OB1203SD-BT-EVK

Integrated Context Engine for Heart Rate and Blood Oxygen Saturation measurement with BLE

The Integrated Context Engine (ICE) for Biosensing (see Figure 2) includes:

- Renesas OB1203 reflective photoplethysmography (PPG), proximity (PS) and light / color (LS/CS) [1] sensor
- Telink's TLSR8258F512 micro controller with Bluetooth Low Energy (BLE) radio
- LiPo's LP201030 rechargeable Li ion battery, 3.7 V, 40mAh, 10 × 30 × 2 mm^3.

[1] Light and color sensing function not used in this application.

The ICE hardware performs reflective, non-invasive measurements (e.g., at the fingertip), transmits the data via BLE to a smartphone or tablet (see Figure 1), where the Heart Rate (HR) and blood oxygen saturation (SpO_2) are determined by an Android app. During this process the proximity sensor function keeps the measurement running as long as there is a finger present.

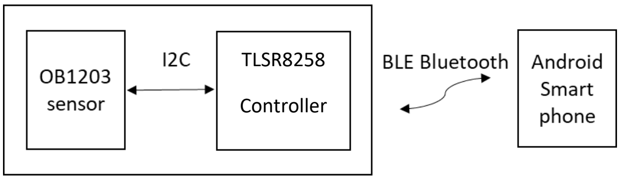

Figure 1. Block Diagram of ICE

OB1203 Sensor Features

- Highly reliable and industry-proven OSIP package with integrated cover glass for hypoallergenic products
- Integrated and factory trimmed LED source, driver, and photodetector
- PPG (Heart Rate and Blood Oxygen Concentration):
  - Aesthetic industrial design options with unique far-red LED allowing SpO_2 measurements behind visibly dark, IR-transmissive ink.
  - 16 to 18 bits output resolution
  - High speed sampling up to 3200 samples per second for highest resolution and improved SNR
  - On-chip averaging and FIFO data storage enable convenient asynchronous access to data
- Proximity Sensor:
  - Up to 16 bits resolution
  - Ambient light suppression
  - Analog and digital crosstalk cancelation
- Wide operation temperature range: -40°C to +85°C
- Wide supply voltage range:
  - 1.7V to 3.6V for digital / analog
  - 3.3 V to 5.0 V for LEDs
- I^2C interface capable of 100kHz or 400kHz communication
- Programmable level-based interrupt functions
- Industry's smallest package: 4.2 × 2 × 1.2 mm^3 14-pin module

Radio Mode Features

- Telink TLSR8258F512
  - BT 4.2 BLE 2.4GHz radio
  - 32-bit MCU at 48MHz, 512 kB flash, 32kB SRAM
  - Wide supply voltage range: 1.9V to 3.6V
- Compact size: 32-pin, 5.0 × 5.0 × 0.75 mm package

ICE Characteristics

- PCB (see Figure 2):
  - Operation temperature range: -40°C to +85°C
  - PCB supply voltage range: 3.3 V to 6.5V
  - PCB: 40mm × 11mm (21mm with program pads) × 5mm with USB charge connector (3.1mm without)
  - Program pad PCB section removable
- Battery life:
  - 150 × 30s measurements
  - Typical PCB quiescence current: 0.5 µA at 4V
  - Battery capacity: 40mAh if charged up to 4.2V
  - Battery operation: 3.3V to 4.2V
  - Rechargeable via USB Micro cable
  - > 70% shelf: 1 year stored (-20°C to 30°C)
- Battery operating temperature range -20C° to + 60°C

Applications

- Mobile devices: Wearables, Fitness, and Accessories
- Industrial: Worker Safety, Driver Assist

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1. ICE Hardware

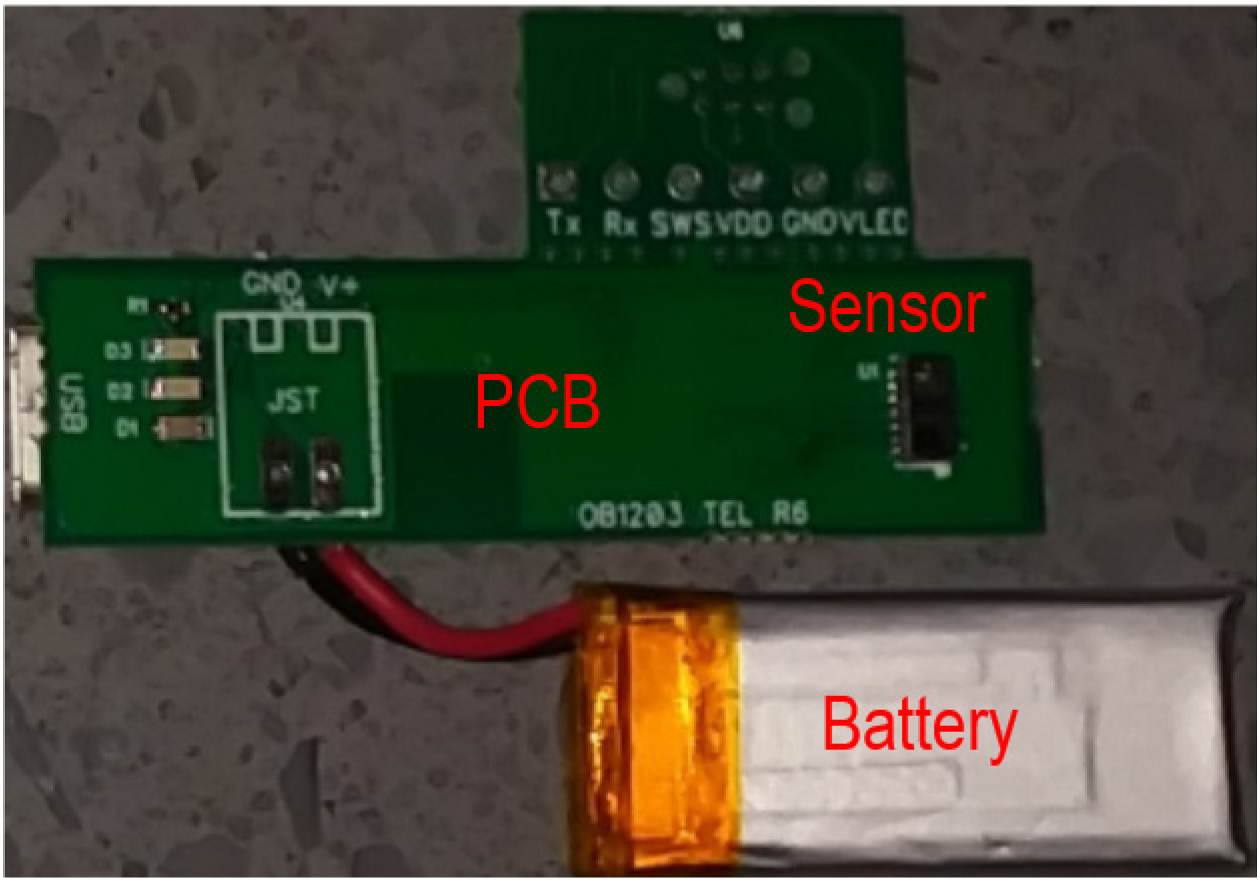


Figure 2. ICE Hardware

2. Sensor Function

Figure 3 shows the principal of a reflective measurement. In this case the sensor is located under a cover glass that uses black and IR transmissive ink to visibly hide the PCB / sensor module. Light from the sensor module's LED is reflected from the finger tissue and detected by the photo diode. As blood absorbs light, changes in blood volume (caused by the heart beat) generate a small change in the intensity of the reflected light.

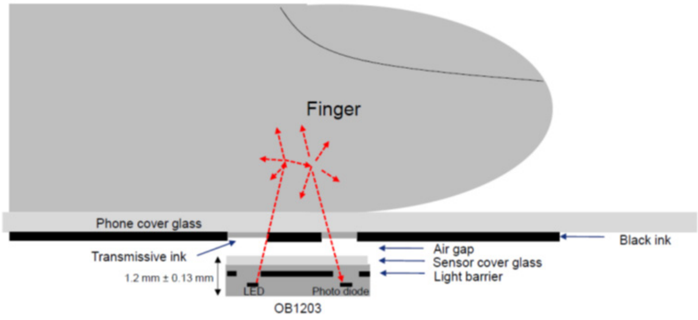


Figure 3. Reflective HR and SpO2 Measurement

Figure 4 shows this signal change of about 3,000 counts (peak to peak) on top of a DC signal of 190,000 counts due to direct reflections from the finger tissue.

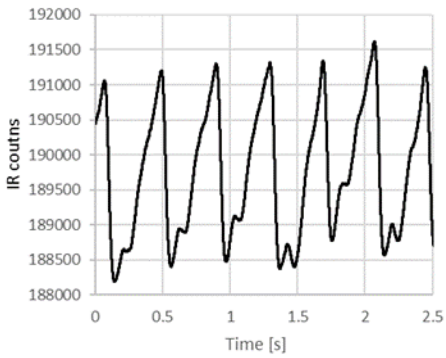


Figure 4. PPG Signal Measured at Finger Tip

The DC content of the signal as well as light reflections in the sensor set up (like reflections from the cover glass, etc.) are called optical crosstalk. For a high AC to DC ratio, a good AC signal and / or a small DC signal are key.

- In order to get a good blood flow / good AC signal, the finger pressure onto the sensor needs to be light.
- In order to keep the optical cross talk small, the distance from the sensor to the finger should be kept to a minimum.

For example, without using a cover glass the finger pressure can be kept low by using a finger rest (like the cover of the provided sensor house) to spread the finger – sensor force over a larger area.

To recycle some of the diffused light the best color for the finger rest is white. To avoid additional optical cross talk the finger rest should not be thicker than the package (see Figure 5).

Figure 5. Recommended Height of a Finger Rest

3. Getting Started

1. Install the Android app:
   a. Download the app from the USB stick or GitHub (https://github.com/hyperdga/Android_OB1203_serial_BLE)
   b. Click on the app to install.
   c. Go to Settings -> Apps -> IDT HR Sensor -> Permissions -> activate 'your location'.
   d. Turn on Bluetooth.
   e. Open app. Activate sensor board by pushing the activation switch (Figure 6). Keep finger off sensor to get a low data rate while pairing Android device with sensor. App asks for Bluetooth pairing. After pairing close app and reopen it.
   f. After sensor re-programming unpair and pair again.
   g. If Bluetooth does not connect, turn Bluetooth off / on and / or reboot Android device.
2. Open the app.
3. Put your finger on the heart rate sensor. Apply pressure until the activation switch on the bottom side of the PCB (see arrow in Figure 6) clicks. Keep pressure until counter starts counting.

   The pressure level sufficient to activate the switch is not required during measurement, as the sensor board stays active for about 30 seconds after the switch is released. Less pressure on the blood vessels produce better results.

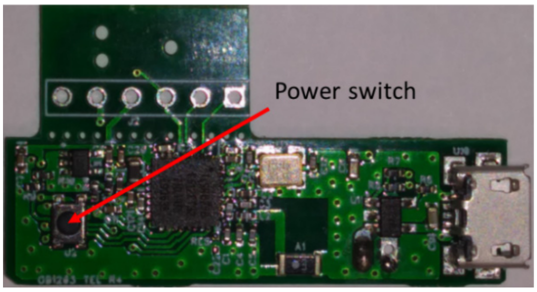


Figure 6. PCB Activation Switch

4. The proximity function of the sensor deactivates / reactivates the red LED and heart rate measurement if the finger is out of / back in range. This allows to relax or repositioning the finger without losing Bluetooth connection.
5. When activated, the sensor measures the reflected LED light signals and transmits them to the Android device which calculates and displays heart rate and SpO2.
6. A Finger Rest around the sensor (examples are shown in Figure 7) distributes the force between sensor and finger, improving the blood flow and accuracy of measurement.

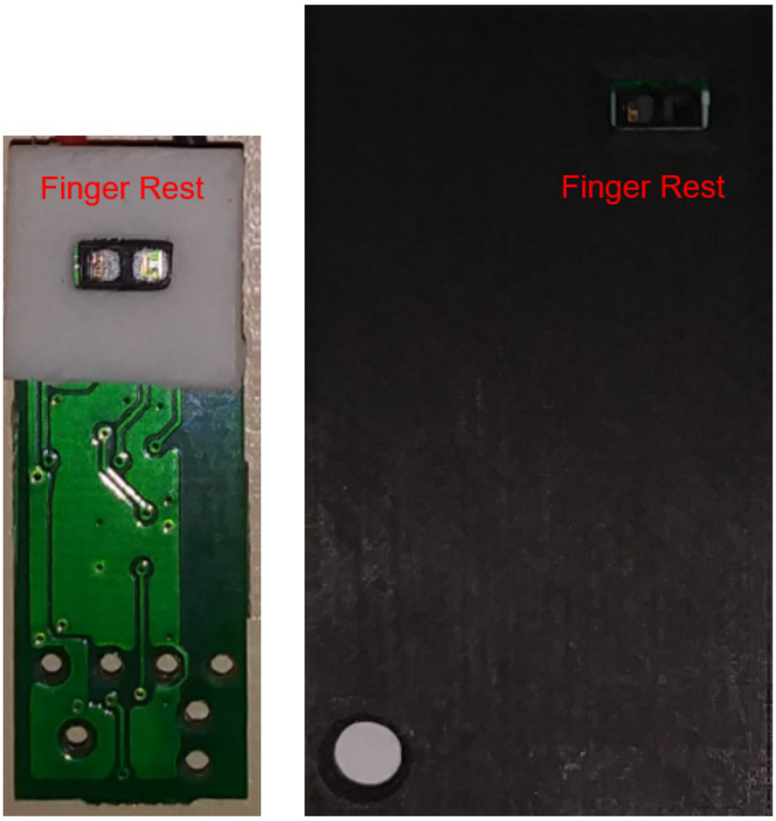


Figure 7. Finger Rest Examples

4. Resources

4.1 PCB Schematics

- The PCB contains the OB1203 and Telink devices as well as the following components:
  - Voltage stabilization and bypass capacitors for the OB1203
  - Voltage stabilization and bypass capacitors, antenna, and quartz for the Telink module
  - Pull-up resistors for the I^{2}C bus and the interrupt
  - A 3.3V voltage regulator
  - A normally open-power switch
  - A re-chargeable battery and a USB 5V to 4.2V Li Ion battery charger

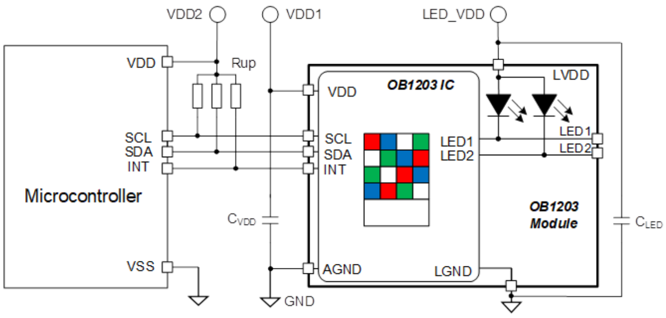


Figure 8. Components for the OB1203 Sensor

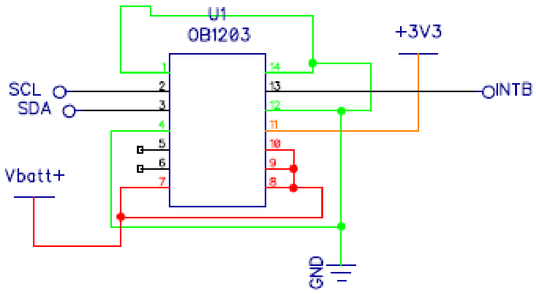


Figure 9. OB1203 Schematics

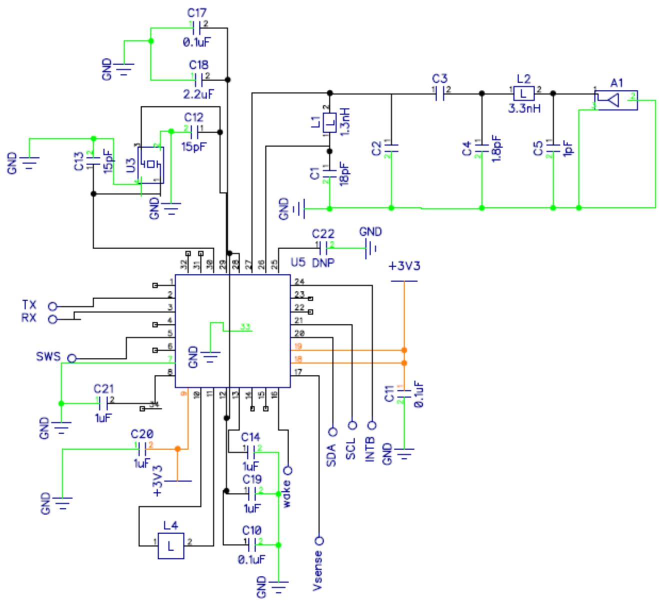


Figure 10. MCU Schematics

(Note: The battery voltage sense feature is supported by HW but not programmed yet in FW.)

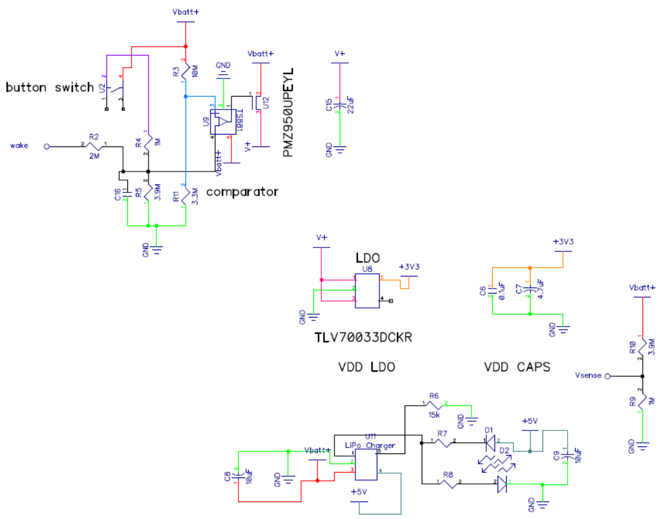


Figure 11. Power Schematics

(Note: When the switch U2 is pressed (upper left), the U12 becomes conductive and the MCU wakes up. The MCU keeps the wake line high for about 40 seconds leaving U12 conductive. When releasing the wake line, the system power is switched off.)

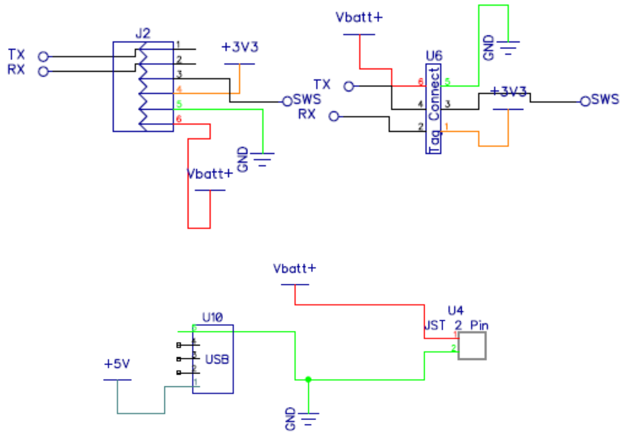


Figure 12. Connector Schematics

4.2 PCB Layout

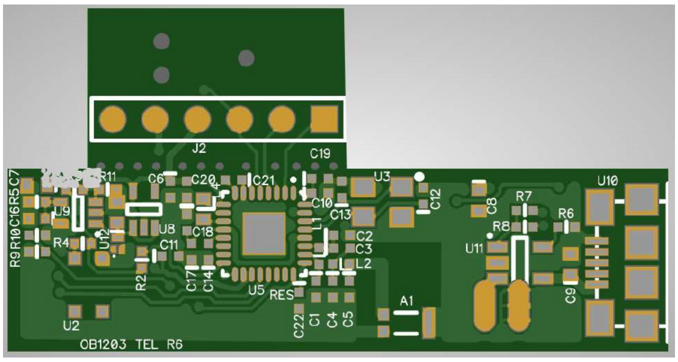


Figure 13. PCB Bottom with Telink Chip Left of the Middle

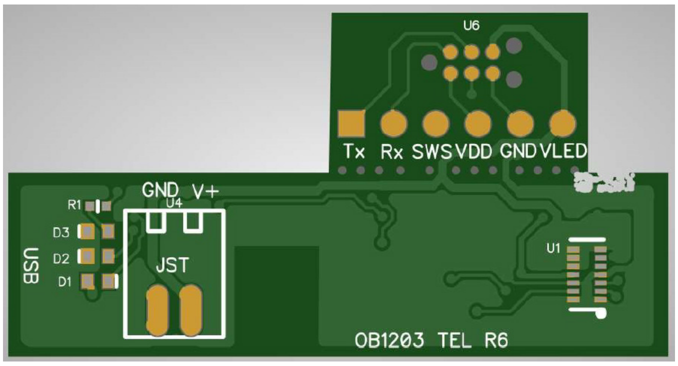


Figure 14. PCB Top with OB1203 at the Right

4.3 PCB Components

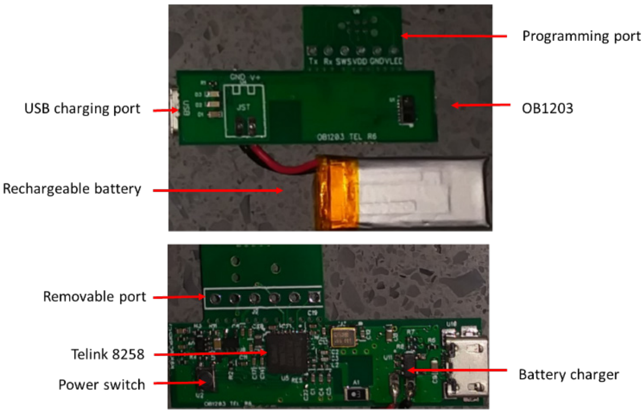


Figure 15. PCB Functions

4.4 Programming Pins

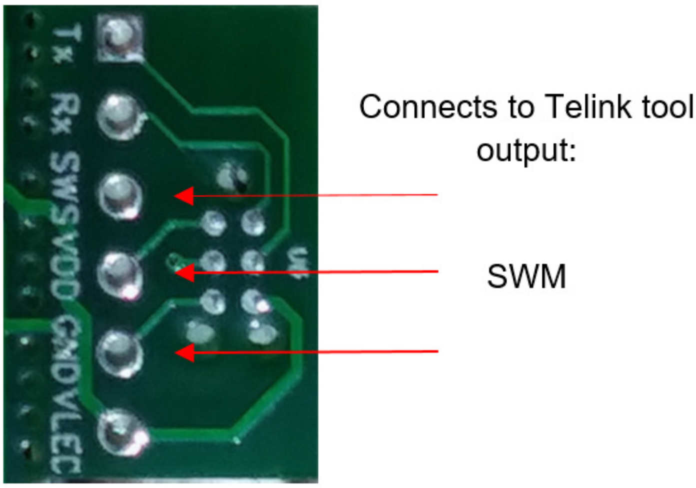


Figure 16. Functions of Programming Pins

(Note: Remove re-chargeable battery for programming)

4.5 Programming Tools

Hardware:

- Telink Programmer, available from Telink

Software:

- Telink-Semi IDE[b] for C coding and compiling
- Telink BDT[b] (Burn & Debug) for code (.bin file) uploading:
  a. Open the .bin file.
  b. Select 8258
  c. Connect the tool to ICE PCB.
  d. Click Erase.

e. Click Activate.
f. Click Download.
g. Click Start mcu.

[b] Available with user manual from https://www.telink-semi.com/.

4.6 Bill of Materials

RefDes	Value	Name	Manufacturer
A1	2.4GHz	ANT3216A063R2400A	Yageo
C1	18pF	CAP 0402 tight	
C2	1.2pF	CAP 0402 tight	
C3	220pF	CAP 0402 tight	
C4	1.8pF	CAP 0402 tight	
C5	1pF	CAP 0402 tight	
C6, C10, C11, C17	0.1uF	CAP 0402 tight	
C7	4.7uF	CAP_0603	
C8, C9	10uF	CAP_0603	
C12, C13	15pF	CAP 0402 tight	
C14, C19, C20, C21	1uF	CAP 0402 tight	
C15	22uF	CAP_0603	
C16	0.2uF	CAP 0402 tight	
C18	2.2uF	CAP 0402 tight	
C22	DNP	CAP 0402 tight	
D1	SML-D12U1WT86	LED Red 0603	Rohm
D2, D3	SML-E12M8WT86	Rohm LED Green 0603	Rohm
J2		HDR-1x6	
L1	1.3nH	0402 IND	
L2	3.3nH	0402 IND	
L4	10uH	IND_0603	
R1	200	RES 0402 tight	
R2	2M	RES 0402 tight	
R3	10M	RES 0402 tight	
R4, R9	1M	RES 0402 tight	
R5, R10	3.9M	RES 0402 tight	
R6	15k	RES 0402 tight	
R7, R8	100	RES 0402 tight	
R11	3.3M	RES 0402 tight	
U1		OB1203	
U2		PTS830GX140 switch	C&K
U3		ECS-240-12-33Q-JES-TR?	
U4		JST+pad 2 pin batt	
U5		TLSR8258F512ET32	Telink
U6		Tag_connect_6_ARM	
U8		TLV70033DCKR	
U9		TS881ICT	
U10		USB micro AMP 10118192-0002LF	
U11	500mA LiPo charger	MCP73831T-2ATI/OT	
U12		PMZ950UPEYL low leakage PMOS	Nexperia

Table 1. Bill of Materials

4.7 OB1203 Run Mode

- 1600 samples per second
- 16 times averaging on OB1203 before data gets stored in FIFO
- Automatic Gain control adjusting the LED currents to keep signal between 70 and 100 % of ADC count range

4.8 HR Algorithm

- Partial autocorrelation coarse / fine search method

4.9 SpO_2 Algorithm

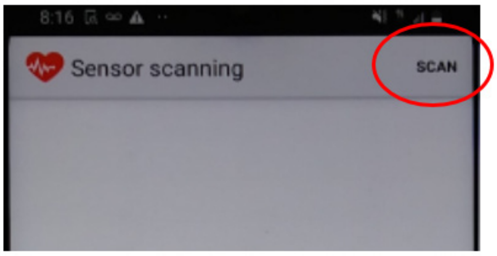
- Collect about 2.5s worth of data
- Measure and remove DC
- Remove slope
- Measure RMS
- R = (Red_rms/Red_dc) / (IR_rms/IR_dc)
- SpO_2 = f(R), where f is a polynomial fit to hypoxia
- Calibration data

4.10 Recharging the Battery

- Use a male micro USB to male USB A cable
- Charge time around 90min
- Do not operate the module and keep sensor face clear from objects during charging

4.11 Troubleshoot

Android app starts but shows no data.



1. Tip on the commands in upper window line:
    a. Restart Bluetooth device scan.
    b. Restart Bluetooth connection.
2. Check phone settings, network, Bluetooth, and pair with OB1203.
    a. Bluetooth pairing shows error message ‘Pairing rejected by OB_1203’. OB1203 was already Bluetooth connected.
    b. Un-pair Bluetooth and pair again. Reboot the phone.

5. Ordering Information

Orderable Part Number	Description
OB1203SD-BT-EVK	OB1203SD-BT Evaluation Board

6. Revision History

Revision	Date	Description
1.2	Feb.8.21	▪ Changed to PCB version R6. ▪ Updated the document to the latest template.
1.1	May.4.20	▪ Reformatted headers and footers within document. ▪ Redefined document title.
1.0	Jan.10.19	Initial release.

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