GENERAL DESCRIPTION

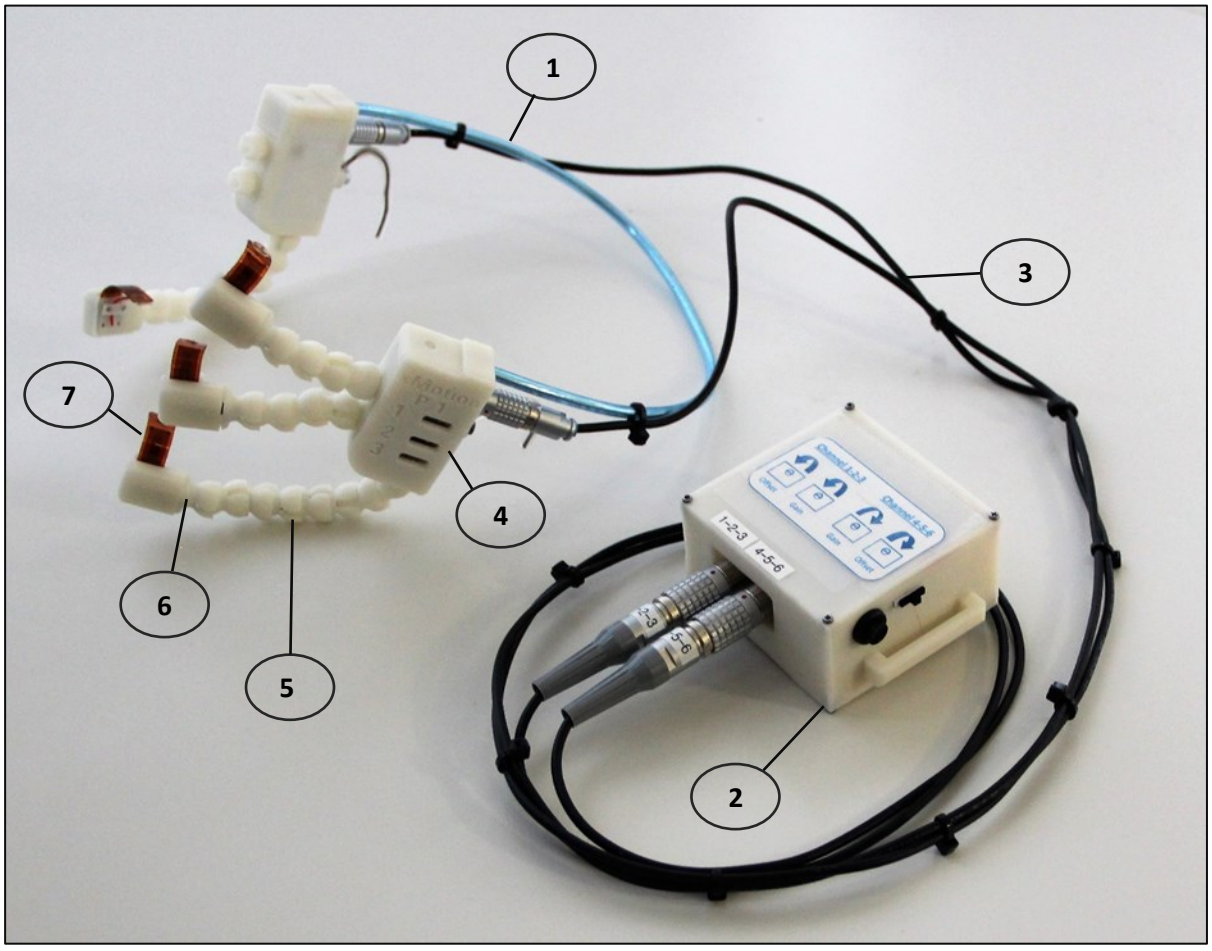
karaloop P1

karaloop – Prototype 1 (P1)

P1 measures voluntary movements of the face and translates them into mouse or keyboard commands sent via Bluetooth Low Energy (BLE) to wirelessly communicate with any PC, iOS or Android device.

P1 consists of a light headset which incorporates up-to six articulated legs (three legs per side) that can conform the contour of any face and capture voluntary movements from any muscle, and a control box housing an open-source Arduino-compatible Bluefruit nRF52 Feather board that is automatically recognized as a human-interface device (HID). **P1** transmits wirelessly preprogramed keyboard or mouse HID commands to any PC, iOS or Android device via BLE. The headset and the control box are connected via two cables relaying sensor signals from both sides of the face to the Bluefruit nR52 board.

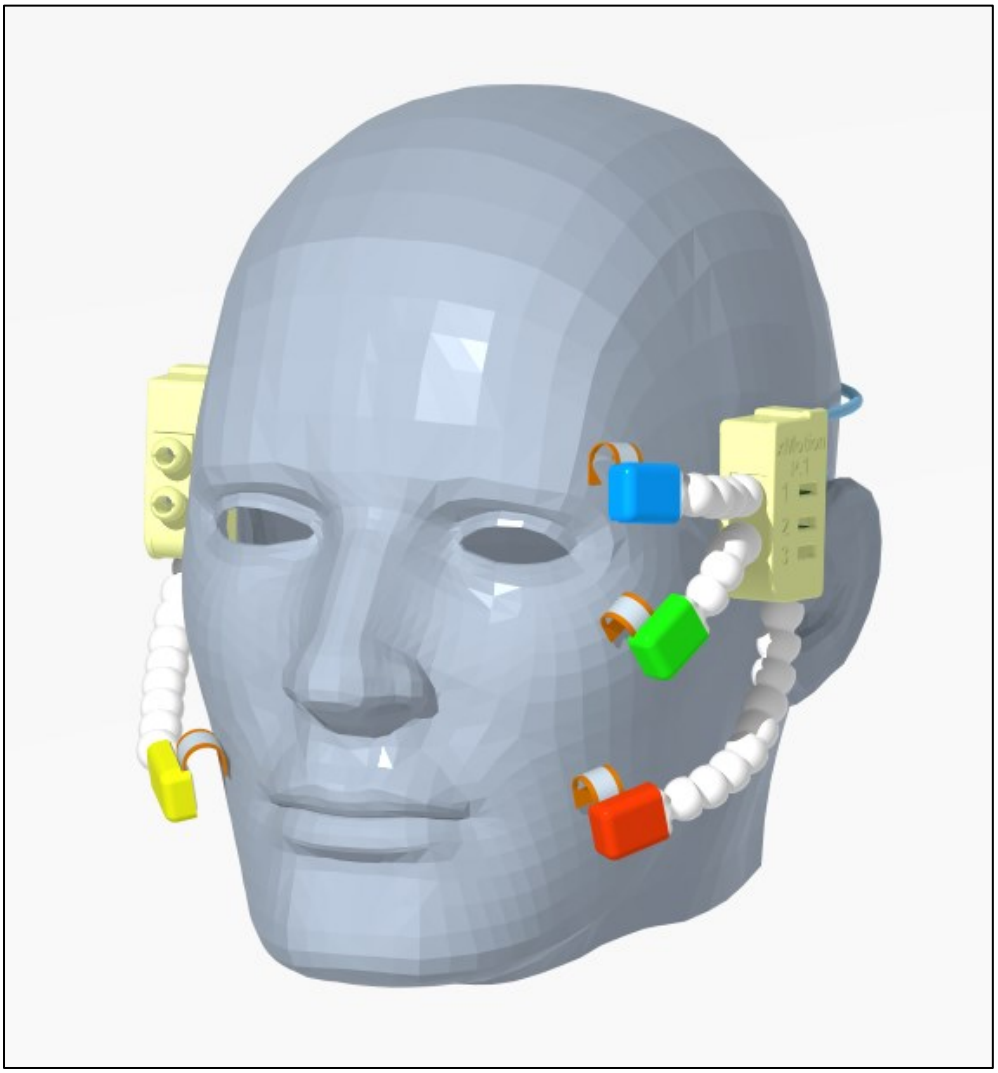
The articulated headset legs are made of 3D printed modular Lego-like pieces with ball joints allowing the required adjustments of length and direction to fit any face contour. The modular design further facilitates replacements if needed. At the end of each leg, a probe incorporates a flexible sensor that, when in contact with the face, captures voluntary movements. The signals from the probes are relayed to an electronic hub (one per side) which amplifies and conditions the signals before sending them to the controller box.



P1 components. (1) Headset**; (2)** Control box; **(3)** Cables connecting headset and control box (two, left and right); **(4)** Electronic hubs (two, left - right); **(5)** Legs (up-to six, three left - three right); **(6)** Probes (up-to six); **(7)** Flexible sensors (up-to six).

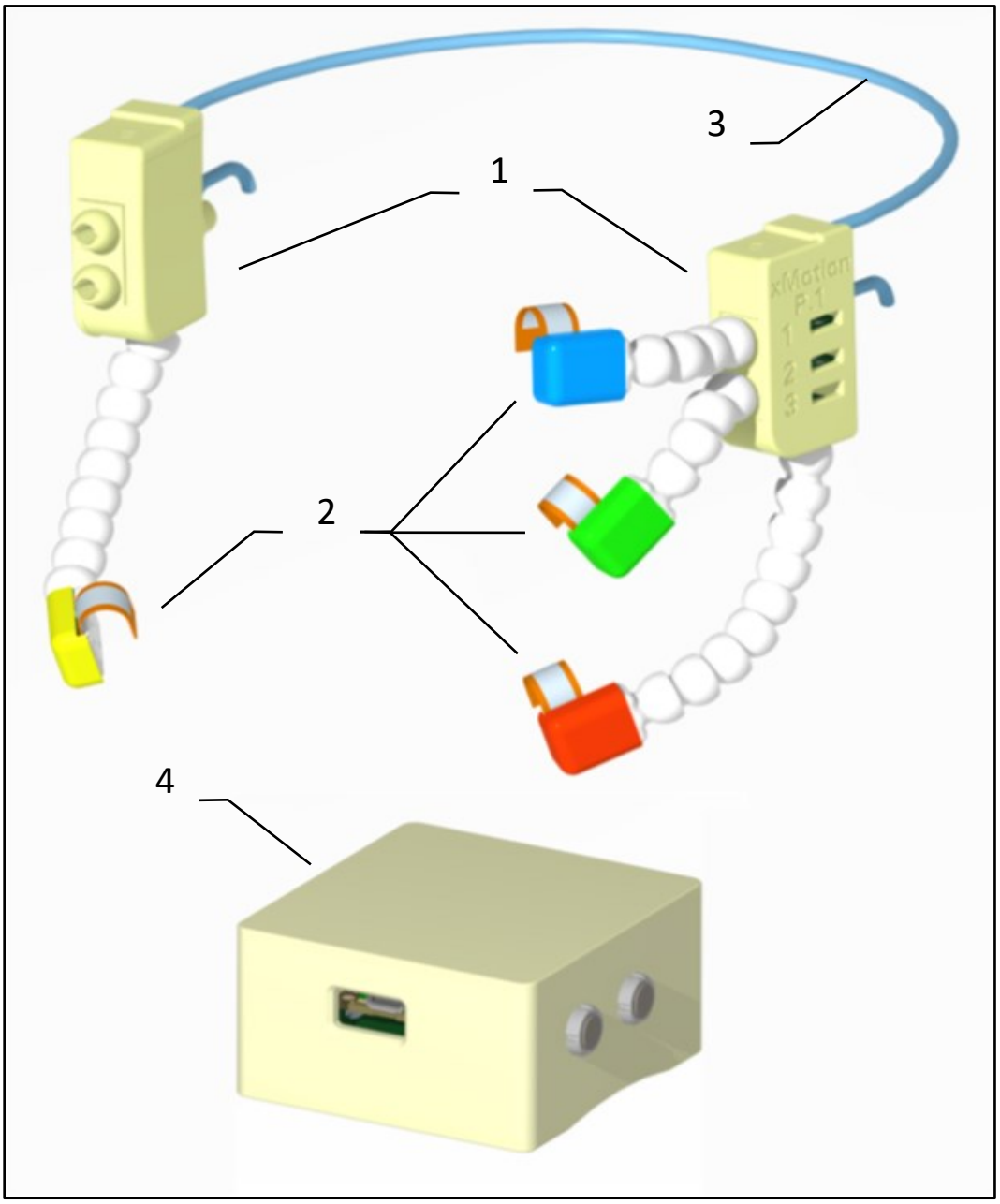
ASSEMBLY DESCRIPTION

karaloop P1



CONTENTS

General assembly

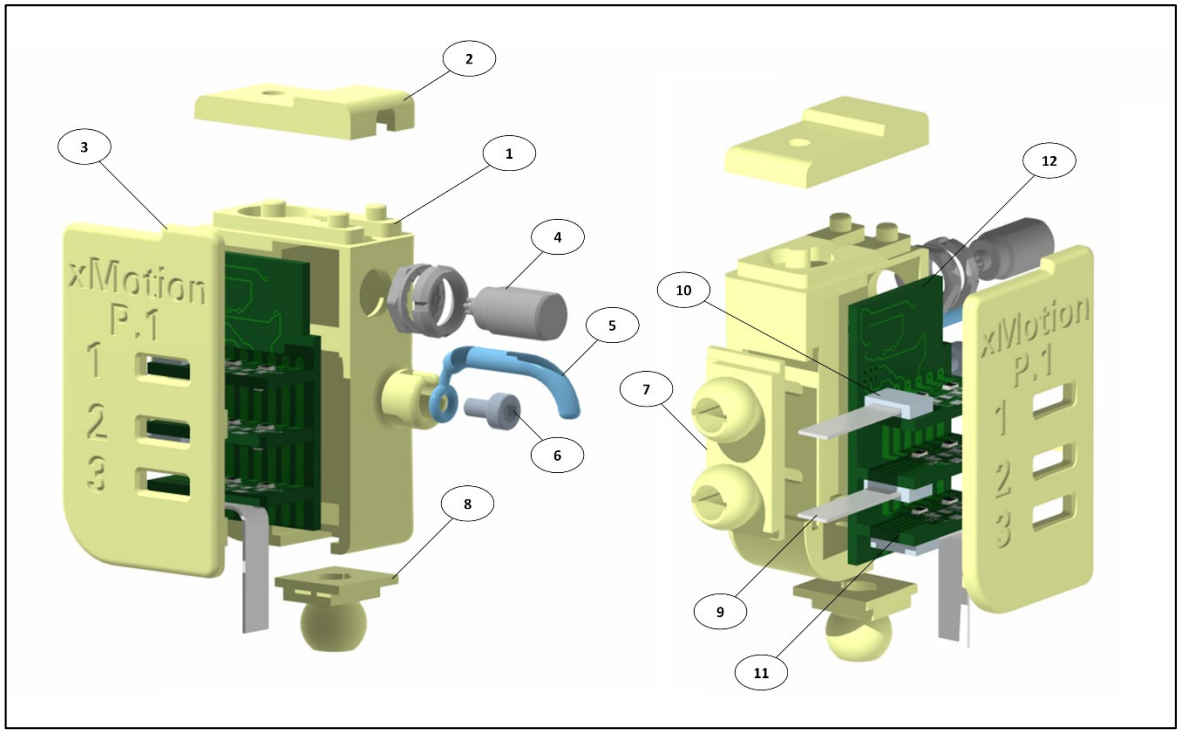


N°	Part description	Abbreviation	Quantity
1	Right/left hub sub-assembly	H	2
2	Sensor probes sub-assembly	SP	4
3	Headset band sub-assembly	HB	1
4	Control box sub-assembly	CB	1

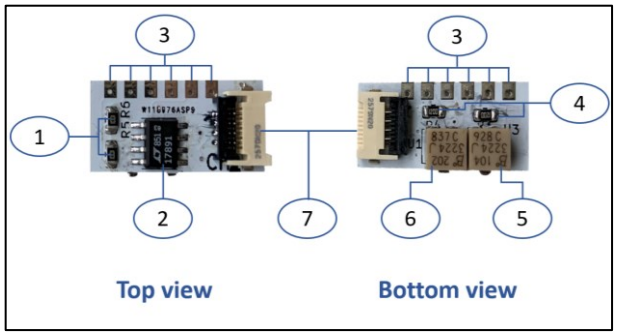
1. Right/left hub sub-assembly

The right/left hub receives the signals from each of the sensors, conditions them, and transmits them to the control box.

N°	Part description
1	Left hub box
2	Left hub support cover
3	Left hub box cover
4	Connector 5 pos. + nut and washer
5	Ear support
6	Allen screw M2.5x6 (1x)
7	Ball joint connector (male): channels 1 and 2
8	Ball joint connector (male): channel 3
9	Flat wire 4 contacts (3x)
10	Backlock connector (3x)
11	PCB channel 1, PCB channel 2, PCB channel 3
12	Perpendicular PCB

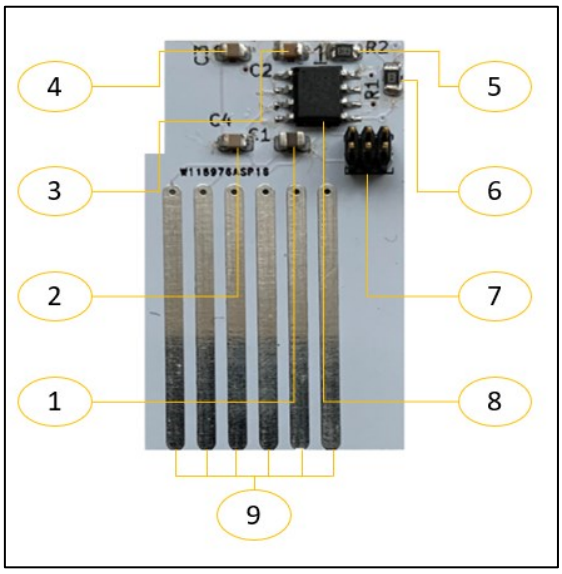


N° 11: PCB channels 1 – 3



N°	Part description
1	10kΩ resistors (2x)
2	Operational amplifier
3	Welding tracks
4	120Ω resistors (2x)
5	Trimmer 100 kΩ 250 mW
6	Trimmer 2 kΩ 250 mW
7	Backlock connector

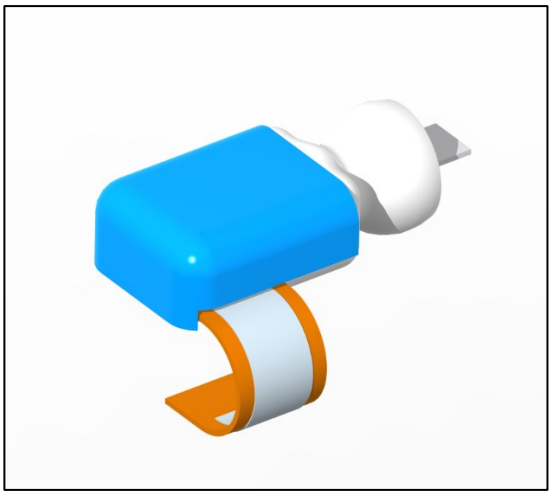
N° 12: Perpendicular PCB



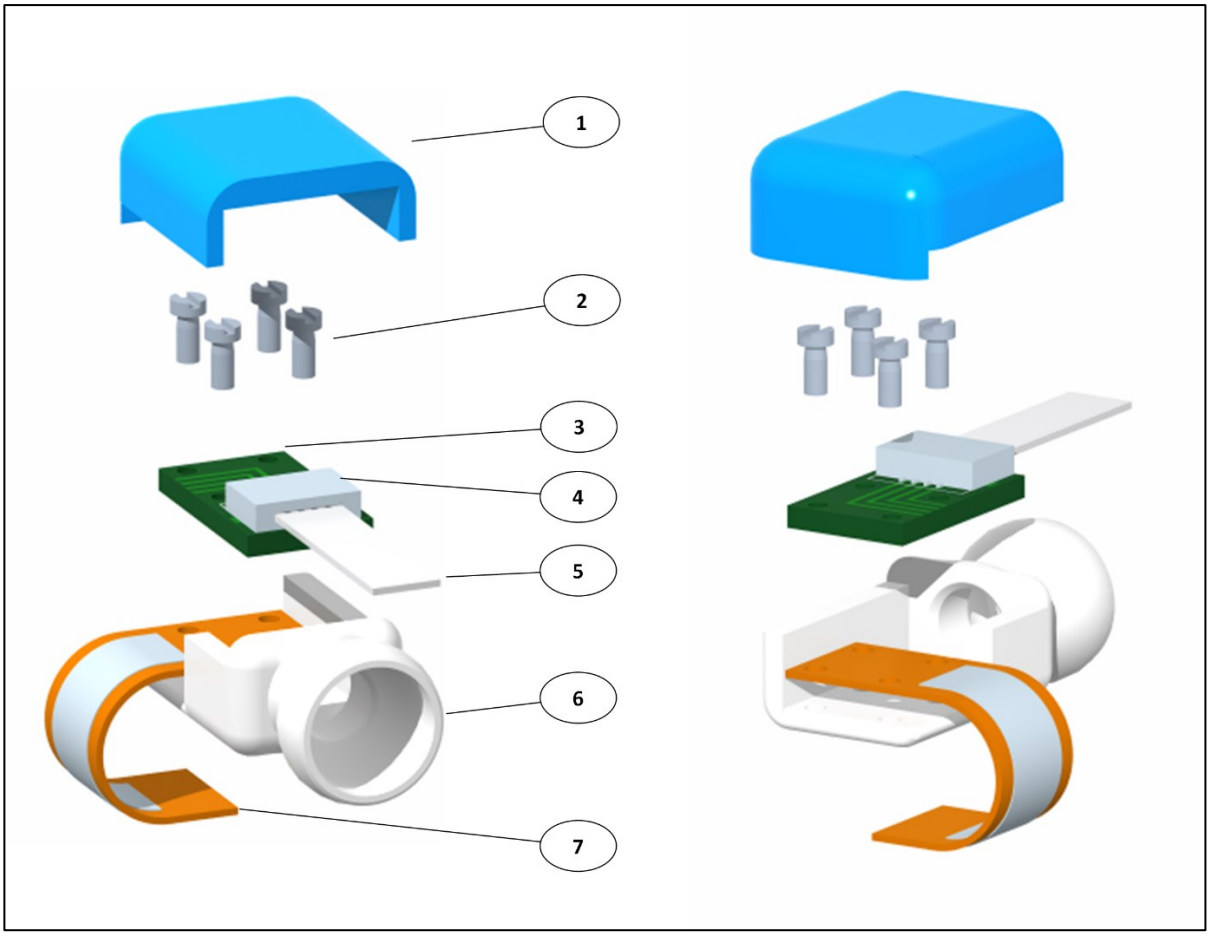
N°	Part description
1	4.7µF capacitor
2	0.15µF capacitor
3	10nF capacitor
4	0.15µF Capacitor
5	100kΩ resistor
6	1kΩ resistor
7	Headers 1.27x1.27mm
8	Linear voltage regulator 1-5.5 V SOIC-8
9	Welding tracks

2. Sensor probes sub-assembly

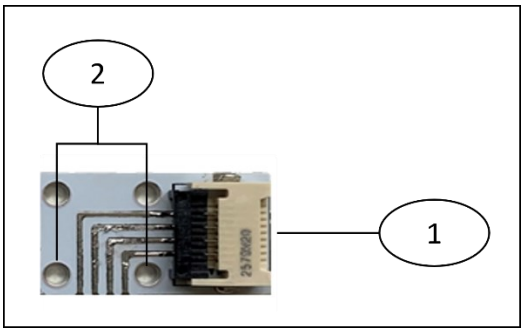
When in contact with the user's face, the sensor is designed to be sufficiently flexible to detect voluntary facial movements. The sensitive element is a flexible piece that bends during the voluntary contraction of one or more muscles of the face. Two strain gauges fixed onto a flexible substrate translate its mechanical deformations into electrical signals.



N°	Part description
1	Probe protective cover left
2	Fillister screw M1.6x6 (4x)
3	PCB probe connection
4	Backlock connector
5	Flat wire 4 contacts
6	Ball joints left (female)
7	Sensor (flexible substrate + 2 strains gauges)



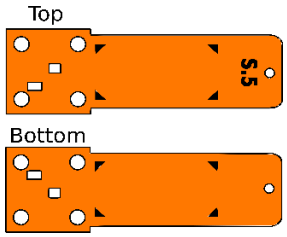
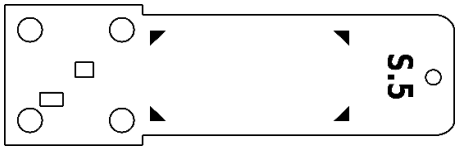
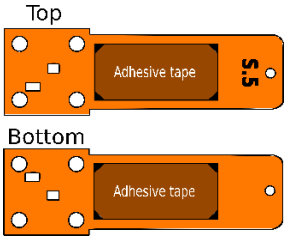
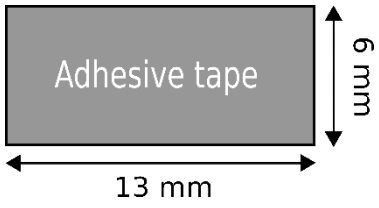
N° 3: Probe connection



N°	Part description
1	Backlock connector
2	Fillister screw M1.6x6 (4x)

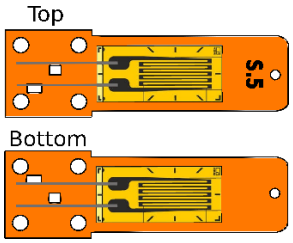
FABRICATION PROCESS

MATERIALS NEEDED can be found in Mechanical Part List (MPL, page 15), Printed Parts List (PPL, page 17) and Electronical part list (EPL, page 16)

Step	Description	Materials needed
1	**Cutting the substrate** Laser cutting the Kapton substrate design. 	○ Laser cutter machine ○ Kapton sheet of 125 µm thickness *(MPL N°10)* ○ Substrate's design *(MPL N°17)* 
2	**Cleaning-up the substrate** Sand the surface with at least a P400 micro-grain sandpaper from step 2.1. Clean both sides of the substrate with Isopropanol.	○ P400 sandpaper *(MPL N°12)* ○ Bottle of Isopropanol
3	**Placing the adhesive double-tape** Place the adhesive double-sided tape on each side of the substrate from step 2.2 in the designated rectangle below. 	○ Double tape Spandex of 50 µm thickness *(MPL N°13)* ○ Scalpel or fine cutter 

4 **Bonding of gauges**

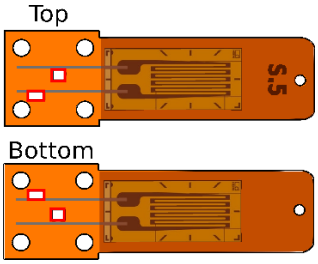
Attach the strain gauges on top of the two adhesive tapes from step 2.3 and put a weight on it, for at least 1 hour, until the adhesive has bonded well.



- 2 Strain gauges HBM of 120 Ω *(EPL N°16)*
- A tweezer to manipulate the strain gauges
- Weight of ≥ 5 Kg

5 **Electrical and mechanical protection**

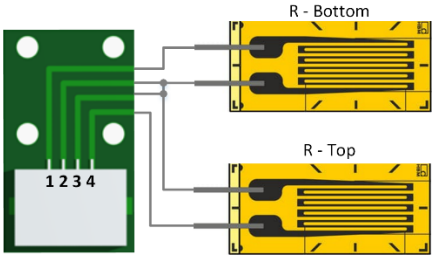
Recover each side of the substrate and strain gauges from step 2.4 with Kapton tape as shown below:

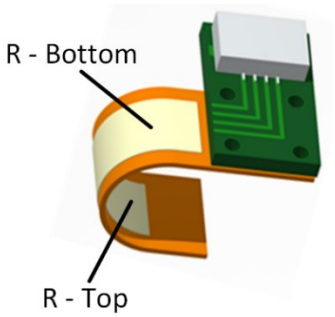


- Kapton tape of 25 µm thickness *(MPL N°11)*
- Scalpel or fine cutter

6 **Electrical wiring**

Place the substrate from step 2.5 on the bottom of the PCB probe connection. Route the strain gauges contacts through the substrate two little rectangular openings, which are highlighted in red in step 2.5. Then, solder the contacts as illustrated below:

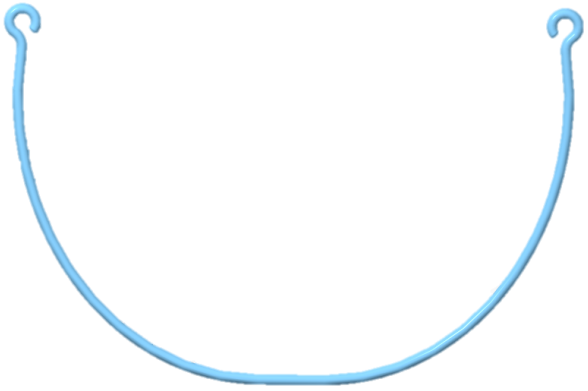




- PCB probe connection with the zero-force connector mounted *(Part N°2.3)*
- Soldering station with tin wire
- A tweezer to manipulate the strain gauges

3. Headband sub-assembly

The headband is made of steel wire of 2 mm diameter. The steel wire is shaped using pliers to adapt to the head contour. Then, the steel wire is inserted into a flexible silicone-based tubing to improve the comfort of the wearable headset.



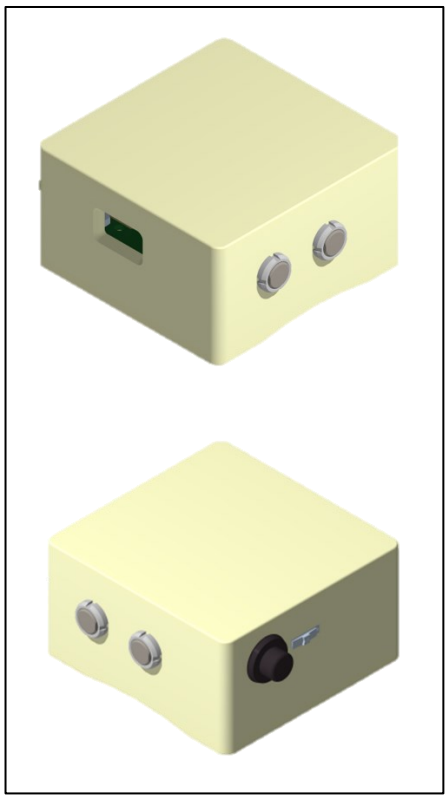
FABRICATION PROCESS

MATERIALS NEEDED can be found in Mechanical Part List (MPL, page 15), Printed Parts List (PPL, page 17) and Electronical part list (EPL, page 16)

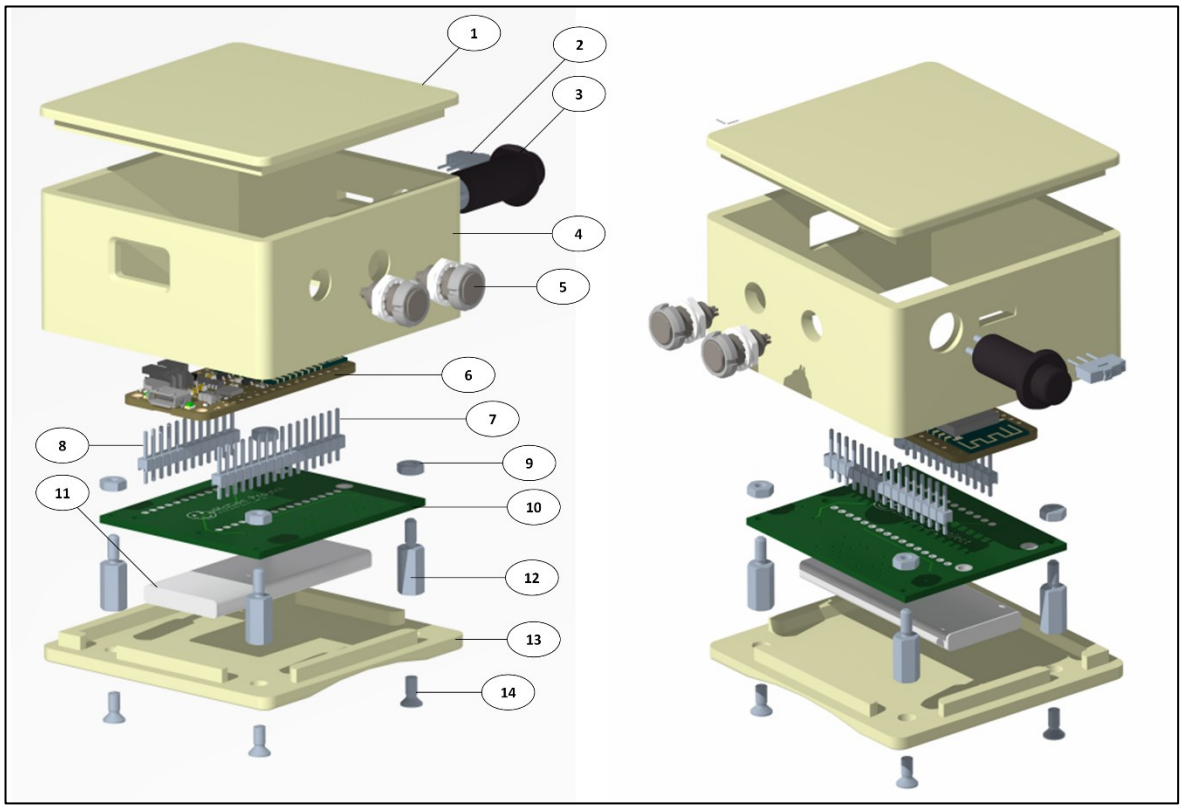
Step	Description	Materials needed
1	**Curve the wire** Curve the 30 cm long wire so that it follows the contour of the head.	○ Wires of Ø1.6 mm *(MPL N°14)*
2	**Assembly with the silicone tube** Slide the curved wire from step 3.1 into the silicone tube.	○ Silicone tube of Ø2 mm *(MPL N°15)*
3	**Curve both ends of the wire and assembly with right/left hub (Part N°1)** Curve each end of the wire from step 3.2, so that it can be attached to the left/right hubs *(Part N°1)*.	○ Right/left hub sub-assembly *(Part N°1)*

4. Control box sub-assembly

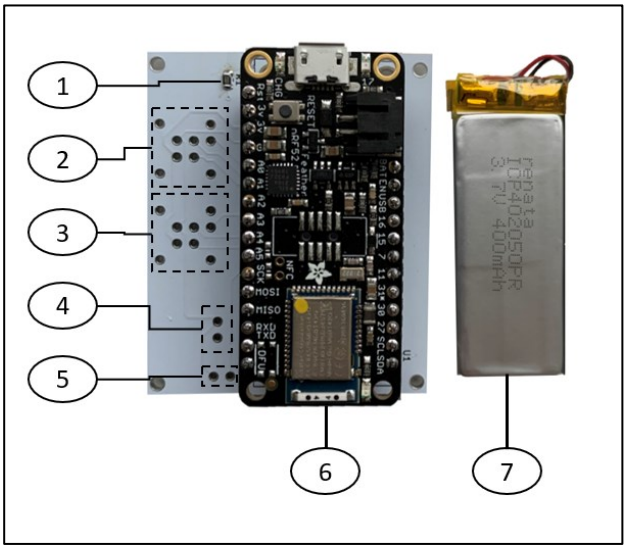
The control box receives the conditioned signals from the left/right hubs, manages the system and sends data wirelessly via BLE to a connected device.



N°	Part description
1	Top cover box
2	Supply switch
3	Push button
4	Middle box
5	Connector 5 pos. + nut and washer (2x)
6	Bluefruit nRF52 Feather
7	Headers 16 pos.
8	Headers 12 pos.
9	Nuts M2.5 (4x)
10	Main PCB
11	Battery LIPO 420mAh 3.7V
12	Spacer M2.5x10 (4x)
13	Bottom cover box
14	Flat screw M2.5x6 (4x)

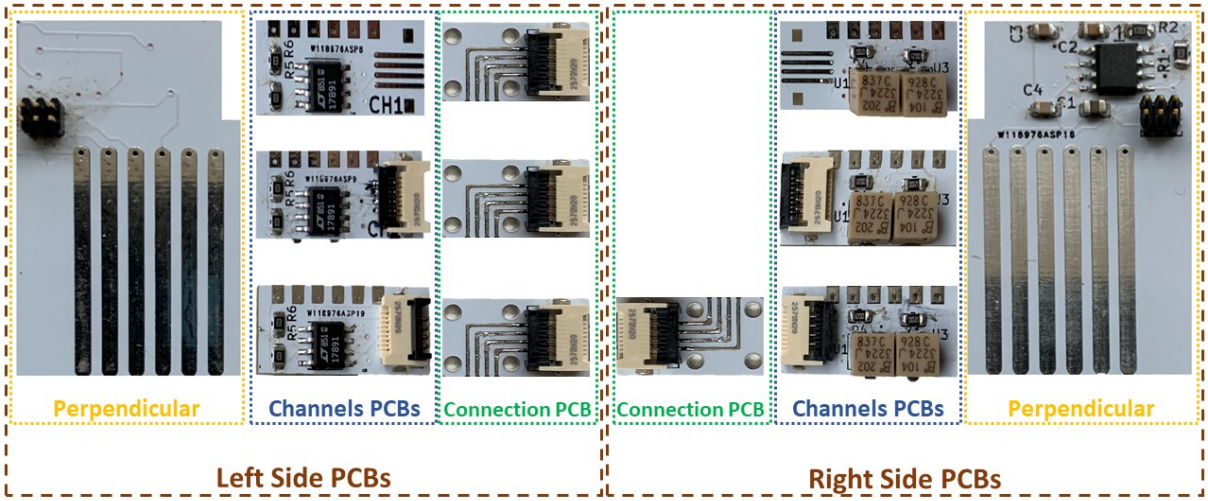


N° 10: Main PCB

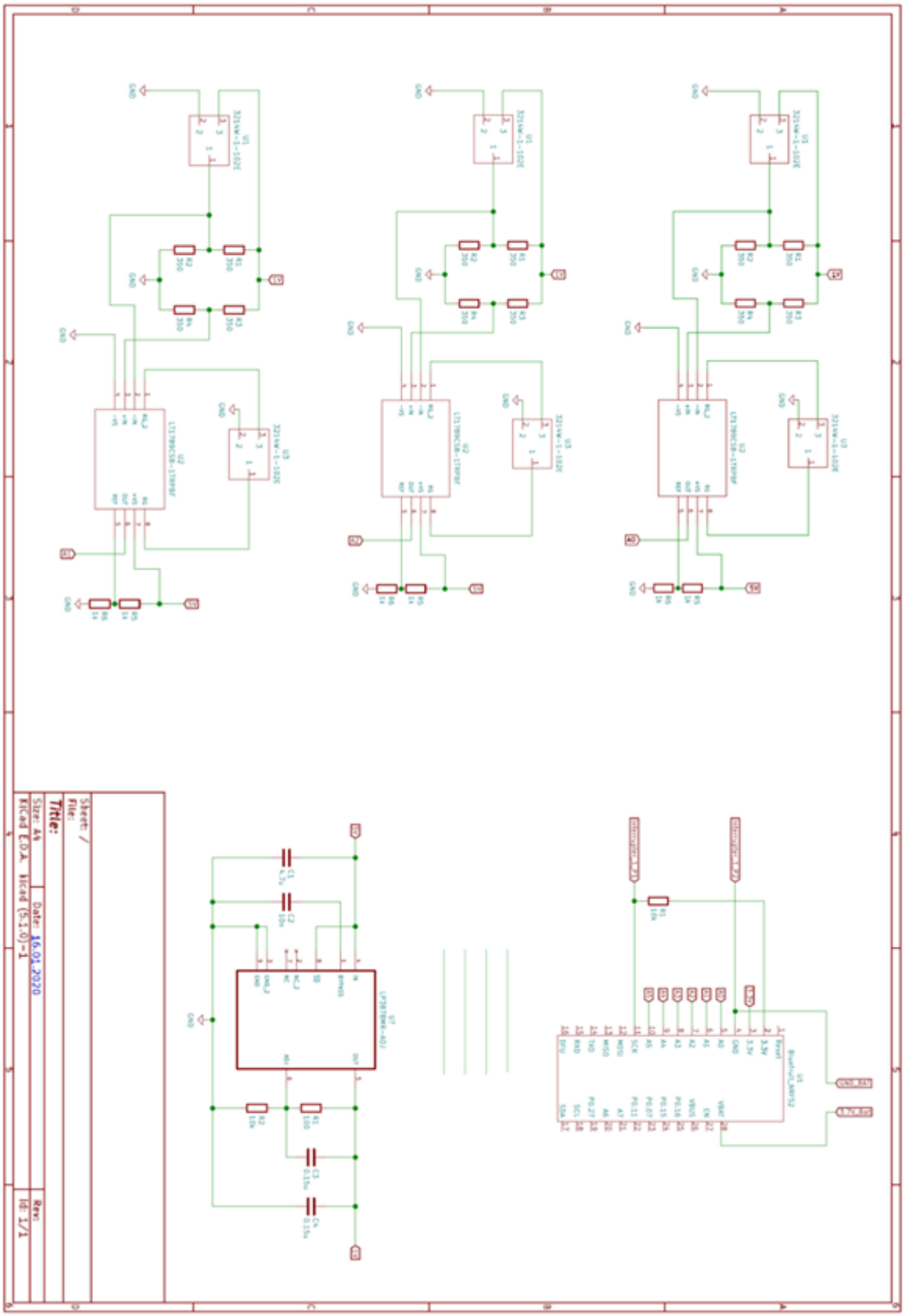


N°	Part description
1	10kΩ resistor
2	Connector pins for right side
3	Connector pins for left side
4	Connector pins for battery
5	Connector pins for push button
6	Bluefruit nRF52 Feather
7	Battery LIPO 420mAh 3.7V

PCBs Overview



Control box circuit schematic



Electronic parts list (EPL)

N°	Part description	PCB	Quantity	Link
1	Operational amplifier	PCB channel 1,2 and 3	3	LT1789-1
2	Trimmer 2 kΩ 250 mW	PCB channel 1,2 and 3	3	3224J-1-202E
3	Trimmer 100 kΩ 250 mW	PCB channel 1,2 and 3	3	3224J-1-104E
4	10 kΩ resistors	PCB channel 1,2 and 3	6	SMD resistors
5	120 Ω resistors	PCB channel 1,2 and 3	6	SMD resistors
6	Backlock Connector (1.0 pitch, 4 pins, Dual Contact)	PCB channel 1,2 and 3+ PCB probe connection	12	XF3M
7	Linear voltage regulator 1-5.5 V SOIC-8	Perpendicular PCB	1	LP3878MR-ADJ/NOPB
8	0.15 µF Capacitors	Perpendicular PCB	2	SMD capacitors
9	10 nF capacitor	Perpendicular PCB	1	SMD capacitor
10	4.7 µF capacitor	Perpendicular PCB	1	SMD capacitor
11	1 kΩ resistor	Perpendicular PCB	1	SMD resistors
12	100 kΩ resistor	Perpendicular PCB	1	SMD resistors
13	Headers 1.27x1.27mm	Perpendicular PCB	1	20021111-00006T4LF
14	Wire housings 1.27x1.27mm	Perpendicular PCB	1	20021311-00006T4LF
15	Bluefruit nRF52 Feather	Main PCB	1	nRF52
16	10 kΩ resistors	Main PCB	1	SMD resistors
17	Batteries LIPO 420mAh 3.7V	Main PCB	1	Rechargable battery
18	Push button opaque	Main PCB	1	Push button
19	Supply switch	Main PCB	1	NK236

Mechanical parts list (MPL)

N°	Part description	Assembly	Quantity	Link
1	Fillister screw M1.6x6	SP	24	M1.6x6
2	Flat wire 4 contacts - 30 mm	SP	4	98267-0701
3	Flat wire 4 contacts - 50 mm	SP	4	686704050001
4	Flat wire 4 contacts - 76 mm	SP	2	15167-0704
5	Allen screw M2.5x6	H	2	M2.5x6
6	Connector 5 pos. + nut and washer	H + CB	4	EGG.00.305.CLL
7	Nuts M2.5	CB	4	Nuts
8	Spacer M2.5x10	CB	4	Spacer
9	Flat screw M2.5x6	CB	4	M2.5x6
10	Kapton sheet of 125 µm thickness	SP	1	Kapton
11	Kapton tape of 25 µm thickness	SP	1	Kapton tape
12	P400 sandpaper	SP	1	A02010
13	Double tape Spandex of 50 µm thickness	SP	1	Spandex
14	Steel wire – 2 mm of diameter	HB	30 cm	Steel wire
15	Silicone pipe – 2.5 mm of internal diameter and 4 mm of outside diameter	HB	30 cm	Silicone pipe
16	Strain gauges HBM of 120 Ω	SP	4	Strain gauges
17	Substrate’s design	SP	-	Substrate’s design

Printed parts list (PPL)

Each piece has been printed with ABS or tough PLA

N°	Part description	Assembly	Quantity	Part name
1	Ball joints	SP	min. 25	ball_joints.stl
2	Protective cover probe left	SP	4	protective_cover_probe_left.stl
3	Protective cover probe right	SP	4	protective_cover_probe_right.stl
4	Ball joints left (female)	SP	3	ball_joints_left.stl
5	Ball joints right (female)	SP	3	ball_joints_right.stl
6	Left hub box	H	1	hub_box_left.stl
7	Left hub box cover	H	1	hub_cover_box_left.stl
8	Left hub support cover	H	1	hub_support_cover_left.stl
9	Right hub box	H	1	hub_box_right.stl
10	Right hub box cover	H	1	hub_cover_box_right.stl
11	Right hub support cover	H	1	hub_support_cover_right.stl
12	Ball joint connector (male): channel 1 and 2	H	2	ball_joint_connector_12.stl
13	Ball joint connector (male): channel 3	H	2	ball_joint_connector_3.stl
14	Top cover box	CB	1	top_cover_control_box.stl
15	Middle box	CB	1	middle_control_box.stl
16	Bottom cover box	CB	1	bottom_cover_control_box.stl

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Quentin Praz, Ahmad Jaafar, Spiros Schoinas and Philippe Passeraub from HEPIA, and Ferran Galán from University of Geneva contributed to the conception and development of ***karaloop*** P1.0, P2.0 and P3.0.