PulseOn OHR Tracker (SP-2D-M) data sheet

Version 1.4
11 Apr, 2018

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1 PulseOn OHR Tracker device overview

1.1 Mission

PulseOn OHR Tracker, white label, ODM, device is for customers looking for a private label solution for their own services, applications, research and data collection purposes. PulseOn OHR tracker enables fast time to market and easy integration to existing solutions through open interfaces, API and example application. The device is *Bluetooth®* enabled and designed for a wide range of use cases. Easy variant creation and co-branding is possible.

1.2 Key benefits

For B2B customers:

- Scientifically validated and accurate optical HR, beat-to-beat HR and activity data which works reliably on a wide range of users
- Exposed raw data
- Fast entry to market with a ready HW and API, example application solution
- Long autonomy (battery life time) enables various use cases
- Fast integration to customer's application or service with API or with open Bluetooth HR profile
- Simple usage minimizes need for end-user technical support
- Possibility for own design and branding
- Bluetooth low energy support

For end-users:

- Reliable all day activity and HR monitoring
- Up to 4-5 days usage time in sampled mode
- Very simple to use: no need to operate UI, only recharging and wearing required
- Automatic data transfer to application or service
- Several use cases enabled by a single device: HR, activity, etc.
- Minimalistic yet stylish design
- Common micro-USB cable/port for charging

1.3 Product communication and features

The product has three ways of transmitting information: open BLE HR profile, proprietary BLE API and physical display.

The open Bluetooth Heart Rate profile can be used directly with a 3rd party application or service as an option to replace the need for a HR chest strap. When HR measurement is started, HR and beat-to-beat HR are streamed over the HR service every second.

The proprietary BLE API provides full functionality for continuous HR and activity tracking. Raw data can be stored for 10 hours and other data can be stored for over 2 weeks and synchronized with a service or application when connected.

The device display shows real-time HR and accumulated data on the screen.

Data available from the device.

Data element	Description	HR profile	Display	BLE API
HR	HR	x	x	x
HRV / IBI	Beat-to-beat interval	x		x
HRQI	HR quality index for evaluating data reliability			x
Raw data	Accelerator, PPG sensor			x
Steps	Accumulated steps		x	x
	Accumulated steps separated for walking, running and biking.			x
Calories	Energy expenditure estimation based on activity data		x	x
Workout detection	Automatic detection of workout			x
Activity class	Accelerometer based information on the activity class including running, walking, other, rest			x

Table 1.

1.4 Key drivers and priorities

The device is mainly aimed as data collector for applications and services. The key drivers for the product are:

Key drivers	Criteria
Accurate HR and HRV measurement	On par or better than best competitor product on the market
Raw data collection	Enables collection of accelerator and PPG sensor data
Simple and reliable to use	Beta testing satisfaction on intuitive ease of use and reliability. Minimal or no instructions needed. Reliable connectivity and operation – connectivity problems rare or non-existent with common Android devices.
Long battery life	30 hours minimum in continuous HR and HRV measurement, target 4-5 days in sampled mode
Well balanced small product suitable for various use cases	Customer acceptance and feedback
Easy variant creation	Lead customer acceptance and feedback
Watertight	IP 68 as target, IP 67 minimum

Table 2.

2 Use cases

This section shows the primary supported use cases from end-user point of view. In some cases the main implementation is on the third party service or application side but it does impact also the wristband implementation.

2.1 Continuous activity tracking use cases

Continuous activity tracking	Wristband	Third party
Daily activity		

Heart rate	x	x
Total calories burned	x	x
Total steps	x	x
Activity pattern		x
Activity history		
Activity data available in different time scales		x
Total energy consumption available in different time scales		x

Table 3.

2.2 Sport training use cases

Sport training	Wristband	Third party
Manual event start/stop	x	x
HR during event	x	x
Steps during event	x	x
Training time	x	x
Calories burned during event		x
Max and min HR during event		x

Table 4.

2.3 General use cases

General use cases	Wristband	Third party
Pair with app/service through API	x	x
Low battery warning and charging indicator	x	
Easy charging, no device specific cable needed	x	
Automatic sync of stored data with application/service when connected	x	x
Firmware update through app/service	x	x
Hardware reset option in case error	x	
Adjustable replaceable strap (size and design variants)	x	

Table 5.

3 Functionality

3.1 Usage modes and mode control

Reference design includes the following usage modes. These modes can be controlled and partly customized by a third party service/app over the BLE API.

Usage mode	Description
Continuous HR	Continuous HR and activity tracking based on green PPG. Mainly intended to be used during sports.
Sampled HR	Sampled HR and continuous activity tracking during daily life. Sampling interval configurable over the API.
Activity	Continuous activity tracking during daily life. No HR is measured.
Proximity	Only tracks whether the device is worn or not. Intended to detect when device is put back on hand.
Idle	No tracking, minimum power consumption.

Factory testing mode	Factory testing for the three sensors (PPG, ACC, PROX) built in into the firmware itself.
Shipping mode	Very deep sleep while shipping.
Firmware update	Special mode used transmitting and applying the firmware update.

Table 6.

3.2 Data storage and sync functionality

HR and activity based data is continuously tracked when worn and stored to a flash memory for later upload. Exact parameters of the collected data (such as selected data, HR interval etc.) are set via API from the application. The device data storage can fit data from over 2 weeks. The data synchronization can be initiated automatically by the app/service without the need for user interaction on the device side.

3.3 Real time data streaming

HR profile is used to stream real-time data (HR and HRV) from the device. All the stored data from the device memory is transferred though Object Transfer Service. The real-time data is also available thought the Heart Rate Data Characteristic and Activity Data Characteristic inside the PulseOn proprietary Device Control Service.

3.4 Bluetooth interface for apps/services

PulseOn device implements several Bluetooth GATT services to enable communication between the device and customer's service. The BLE API is described in section 3.6.

The API includes services for the following:

- Controlling of the usage mode and mode related settings
- Setting user information (age, height, weight, gender, activity class) to the device
- Setting time for the device
- Transferring data from device to service from the device memory
- Getting general device information, including device name, firmware version and battery level
- Updating device firmware

3.5 Android device API library and example application

PulseOn provides a device API library and an example application that uses the library for Android platform. They both are delivered as one Gradle project that can be imported to e.g. Android Studio for customers to use in their development. The project includes the documentation is a Javadoc format.

The device library Includes services for communicating with the device over the BLE API and storing the received data into a native database.

3.6 Device communication

3.6.1 Overview

PulseOn supports seven Bluetooth LE services. Five of these, Heart Rate Measurement-, Device Information-, Battery-, Current Time-, and the Object Transfer Service are GATT-services adopted by the Bluetooth consortium. The sixth is the Device Firmware Update Service provided by Nordic Semiconductor. The seventh is a PulseOn proprietary Device Control Service designed for the functionality of our library.

3.6.2 Heart Rate Measurement Service

The Heart Rate Measurement Service is described on the bluetooth.org website. PulseOn supports the optional RR-interval value but not Energy Expended.

3.6.3 Device Information Service

The Device Information Service is described on the bluetooth.org website.

3.6.4 Battery Service

The Battery Service is described on the bluetooth.org website.

3.6.5 Current Time Service

The Current Time Service is described on the bluetooth.org website.

3.6.6 Object Transfer Service

The Object Transfer Service is described on the bluetooth.org website. Note: Object Transfer Service is not standard in first releases as it doesn't support the L2CAP Connection Oriented Channel for data streaming but uses one custom GATT characteristic to stream the data as notifications instead. L2CAP is planned for implementation later.

The sent data is encoded and requires PulseOn device API library to decode.

3.6.7 Device Firmware Update Service

The Device Firmware Update Service is provided by Nordic Semiconductor and documented on the website.

3.6.8 PulseOn proprietary Device Control Service

3.6.8.1 Service characteristics

The Device Control Service Contains five characteristics as shown in Table 7.

Characteristic	Description	Properties
Operational Parameters	Defines the basic configuration of the library, including whether to measure heart rate continuously or periodically	Read, Write, and Notify
Operational Settings	Some static properties of the library, for example whether distance estimation is enabled.	Read Only
User- and Device Data	User data, such as age and gender, and device data, such as time and date	Read and Write
Activity Data	Activity data, such as activity type (walking, running...)	Read and Notify
Heart Rate Data	Data related to heart rate, such as heart rate in beats-per-minute (BPM) and heart rate quality (a confidence estimate)	Read and Notify

Table 7. The characteristics in the Device Control Service

The maximum payload a characteristic holds is 20 bytes. Each characteristic contain fields grouped according to the type of its contents. All characteristics have Read access. The client can write to Operational Parameters and User- and Device data. The notify property applies to Operational Parameters and Activity- and HR Data. The Operational Settings are Read Only, and their values are static and never changes.

3.6.8.2 Operational Parameters Characteristic

The Operational Parameters Characteristic holds 11 fields as shown in Table 8.

Field	Description	Values	Data type
Operating Mode Changed	Status flag that indicates whether the operating mode has changed	Yes or No	1 bit
Operating Mode	The active operating mode	Powerdown, Hw_Testing, Activity, Proximity_only, Sampled_Hr, Continuous_Hr, Firmware_update	3 bits
Analysis Set	The active analysis sets	None, HR, Activity, Sleeping, HRV	Uint8 (mask)
Raw Data	The active types of raw data being transmitted	None, Acc_only, Acc_Ppg, Algo, Afe, Prox	Uint8 (mask)
Activity Data Interval	The interval between activity data updates	Milliseconds	Uint16
HR Data Interval	The interval between heart rate data updates	Milliseconds	Uint16
HR Sampling Interval	The interval between the start of consecutive heart rate measurements in sampled mode	Seconds	Uint16
HR Sampling Duration	If not zero makes the heart rate measurement run for the duration specified	Seconds	Uint16
HR Max Seeking Duration	The maximum duration of a heart rate measurement in sampled mode	Milliseconds	Uint16
Workout Detection	Flag used to enable and disable the automatic workout detection	On or Off	1 bit
Reset Accumulated Data	Flag that when set causes the library to reset accumulated values to zero	On or Off	1 bit

Table 8. The fields in the Operational Parameters Characteristic

The client must never modify the Operating Mode Changed status flag. It can write to all other fields.

3.6.8.3 Operating Mode Changed

The Operating Mode Changed status flag can be set by the server either when the client requests the change or when the device changes the operating mode without interaction with the client. The latter happens for example when a workout is started manually by the user pressing a button or automatically by the device after a few minutes of vigorous physical activity is detected. The Operating Mode Changed status flag is the only field in the Operational Parameters Characteristic that can cause a Notify message. The flag must never be modified by the client.

3.6.8.4 Operating Mode

The Operating Mode determines how the device works at the most fundamental level. There are seven operating modes.

- **Powerdown**. No sensors are active and no processing takes place.
- **Hw_Testing**. A special mode that runs tests on the sensor hardware.
- **Activity**. Processes accelerometer data and calculates the results contained in the Activity Data Characteristic
- **Proximity_only**. Calculates the worn state only. Other sensors and processing are switched off. Intended for use when the user is not wearing the device.
- **Sampled_Hr**. Measures heart rate a regular intervals, typically of the order of every 5 minutes. Activity Data is calculated continuously.
- **Continuous_Hr**. Measures heart rate continuously. Intended for use when the user is exercising vigorously. Activity Data is calculated continuously.
- **Firmware_update**. A special mode that allows flashing of a new firmware image.

3.6.8.5 Analysis Set

The Analysis Set determines which results are calculated and which notifications are sent. There are six **Sleeping**. Sleep results are calculated if the Sleep Detection flag is set in the Operational Settings Characteristic

- **Hr**. Results are calculated, and notifications sent, for HR and HR Quality in the Heart Rate Data Characteristic
- **Hrv (heart rate variability)**. Results are calculated, and notifications sent, for IBI (interbeat intervals) and IBI Quality in the Heart Rate Data Characteristic

The results reported depend on both the analysis set and the operating mode. For example, if the operating mode is Activity then no heart rate statistics is available regardless of the active analysis sets because heart rate is not measured in the Activity mode.

3.6.8.6 Raw Data

The Raw Data determines which types of sensor data are sent. Several types of raw data can be collected at the same time. However, since the raw data is collected at a high sample rate, and most data types take up quite a lot of space per sample, care must be taken to ensure the overall size of each packet is no more than 20 bytes. There are three types of raw data samples.

- **None**. Disables raw data collection.
- **Acc_only**. Accelerometer samples in triples.
- **Acc_Ppg**. Accelerometer samples in triples and single optical samples

3.6.8.7 Activity- and HR Data Interval

The Activity Data Interval and the HR Data Interval specify the time between consecutive notifications sent for the Activity Data Characteristic and Heart Rate Characteristic respectively.

3.6.8.8 HR Sampling Interval, HR Sampling Duration and HR Max Seeking Duration

HR Sampling Interval, HR Sampling Duration, and HR Max Seeking Duration are used in Operating Mode Sampled Hr. If for example we want to measure the user's heart rate every five minutes then HR Sampling Interval is 300. HR Max Seeking Duration is the maximum time the optical heart rate measurement is allowed to take. If a valid heart rate has not been found after the HR Max Seeking Duration, the measurement is stopped. If a valid heart rate is found before then the measurement is stopped

immediately. If HR Sampling Duration is set to a non-zero value the measurement is kept on for the specified regardless of whether a valid heart rate is found or not.

3.6.8.9 Workout Detection

The Workout Detection flag can be enabled or disabled by the client. When it is disabled, the Workout State in the Activity Data Characteristic never changes.

3.6.8.10 Reset Accumulated Data

When the Reset Accumulated Data flag is set by the client, the Steps, Distance, and kCalories in the Activity Data Characteristic are set to zero, and the Reset Accumulated Data flag is cleared.

3.6.9 Operational Settings Characteristic

The Operational Settings Characteristic holds 5 fields as shown in Table 9.

Fields	Description	Values	Data type
Sleep Detection	Flag that indicates whether sleep detection is enabled	On or Off	1 bit
Speed Detection	Flag that indicates whether speed is calculated	On or Off	1 bit
Distance Detection	Flag that indicates whether distance is calculated	On or Off	1 bit

Table 9. The fields in the Operational Settings Characteristic

The Operational Settings are static properties of the library. In the version we deliver all the flags are zero. That means that the fields Sleep Data Present, Speed Data Present, Distance Data Present, Speed, and Distance in the Activity Data Characteristic are all zero. Furthermore, the Activity Type can never have the values Sleeping_undetermined, Sleeping_light, Sleeping_deep. Any type of Sleep is instead classified as Rest.

3.6.10 User- and Device Data Characteristic

The User- and Device Data Characteristic holds 6 fields as shown in Table 10.

Fields	Description	Values	Data type
Age	User age in years	1-115	Uint8
Weight	User weight in kg	30-200	Uint8
Height	User height in millimeters	1200-3000	Uint16
Gender	User gender	Male or Female	1 bit
Time and Date	Time since January 1st 1970	Seconds	Uint32
Turn Off Screen During Workout	Indicates whether the screen should be on all the time when a workout is active	Yes or No	1 bit

Table 10. The fields in the User- and Device Data Characteristic

3.6.10.1 Age, Weight, Height, and Gender

The client must set the user data to values in the ranges given in Table 5, otherwise they won't be updated internally in the library. If the values are not set, the following default values are used: Age 30, Weight 78, Height 1754, Gender Male.

3.6.10.2 Time and Screen

The current time is set using the BLE GATT Current Time Service.

3.6.11 Activity Data Characteristic

The Activity Data Characteristic holds 15 fields as shown in Table 11.

Fields	Description	Values	Data type
Sleep Data Present	Flag to indicate whether sleep data is calculated	Yes or No	1 bit
Speed Data Present	Flag to indicate whether speed data is calculated	Yes or No	1 bit
Distance Data Present	Flag to indicate whether distance data is calculated	Yes or No	1 bit
Workout Status Changed	Flag to indicate whether the workout status has changed	Yes or No	1 bit
Worn Status Changed	Flag to indicate whether the worn status has changed	Yes or No	1 bit
Activity data changed	Flag to indicate whether the activity data	Yes or No	1 bit
Rolling Counter	Counter that is incremented by one every time the characteristic is updated	Integer	Uint32
kCalories	Energy Expenditure in kCalories since last reset of accumulated data	Energy Expenditure in kCalories	Uint24
Speed	Instantaneous speed in hundreds of meters per hour	Integer	Uint16
Steps	Number of steps since last reset of accumulated data	Integer	Uint24
Distance	Distance in meters since last reset of accumulated data	Integer	Uint24
Activity Type	The physical activity type	Rest, Other, Walking, Running, Biking, Other_rythmic	4 bits
Workout State	Indicates whether the user is in a workout or not	Yes or No	1 bit
Worn State	Indicates whether the user is wearing the device or not	Yes or No	1 bit

Table 11. The fields in the Activity Data Characteristic

3.6.11.1 Speed-, Distance-, Data Present

The four flags indicate which of the four types of data the Activity Data Characteristic provides results for. Their values depend on the active analysis sets in the Operational Parameters Characteristic and the values in the Operational Settings Characteristic. In the library made for Maxim the four flags are all zero.

3.6.11.2 Workout- and Worn Status Changed

The Workout Status Changed flag is set when a workout is started or stopped. The automatic workout detection requires five minutes of vigorous exercise to detect the start of a workout and three minutes of less strenuous physical activity to detect the end of a workout. For example, if the workout flag is set at ten minutes and cleared at 30 minutes then in reality the workout started at five minutes and ended at 27 minutes.

The Worn Status Changed flag indicates the user has just started wearing the device, or has just stopped wearing the device.

3.6.11.3 Activity Data Changed

The Activity Data Changed flag is set when one or more of the values of kCalories, Speed, Steps, Distance, and Activity Type has changed.

3.6.11.4 Rolling Counter

The Rolling Counter is incremented by one every time some data in the Activity Data Characteristic is updated.

3.6.11.5 kCalories, Speed, Steps, Distance, Activity Type

The five fields contains quantitative data about the user's physical activity. Speed and Activity Type are instantaneous values whereas kCalories, Steps, and Distance are accumulated values.

3.6.11.6 Worn- and Workout State

Worn State indicates whether the user is wearing the device or not and Workout State indicates whether the user is in a workout or not.

3.6.12 Heart Rate Data Characteristic

The Heart Rate Data Characteristic holds 15 fields as shown in Table 12.

Fields	Description	Values	Data type
Rolling Counter	Counter that is incremented by one every time the characteristic is updated	Integer	Uint32
HR Reliable	Flag set when a reliable heart rate is found	Yes or No	1 bit
HR at Timeout	Flag set when timeout in a sampled mode measurement is reached	Yes or No	1 bit
New IBI Data	Flag set if new IBI data is available	Yes or No	1 bit
HR	Heart rate in beats per minute	Integer	Uint8
HR Quality	Confidence estimate in percent	0-100	Uint8
IBI	Array of Interbeat Intervals in milliseconds	Integer	Uint16
IBI Quality	Array of confidence estimates in percent	0-100	Uint8

Table 12. The fields in the Heart Rate Characteristic

3.6.12.1 Rolling Counter

The Rolling Counter is incremented by one every time some data in the Heart Rate Data Characteristic is updated.

3.6.12.2 HR Reliable

The HR Reliable flag is set when a valid heart rate is found in the Operating Mode Sampled_Hr. The flag is cleared at the beginning of the next measurement

3.6.12.3 HR At Timeout

The HR At Timeout flag is set if a heart rate measurement in Operating Mode Sampled_Hr is stopped after HR Max Seeking Period as specified in the Operational Parameters Characteristics has expired.

3.6.12.4 New IBI Data

The New IBI Data flag is set when the IBI- and IBI Quality fields are updated. Note that these two fields are arrays with variable length.

3.6.12.5 HR and HR Quality

The HR and HR Quality fields contain the results of the latest heart rate measurement regardless of the Operating Mode and the time the measurement was made.

3.6.12.6 IBI and IBI Quality

The IBI and IBI Quality fields contain the results of the latest heart rate measurement regardless of the Operating Mode and the time the measurement was made.

3.7 Device usage times

Target usage time is 4-5 days in Sampled HR mode and 30 hours in Continuous HR mode.

3.8 OTA firmware update

OTA firmware update from the third party service or application is supported.

3.9 User interface

Reference design includes a device application logic / UI. The UI elements are based on:

- One button for device control
- Display
- Vibration motor

Details of UI can been found in a separate document (*Maxim reference design display UI.pptx*).

4 Mechanical design

4.1 Industrial design drivers

Main drivers for industrial design are:

- Aimed for continuous use and measures HR also during exercise
- Physical shape well suited for continuous HR measurement
- Size and shape suitable for both men and women
- Modern and good looking
- Easy and logical variant creation
- Changeable strap

A preliminary design is shown in the picture below, subject to slight modifications for final design.

4.2 Display information

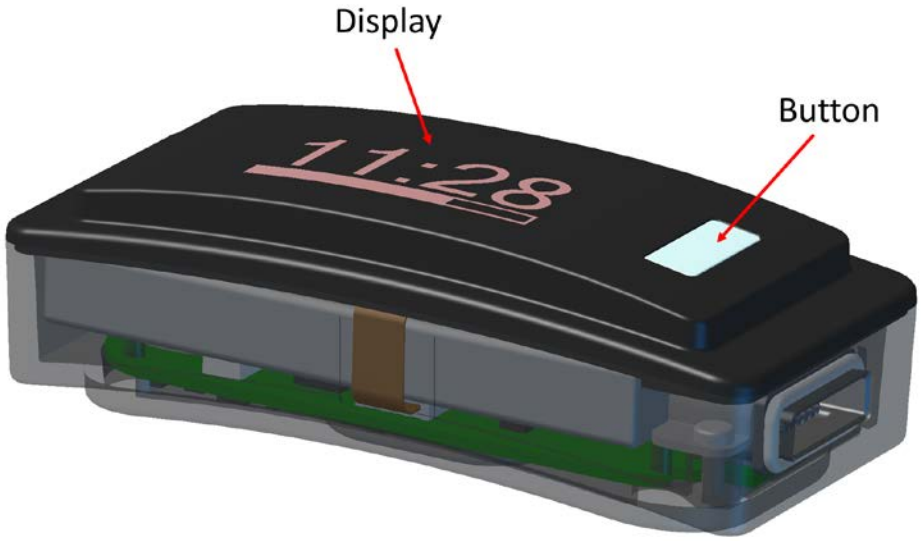
Reference design integrates a mono color OLED display that allows instant information to be seen from the device.

Display details	
Resolution	96 x 24 px
Pixel Pitch	0.188 x 0,191 mm
Active Area	18,024 x 4,560 mm
Glass Size	22,30 x 9,00 mm
Colour of Illumination	White
Gray Scale	2
Luminance	450 cd/m²
Drive Method	Passive Matrix
Mass	0,49 g

Table 13.

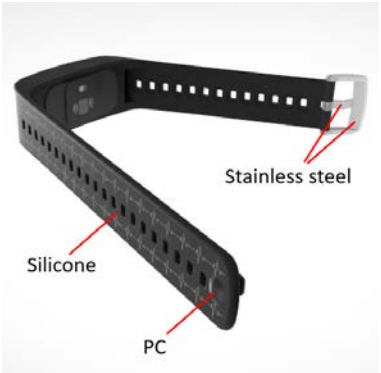
4.3 Physical UI

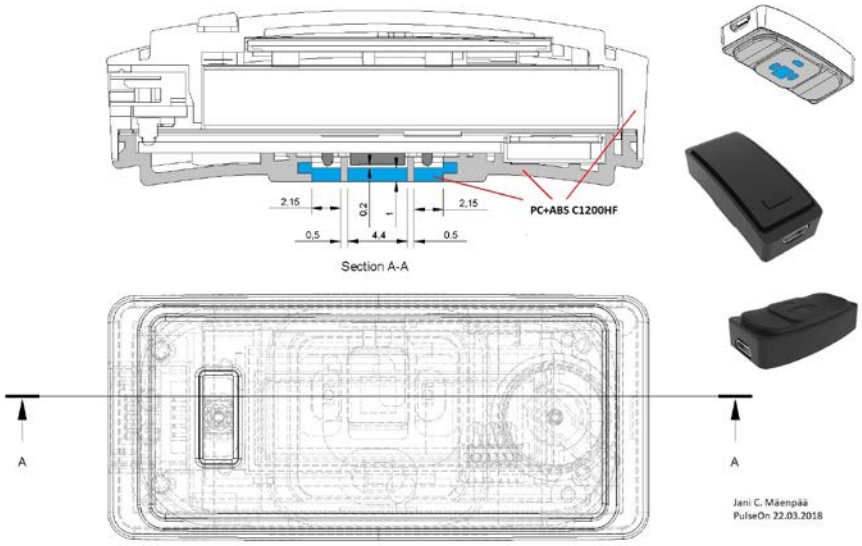
Device has two main components for the physical UI, the display and one button. In addition, the UI is enhanced with a vibration motor.



4.4 Structure and material

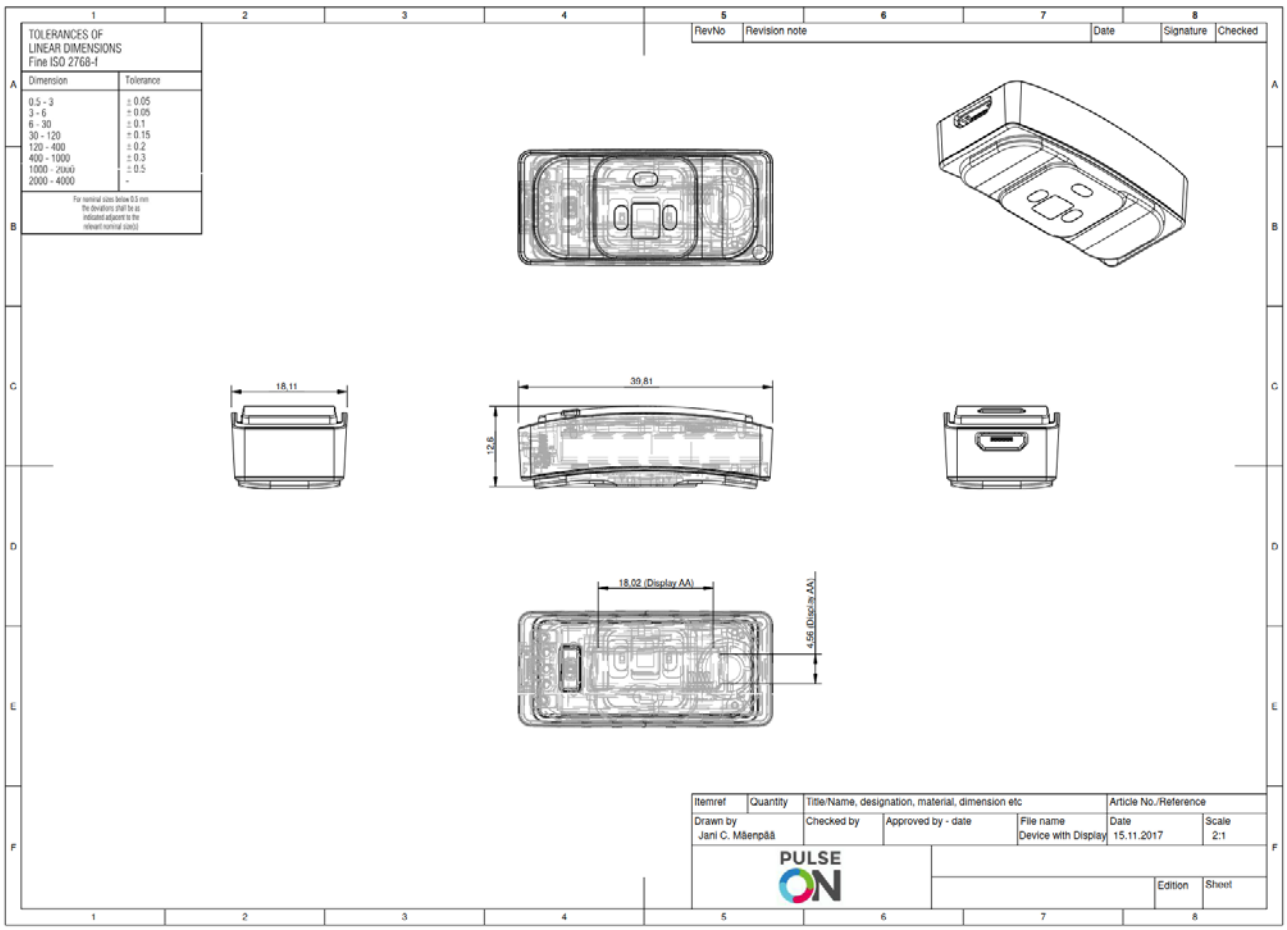
Structure and materials of the device are presented below. Strap material and its possible silicon treatment can be modified based on customer requirements. Lenses are clear PC+ABS.



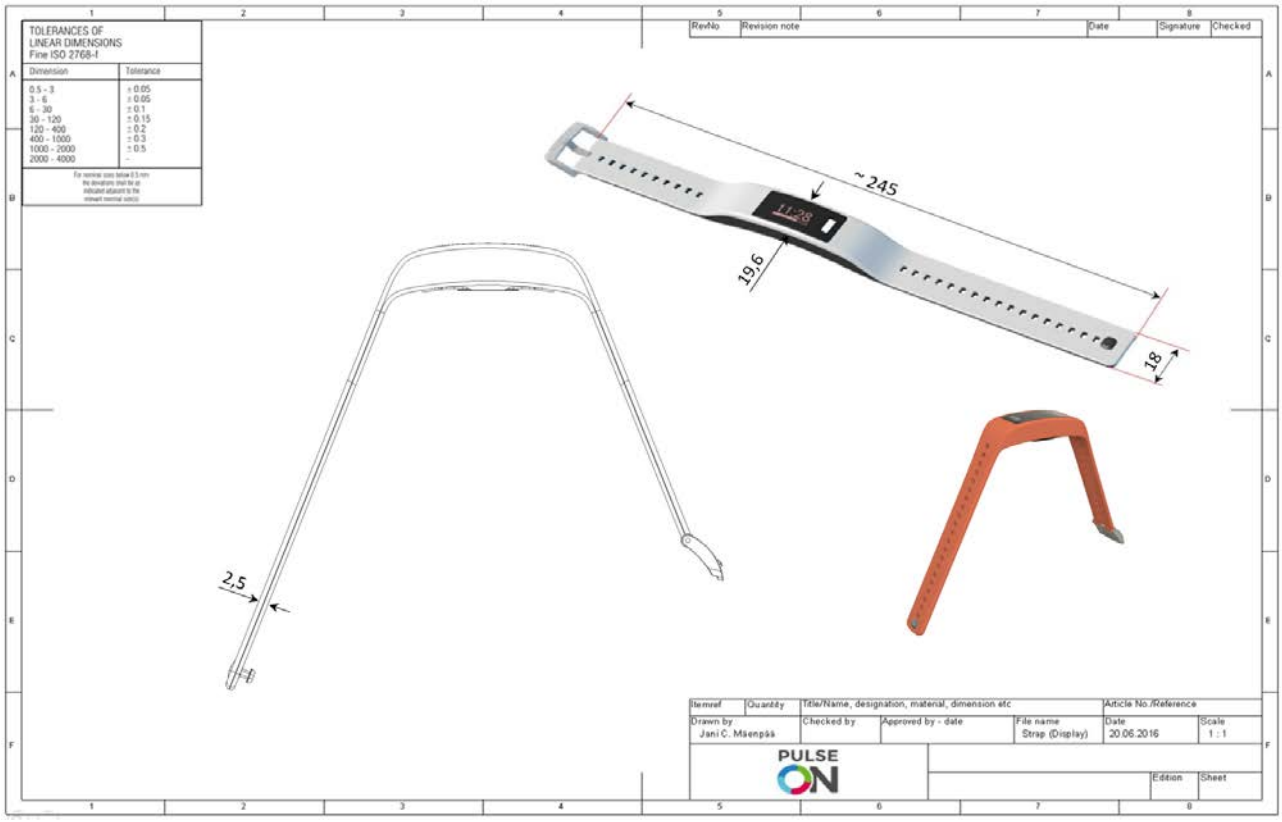


4.5 Physical dimensions

The size of the device module is shown on the picture below. The device is watertight (IP68 targeted, IP67 minimum).

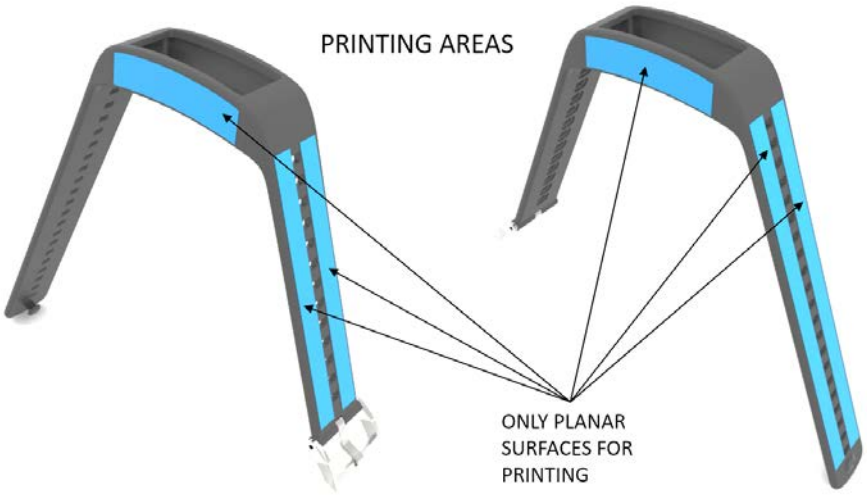


The product is designed to have three strap lengths. On the picture below are the dimensions for medium (M) size strap with total length of 245 mm (small 195 mm and large 275 mm). Dimensions can be modified based on customer needs.



4.6 Customer variant creation options

The easiest way to create variants for B2B customer is by changing the strap (shape, colors, buckle, logo).



Possible design variants:

- Strap design
- Strap materials
- Strap colors (2 colors maximum in one strap)
- Print logos on the strap
- Buckle (additional cost if not standard)

5 Electronics design.

5.1 Electronics design drivers

Main drivers for electronics are:

- Low power consumption
- High performance
- Easy to use – single button UI with simple low cost display
- CM4 core
- Small size

5.2 Open source components

- FreeRTOS

http://www.freertos.org/index.html

License: modified GNU General Public License

- micro-eec

https://github.com/kmackay/micro-ecc

License: BSD 2-clause

- Nordic SDK

https://www.nordicsemi.com/eng/Products/Bluetooth-low-energy/nRF5-SDK

License:
Multiple http://developer.nordicsemi.com/nRF5_SDK/nRF5_SDK_v12.x.x/doc/12.3.0/licenses.html

- BluetoothLeGatt

https://github.com/googlesamples/android-BluetoothLeGatt

License: Apache License Version 2.0

- Android Open Source Project

http://www.apache.org/licenses/LICENSE-2.0

License: Apache License Version 2.0