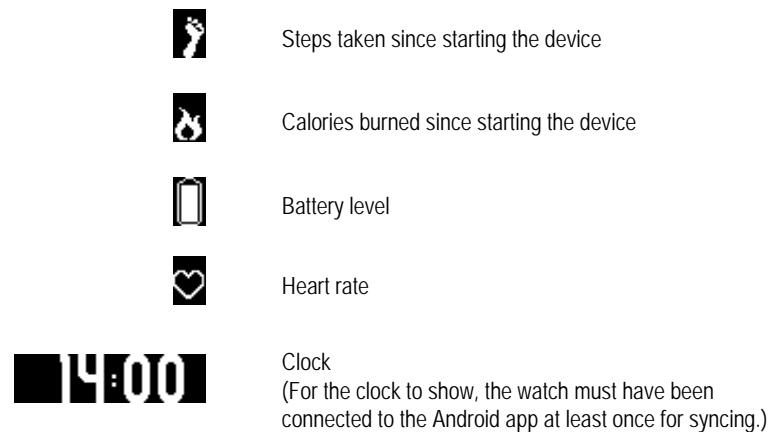


Figure 1. Sampled mode display.

Continuous Mode

In continuous mode, photoplethysmogram (PPG) and acceleration are sampled constantly at 100Hz and averaged over four samples. Heart rate (HR) is estimated once per second. A small heart is shown in the display's upper-left corner while the watch is in continuous mode.

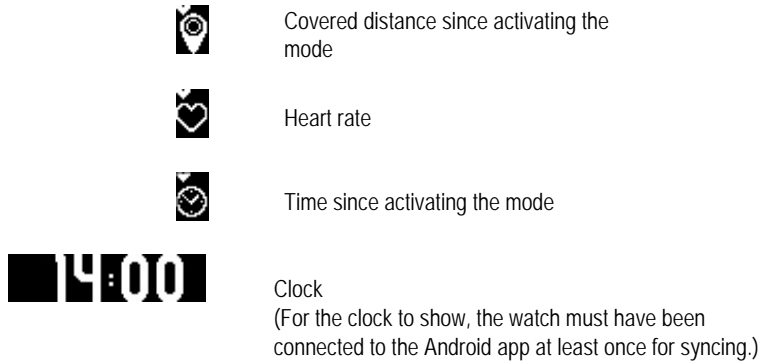


Figure 2. Continuous mode display.

Miscellaneous Displays

Heart Rate

The following heart rate display items appear in both sampled mode and continuous mode.

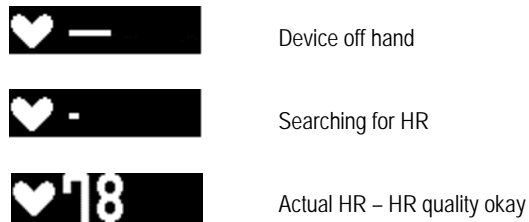


Figure 3. Heart rate display.

Operating and Warning

The following displays appear when powering on and powering off.

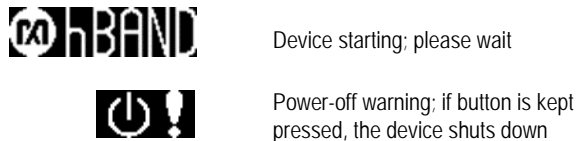


Figure 4. Operating and warning display.

Health Map App

For data logging, the user must install the provided Health Map app for Android. The watch can measure both optical count and HR. While use of Bluetooth® LE HR and heart rate variability (HRV) data is not limited to a specific app (e.g., nRF® Toolbox can be used to receive HR and HRV information), all other data (steps, calories, and raw data) can only be read using the Health Map app. Moreover, to get the clock display to work, the device must be connected to the app after a reboot.

To ensure uninterrupted data logging and watch connection, change the display setting of the Android phone or tablet to keep the screen always ON before running the app.



Raw data refers to the optical and accelerometer data before it is fed through the internal algorithm.

Installing the App

To install the Health Map app:

1. Save the provided .apk-file to a location that you can access by phone (for example, to the phone memory if you have a file browser or to Dropbox®). Accessing the file prompts the user to install the app.
2. If the app detects that the firmware is outdated, you can upgrade the firmware.
3. Grant permission when the app asks for access to the files on the phone and the location. These are required for the Bluetooth connection to work.

Connecting to an hBAND Watch

The app's initial start-up screen is blank with a SCAN button at the top right corner.

To connect the Health Map app to an hBAND device:

1. Press SCAN to bring up a list of available watches in range.
2. Select the device named hBAND. The MAC-address can be used to distinguish between multiple watches. The signal strength is also displayed to assist with finding the right device: a watch next to the phone usually gives a strength between -35dB and -55dB; -95dB is a very poor connection.

When the user does not select a device, the app connects to the device that is clearly closest to the phone. If multiple devices are close according to the signal strength, however, the app doesn't choose any device and instead displays an error message. The user can then manually connect to the desired device.

The main screen (see figure below) is displayed after a successful connection.

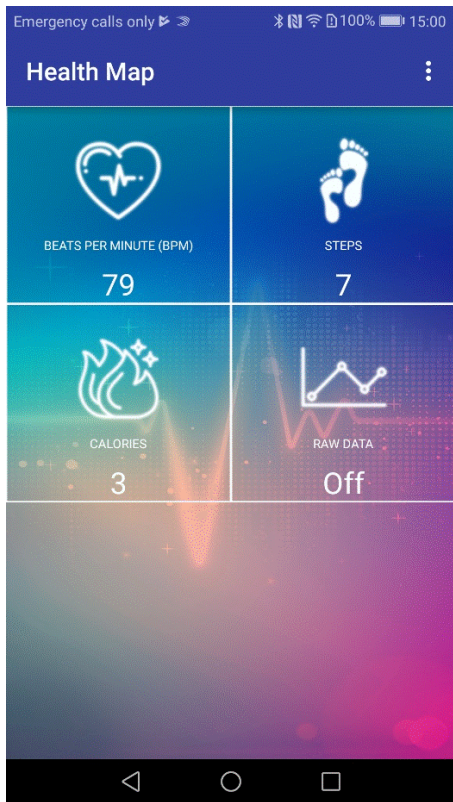


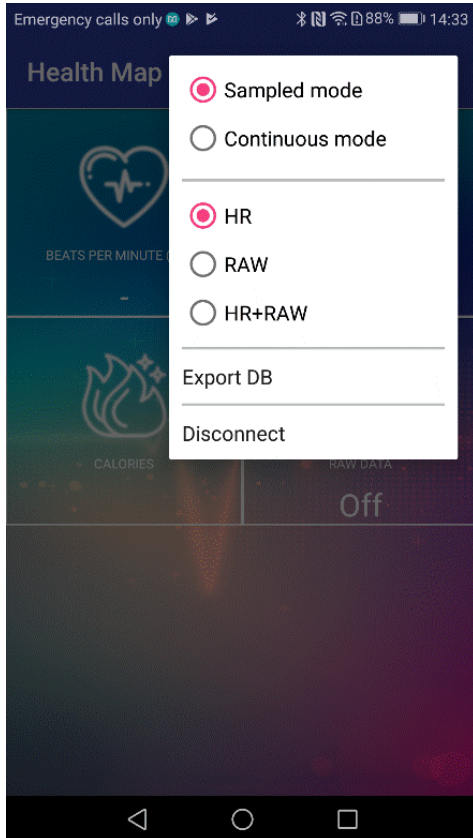
Figure 5. Health Map main screen.

The HR, calories, and steps should be the same as displayed on the watch, although there may be differences caused by a slight delay due to transmission.

Disconnecting an hBAND Watch

To disconnect a device:

1. Press the three dots in the upper right corner to bring up a pop-up menu (see figure below).



2. Select Disconnect.

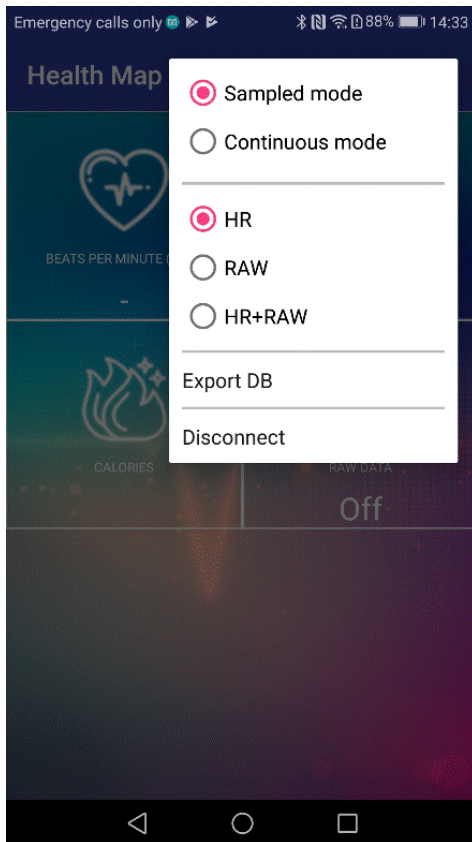
In the event a device is disconnected unintentionally (e.g., when the device is out of Bluetooth range), the app automatically attempts to reconnect to the device.

Collecting Data

The watch can measure both optical count and HR. By saving data to a database, users can access the raw optical count, computed HR based on an internal algorithm, and other information.

To start data collection:

1. Press the three dots in the upper right corner to bring up a pop-up menu (see figure below).




2. Select Continuous mode for a fast sampling rate.
3. Select either RAW or HR+RAW. Both RAW and HR+RAW export identical data to the database. When HR+RAW is selected, however, the heart rate value is also displayed on the phone display screen in real time.

The Raw Data icon status in the main screen is automatically turned to ON.

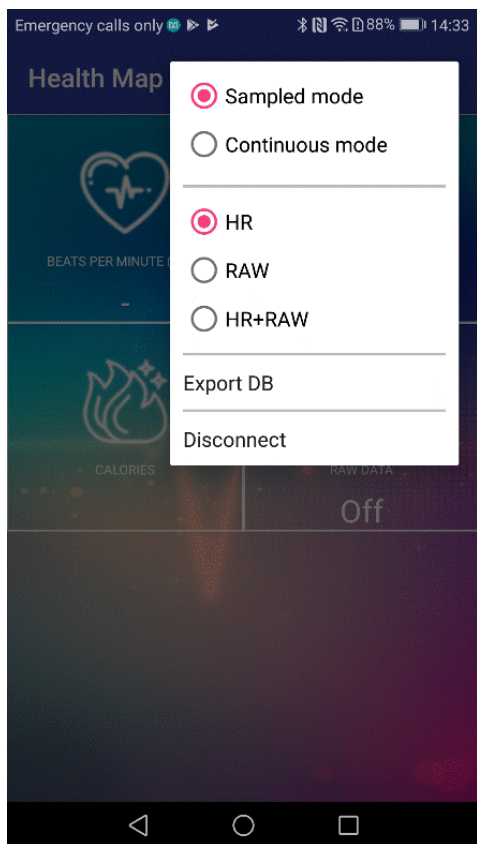
Data is now being stored in the device memory. As long as the Bluetooth connection remains, data is transferred (and deleted) from the watch memory to the phone database. If the Bluetooth connection is interrupted while data is being collected in the device memory, new data is not lost, but is streamed to the phone as soon as the Bluetooth connection is reestablished.

The SQLITE database can be found in the phone under the folder `/sdcard/PulseOnOHR/pulseon_ohr.sqlite`. This database includes two different tables: RawData and ContinuousData. Refer to the detailed description in the next section.

-  The transfer might take a long time if the device memory has a lot of stored data (e.g., when the Bluetooth connection is lost for an extended period). When this happens, leave the app on to allow the file transfer to take place.

To stop collecting data:

1. Press the three dots in the upper right corner to bring up a pop-up menu (see figure below).



2. Select HR. The RAW DATA icon status is automatically changed to OFF

Viewing Real-Time Data

Charting is optional. Data is saved whether or not charting visualization is activated. This section describes how to open and close the data visualization.

To view real-time charting of the raw data:

1. Return to the main screen.
2. Select the RAW DATA icon. A new charting window appears (see figure below). The y-axis is in units of optical count.



To close the charting window:

1. Press the Back button on the Android device.
2. Close the charting window and return to the main screen as soon as visualization of data is no longer required.



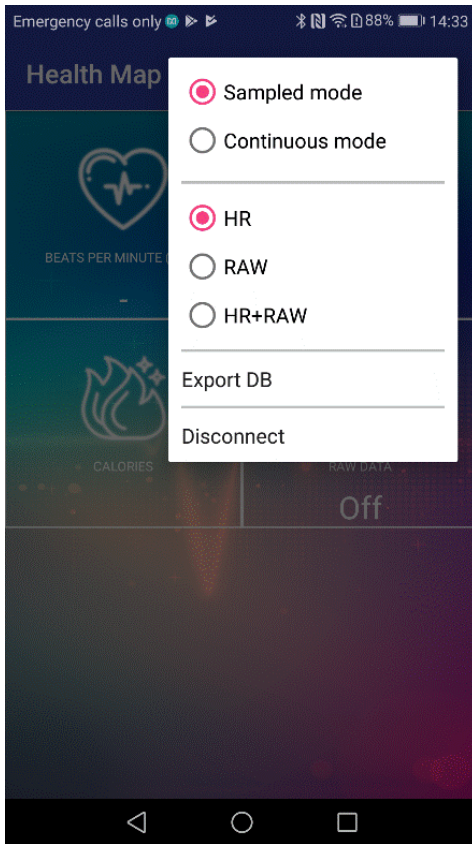
When the charting window is open, data is stored locally on the watch, but it is not streamed to or synchronized with the database on the phone until the charting window is closed. To ensure proper saving of data to the database, exit the real-time charting window and return to the main screen promptly after validation is complete.

Exporting Data

The user can export, or copy, the SQLITE database to a .csv file. When exporting, the original data remains in the SQLITE database, and newly collected data is appended to it. Subsequent exports of database data into .csv files contains both previous and new data, so when starting a new study, Maxim recommends users clear the database before data acquisition (see the *Resetting the SQLITE Database* section).

To export data to .csv format for analysis:

1. Press the three dots in the upper right corner to bring up a pop-up menu (see figure below).



2. Select Export DB.

Each time Export DB is selected, all the data in the SQLITE database is converted to three .csv files in the /sdcard/PulseOnOHR/csvexport/ folder (see figure below).




 20180525_143617-adl.csv
 20180525_143617-cont.csv
 20180525_143617-raw.csv

Figure 6. Example of SQLITE database .csv files.

Examples of each .csv file are given in figure 7 through figure 9 below. Refer to the *SQLITE Database Columns* section for a detailed explanation of the .csv file format.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	timestamp	running_counter	activity_class	sleep_class	workout_class	speed	walk_steps	run_steps	bike_steps	walk_distance	run_distance	calories	hr	hr_qi	rsi
2	1.52487E+12	672	0	0	0	0	2	0	26	0	0	29	69	52	-71
3	1.52487E+12	673	0	0	0	0	2	0	26	0	0	29	69	50	-71
4	1.52487E+12	674	0	0	0	0	2	0	26	0	0	29	69	51	-71
5	1.52487E+12	675	0	0	0	0	2	0	26	0	0	29	70	29	-71
6	1.52487E+12	676	0	0	0	0	2	0	26	0	0	29	70	42	-71
7	1.52487E+12	677	0	0	0	0	2	0	26	0	0	29	70	46	-71
8	1.52487E+12	678	0	0	0	0	2	0	26	0	0	29	69	46	-71

Figure 7: Screenshot of *cont.csv.

	A	B	C	D	E	F	G	H	I	J
1	timestamp	running_counter	ppg1	ppg2	ppg3	ppg4	acc1	acc2	acc3	rsi
2	1.52487E+12	9695	233165	896	-1	-1	-226	17	998	-71
3	1.52487E+12	9696	232983	896	-1	-1	-225	19	994	-71
4	1.52487E+12	9697	232864	898	-1	-1	-223	20	998	-71
5	1.52487E+12	9698	232629	897	-1	-1	-223	20	995	-71
6	1.52487E+12	9699	232725	897	-1	-1	-226	18	992	-71
7	1.52487E+12	9700	232700	897	-1	-1	-223	19	998	-71
8	1.52487E+12	9701	232804	896	-1	-1	-222	21	997	-71

Figure 8: Screenshot of *raw.csv.

	A	B	C	D	E	F	G
1	timestamp	running_counter	ibi	sqe_class	rhythm_c	arrhythm	rsi
2	1.52487E+12	1027	882	0	0	0	-71
3	1.52487E+12	1028	811	0	0	0	-71
4	1.52487E+12	1029	833	0	0	0	-71
5	1.52487E+12	1030	848	0	0	0	-71
6	1.52487E+12	1031	870	0	0	0	-71
7	1.52487E+12	1032	887	0	0	0	-71
8	1.52487E+12	1033	913	0	0	0	-71

Figure 9: Screenshot of *adl.csv.

Resetting the SQLITE Database

Delete the SQLITE files to clear the database. New SQLITE files are created automatically in the next data-logging session.

SQLITE Database Columns

Table 1. Continuous Data Table Column Definitions

Column	Description
timestamp	Milliseconds from 01.01.1970 (UNIX® epoch in milliseconds)
running_counter	A running 16-bit number to check no data is missing
activity_class	0 - Rest 1 - Other 2 - Walking 3 - Running 4 - Biking 5 - Other rhythmic 6 - Sleep: other 7 - Sleep: light 8 - Sleep: deep
workout_class	0 - No workout 1 - Workout ongoing
speed	Current speed, in km/h
walk_steps	Cumulative number of walking steps since turning on the device
run_steps	Cumulative number of running steps since turning on the device
bike_steps	Cumulative number of pedal strokes since turning on the device
walk_distance	Cumulative distance walked since turning on the device, in meters
run_distance	Cumulative distance run since turning on the device, in meters
calories	Number of calories burned since turning on the device
hr	Current heart rate
hr_qi	The quality index of the heart rate measurement
rssi	Signal strength during the transfer of the file containing this line
savetime	Time according to the phone when the file was transferred (for SQL table only, not csv)

Table 2. Raw Data Table Column Definitions

Column	Description
timestamp	Milliseconds from 01.01.1970 (UNIX epoch in milliseconds)
running_counter	A running 16-bit number to check no data is missing
ppg1	Green PPG signal
ppg2	Ambient for green PPG signal
ppg3	Not in use
ppg4	Not in use
acc1	Acceleration in one dimensions
acc2	Acceleration in one dimensions
acc3	Acceleration in one dimensions
rsi	Signal strength during the transfer of the file containing this line
savetime	Time according to the phone when the file was transferred (for SQL table only, not csv)

Table 3. ADL Table Column Definitions

Column	Description
timestamp	Milliseconds from 01.01.1970 (UNIX epoch in milliseconds)
running_counter	A running 16-bit number to check no data is missing
IBI	Interbeat interval
sqeclass	0 - reliable 1 - unreliable
rhythm_class	Proprietary information
arrhythmia_state	Proprietary information
rsi	Signal strength during the transfer of the file containing this line
savetime	Time according to the phone when the file was transferred (for SQL table only, not csv)

Firmware Update

Automatic Firmware Update

When opening the app, it automatically detects whether the device has an outdated firmware version. If the firmware is out of date, the app prompts the user for an update, as shown in the figure below.

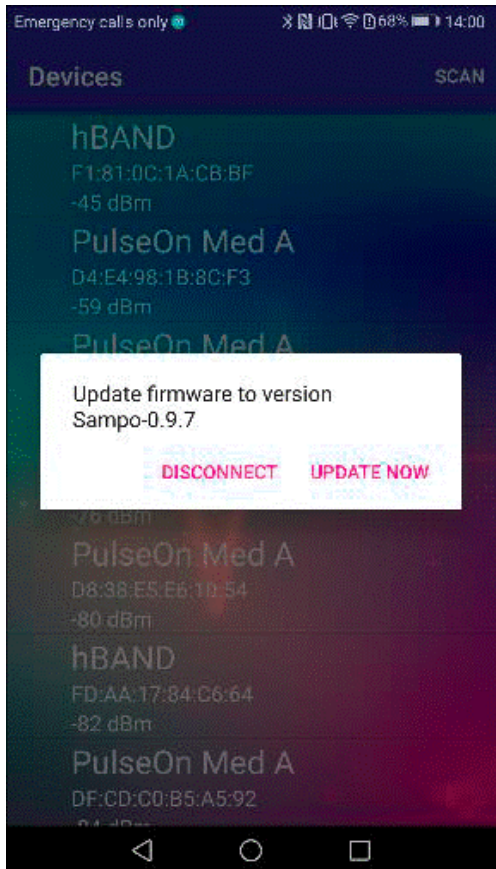


Figure 10. Firmware update.

Pressing UPDATE NOW causes the hBAND automatically to go into device firmware upgrade (DFU) mode, which puts the watch in an inactive state, and starts installing the new version of the firmware.

After a successful update, the watch exits DFU mode and powers up (wakes up) automatically. It can then be detected as a Bluetooth device.

The app has been tested successfully on multiple phones. Unfortunately, however, the update is known to malfunction occasionally with some models. If the automatic update is not successful, then proceed with a manual update, as described in the next section, *Manual Firmware Update with DFU*.



Even if an automatic-update attempt fails, the watch most likely has still been placed in DFU mode, so step 1 in the next section would be unnecessary.

Manual Firmware Update with DFU

To update the firmware manually with DFU:

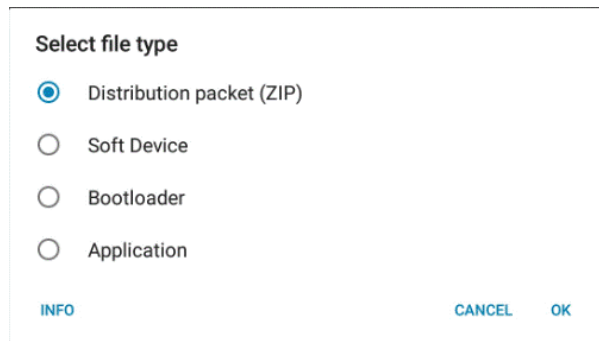
1. Put the watch in DFU mode: When the watch is in the off state, hold the power button for 10 seconds (use a timer, as this must be precise). The screen remains blank, but the device has silently gone into DFU mode.
2. Install on the Android device the nRF Toolbox app from Google Play®.
 - a. Select the DFU icon.



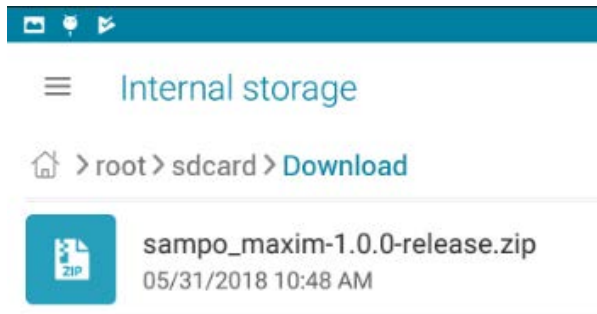
- b. Click SELECT FILE.



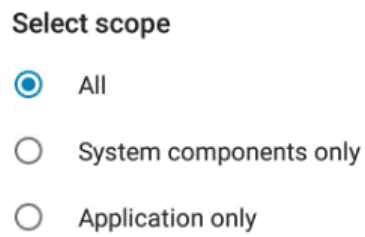
c. Select Distribution packet (ZIP) as type.



d. Select the zipped distribution packet file.

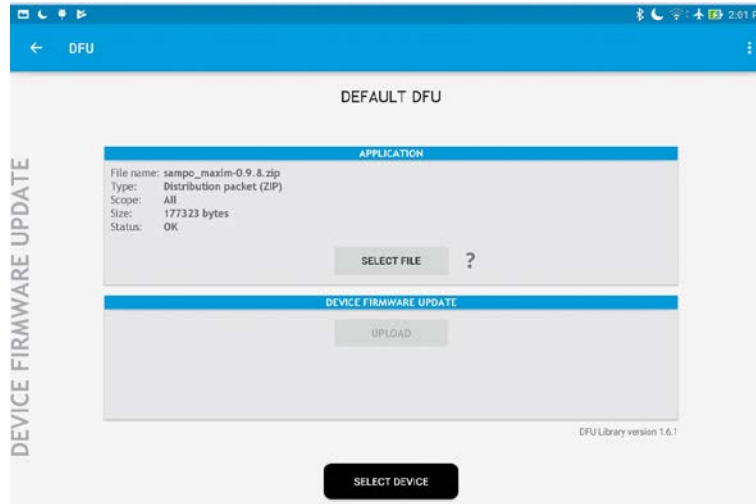


e. Select All for scope.



OK




- f. Click SELECT DEVICE at bottom of screen.



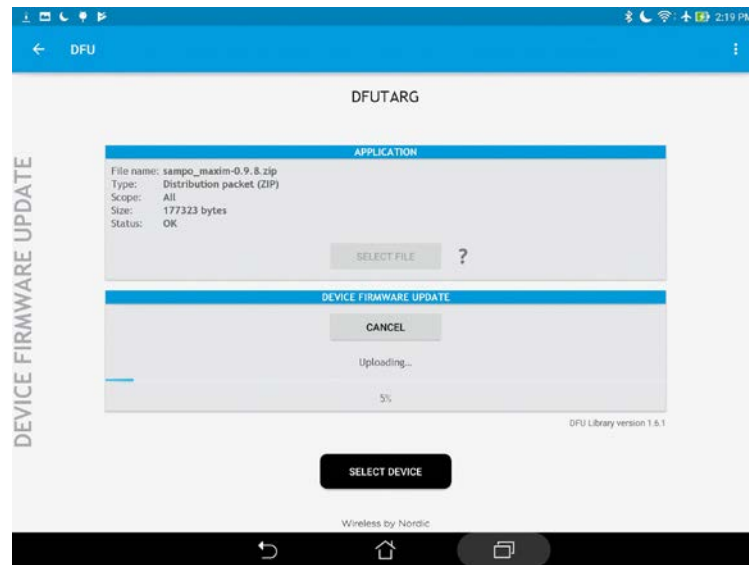
- g. Select the desired device with ID "DfuTarg" (indicating a device in DFU mode per step 1). Any device identified as hBAND should not be selected, as it is not yet in DFU mode.

Select device:

AVAILABLE DEVICES:

DfuTarg CA:40:97:D5:E7:39	
hBAND D4:F9:C4:16:42:29	
n/a 05:87:49:0A:36:2A	

h. Click Upload. The upload status is shown in status bar.



The application has been transferred successfully, as shown in the figure below.

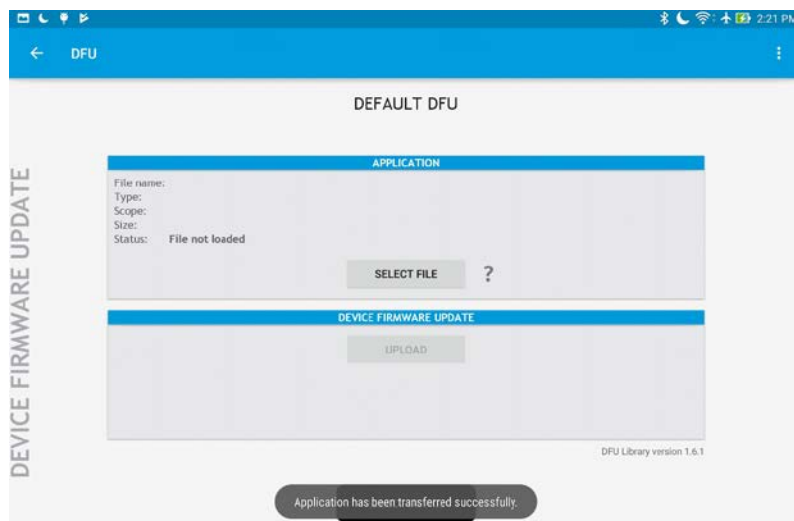


Figure 11: Transfer successful.

After a successful upload, the watch exits the DFU mode automatically. The watch can then be powered on and detected as an available Bluetooth device.

In the unlikely event that the watch is put into DFU mode without any subsequent firmware upgrade, the user can exit the DFU mode manually by holding the watch button for 10 seconds. The watch can then be powered on as normal and detected as a Bluetooth device.

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