contactile

PapillArray Tactile Sensor Communications Hub (Beta v1.3)

Specifications

Document #: PTSCH_B1.3_SPEC_JAN21

January, 2020

Foreword

Information contained in this document is the property of Contactile Pty Ltd. and shall not be reproduced in whole or in part without prior written approval of Contactile Pty Ltd. The information herein is subject to change without notice and should not be construed as a commitment on Contactile Pty Ltd. This manual is periodically revised to reflect and incorporate changes made to the PapillArray Tactile Sensor Development Kit.

Contactile Pty Ltd assumes no responsibility for any errors or omissions in this document. Users' critical evaluation is welcome to assist in the preparation of future documentation.

In consideration that Contactile Pty Ltd (Contactile) products are intended for use with robotic and/or automated machines, Contactile does not recommend the use of its products for applications wherein failure or malfunction of a Contactile component or system threatens life or makes injury probable. Anyone who uses or incorporates Contactile components within any potentially life threatening system must obtain Contactile's prior consent based upon assurance to Contactile that a malfunction of Contactile's component does not pose direct or indirect threat of injury or death, and (even if such consent is given) shall indemnify Contactile from any claim, loss, liability, and related expenses arising from any injury or death resulting from use of Contactile components.

Compliance

The devices are sold as is.
The devices are specifically designed solely for the purposes of research and development only made available on a business-to-business basis.
The devices are not for resale.

Table of Contents

1 Introduction

The PapillArray Tactile Sensor Development Kit (Beta v1.3) is a system of (up to) two PapillArray Tactile Sensor arrays and a Communications Hub. Each PapillArray Tactile Sensor array can measure 3D displacement, 3D force, and vibration on each sensing element, as well as global 3D force, global 3D torque, the onset of slip, and friction. The Communications Hub supplies power for (up to) two sensors and coordinates the simultaneous data acquisition from up to two PapillArray Tactile Sensors; i.e., coordinates sampling of the 9 pillars if one sensor is connected to the Communications Hub, 18 pillars if two sensors are connected to the Communications Hub. The Development Kit is shipped with a calibration file for each sensor, as well as visualisation software and a C++ Library for developing software control algorithms using the sensor signals.

The main components of the PapillArray Tactile Sensor Development Kit (Beta v1.3) are shown in Figure 1.1, connected to a laptop running the visualisation software.

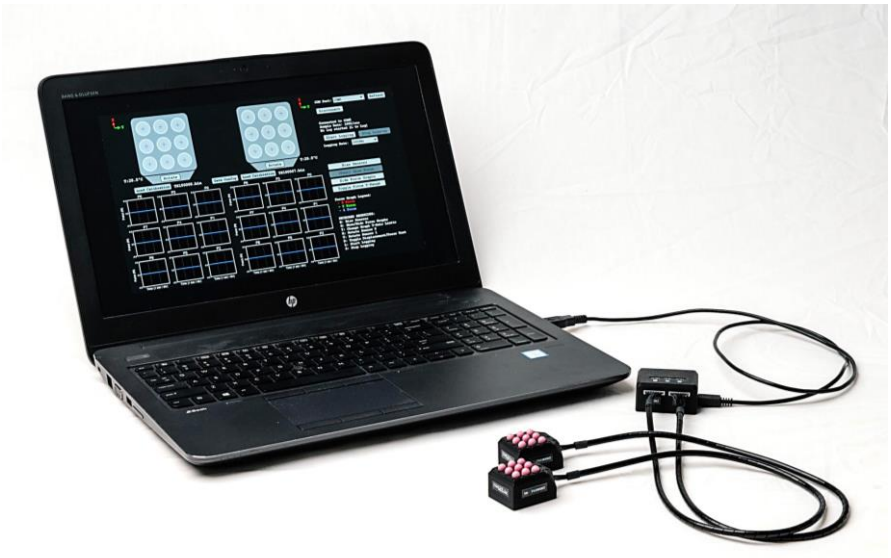

Figure 1.1 – The PapillArray Tactile Sensor Development Kit (Beta v1.3). Laptop not included.

This document contains the specifications for the PapillArray Tactile Sensor Communications Hub (Beta v1.3). Figure 1.2 shows the PapillArray Tactile Sensor Communications Hub (Beta v1.3).

Figure 1.2 – The PapillArray Tactile Sensor Communications Hub (Beta v1.3).

2 Safety

2.1 General

The customer should verify that the maximum loads and moments expected during operation fall within the sensing range of the sensor as outside this range, sensor reading accuracy is not guaranteed (refer to Document #PTS_B1.3_SPEC_JAN21). Particular attention should be paid to dynamic loads caused by robot acceleration and deceleration if the sensors are mounted on robotic equipment. These forces can be many multiples of the value of static forces in high acceleration or deceleration situations.

2.2 Explanation of warnings

The warnings included here are specific to the product(s) covered by this manual. It is expected that the user heed all warnings from the manufacturers of other components used in the installation.

Danger indicates that a situation could result in potentially serious injury or damage to equipment.

Caution indicates that a situation could result in damage to the product and/or the other system components.

2.3 Precautions

DANGER: Do not attempt to disassemble the sensor. This could damage the sensor and will invalidate the calibration.

DANGER: Do not attempt to drill, tap, machine, or otherwise modify the sensor casing. This could damage the sensor and will void any warranty.

DANGER: Do not use the sensor on abrasive surfaces or surfaces with sharp points/edges. This could damage the silicone surface of the sensor.

DANGER: Do not simultaneously connect the Communications Hub to multiple PCs through the MAIN and MNTR micro-USB ports. This will damage the Communications Hub and sensor electronics.

CAUTION: Sensors may exhibit a small offset in readings when exposed to intense light sources.

CAUTION: Exceptionally strong and changing electromagnetic fields, such as those produced by magnetic resonance imaging (MRI) machines, constitute a possible source of interference with the operation of the sensor and Communications Hub.

CAUTION: Temperature variations can cause drift in sensor readings. Some temperature compensation is included in Development Kit version of the PapillArray. However, bias removal in software prior to operation is necessary, and it is recommended that biasing is performed each time the sensor is known to be unloaded.

3 Physical specifications

3.1 Sensor ports

The Communications Hub has two sensor ports, labelled SEN0 and SEN1. The sensor ports are shown in Figure 3.1.

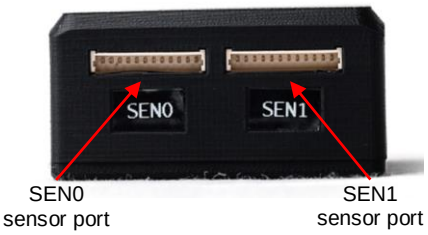

Figure 3.1 – Sensor ports of the PapillArray Tactile Sensor Communications Hub (Beta v1.3)

3.2 Micro-USB ports

The Communications Hub has two micro-USB ports, labelled MAIN and MNTR. The micro-USB ports are shown in Figure 3.2.

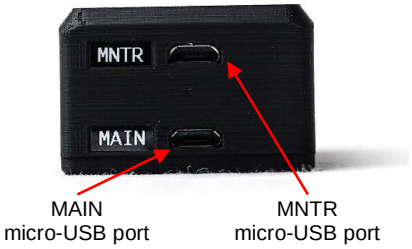

Figure 3.2 – Micro-USB ports of the PapillArray Tactile Sensor Communications Hub (Beta v1.3)

Both micro-USB ports can be used with the Visualisation Software and the C++ Library – see Section *6 Software and algorithms.* However, the micro-USB ports have different specifications:

- MAIN: supplies power to the Communications Hub from the PC and transmits data to the PC from up to two sensors at a rate of 1000 Hz.
- MNTR: transmits data from the Communications Hub to the same PC at a rate of 50 Hz.

3.3 Indicator panel

On the top face of the Communications Hub, there are three indicator LEDs labelled HUB, SEN0 and SEN1. The indicator panel is shown in Figure 3.3. The LEDs indicate the status of the system:

- HUB – indicates the Communications Hub status
- SEN0 – indicates the status of sensor connected to the SEN0 port
- SEN1 – indicates the status of sensor connected to the SEN1 port

In general, a solid white LED indicates that the status is functional, a flashing white LED indicates waiting for some event, and a solid red LED indicates an error. For more information on the different states of the LEDs, see section *5 Status indicator*.

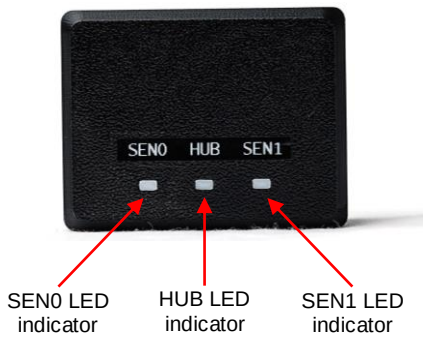

Figure 3.3 – Indicator LEDs of the PapillArray Tactile Sensor Communications Hub (Beta v1.3)

3.4 Casing

CAUTION: The communications hub casing material is ABS plastic. Do not clean with solvents such as acetone as this may damage the casing. Isopropanol is a suitable cleaning agent; however care must be taken to avoid liquid ingress.

The physical characteristics of the casing of the Communications Hub are summarised in Table 3.1.

Table 3.1 – Physical characteristics of plastic casing.

Dimensions (W x L x H mm)	49 × 38 × 24.5
Material	ABS
Mounting	4x M3 threaded holes on bottom-side – see Figure 3.4

3.5 Environmental conditions

The Communications Hub is designed to be used in standard laboratory or light-manufacturing conditions and does not yet have ingress protection to withstand dusty environments, or fresh- or salt-water immersion to any depth. The Communications Hub may be used in environments with up to 95% relative humidity, non-condensing.

3.6 Mechanical drawings

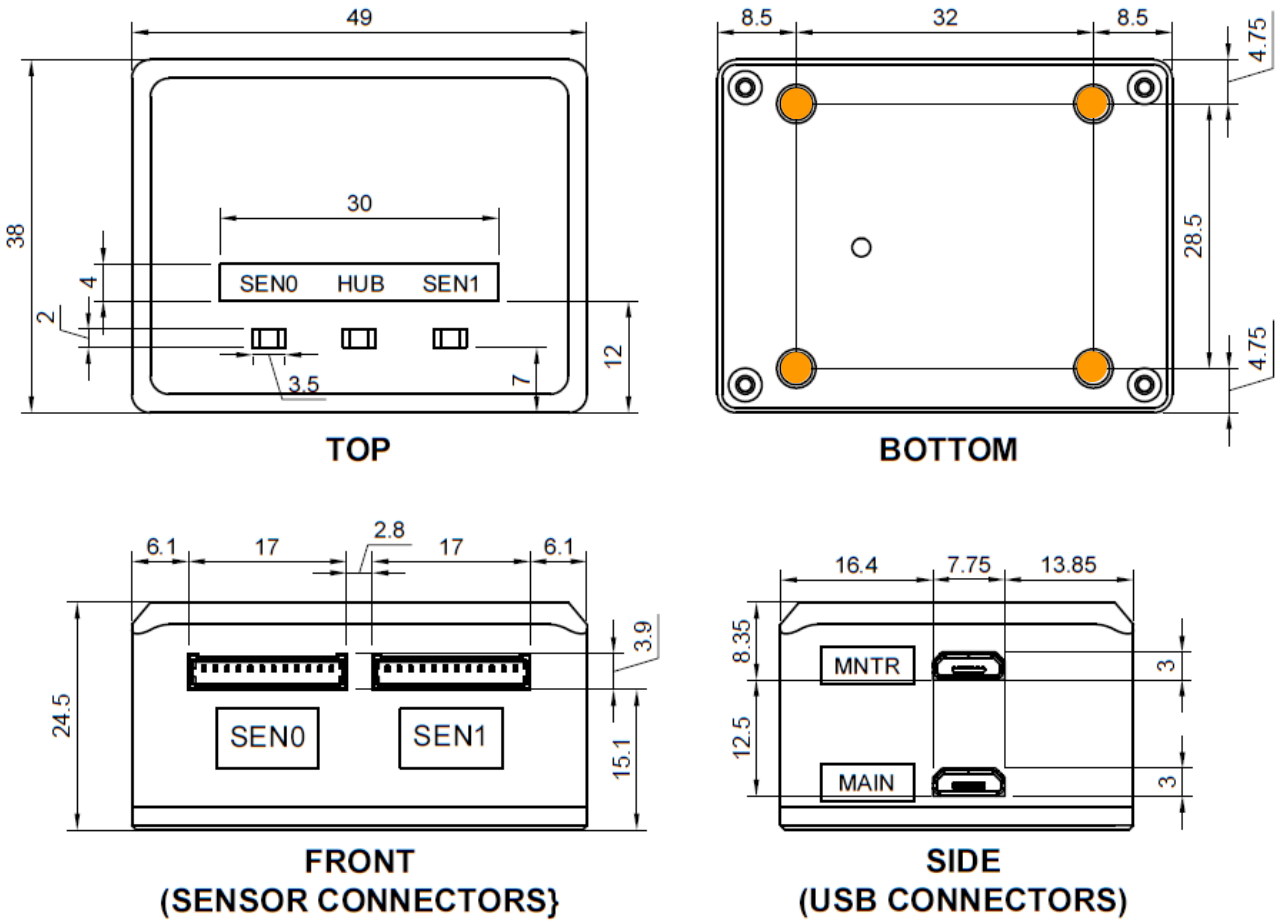

Figure 3.4 – Mechanical drawing of PapillArray Tactile Sensor Communications Hub (Beta v1.3). All dimensions are in mm. Customer mounting interface is shown as orange circles (●).

4 Installation

4.1 Mounting the Communications Hub

DANGER: Do not attempt to drill, tap, machine, or otherwise modify or disassemble the Communications Hub. This could damage the Communications Hub and will void any warranty.

The Communications Hub can be mounted if desired. Mount the Communications Hub to a structure with sufficient mechanical strength that is moving together with the sensors to avoid mechanically loading/cycling the sensor cables. Not doing so can lead to suboptimal performance and may cause premature damage to the sensor cables. The Communications Hub can be mounted using the bolt pattern provided – See Document # PTSCH_B1.3_SPEC_JAN21.

4.2 Interfacing

DANGER: Do not simultaneously connect the Communications Hub to multiple PCs through the MAIN and MNTR micro-USB ports. This will damage the Communications Hub and sensor electronics.

A separate Communications Hub device coordinates the simultaneous data acquisition from up to two PapillArray Tactile Sensors (Beta v1.3); i.e., coordinates sampling of 18 pillars across two independent sensors.

Data transmission between the Communications Hub device and the host computer (i.e., laptop, PC) is via a serial connection emulated on the USB connection, visible as a COM port on the host computer.

Raw photodiode readings are read on the host computer through a closed application programming interface (API) provided. The calibrated values are also calculated through this API (See section *6 Software and algorithms*).

4.3 Powering up

DANGER: Do not simultaneously connect the Communications Hub to multiple PCs through the MAIN and MNTR micro-USB ports. This will damage the Communications Hub and sensor electronics.

Power for the Communications Hub and up to two PapillArray Tactile Sensors (Beta v1.3) is supplied over the same single micro-USB to USB cable used to communicate with the Communications Hub. A standard USB 2.0 5 V / 500 mA port is sufficient. USB 3.0, 3.1, or 3.2 are also compatible.

For more information about installation and operation of the Development Kit, refer to Document #PTSDK_B1.3_MAN_JAN21.

4.4 Normal operation start-up sequence

Under normal operation when a PapillArray Tactile Sensor is connected to each of the sensor ports, SEN0 and SEN1, as soon as the Communications Hub is connected to a laptop/PC via a micro-USB to USB cable, the HUB LED will then start flashing white as the Communications Hub waits for a serial connection to be established with the laptop/PC. When a serial connection is established, the HUB LED will turn solid white, and if a sensor was connected to the SEN0 sensor port, then the SEN0 LED will turn solid white, and if a sensor was connected to the SEN1 sensor, then the SEN1 LED will turn solid white.

5 Status indicators

5.1 HUB LED

Once the Communications Hub is powered, the HUB LED indicates the status of the Communications Hub. The HUB LED can be in one of four states which are described in Table 5.1.

Table 5.1 – States of the HUB LED

State	Description
Off	There is no power to the Communications Hub
Flashing white	The Communications Hub is waiting for a serial connection to be established
Solid white	The Communications Hub is functioning normally and sampling data
Solid red	The Communications Hub has experienced an error

5.1.1 HUB LED error state

When the HUB LED is solid red, the Communications Hub is experiencing an error. An error could be due to failure to initialise or a low voltage supply being delivered to the connected sensors.

5.2 SEN0 LED and SEN1 LED

Once the Communications Hub is powered, the SEN0 LED and SEN1 LED indicate the status of a sensor that is connected to the SEN0 sensor port and the SEN1 sensor port, respectively. The SEN0 LED and SEN1 LED can each be in one of four states which are described in Table 5.2.

Table 5.2 – States of the SEN0 LED and SEN1 LED

State	Description
Off	If the PWR LED is also off, there is no power to the Communications Hub; If the PWR LED is solid white, then there is no sensor connected to the SEN0/SEN1 sensor port
Solid white	The Communications Hub is sampling data from the sensor connected to the SEN0/SEN1 sensor port
Solid red	The Communications Hub is experiencing an error related to the sensor connected to the SEN0/SEN1 sensor port

5.2.1 SEN0 LED and SEN1 error states

When the SEN0 LED or SEN1 LED is solid red, the corresponding sensor has invalid or missing data. This could be due to the sensor being disconnected.

6 Software and algorithms

6.1 Visualisation software

A Java-based graphical user interface (GUI) is provided for basic post-installation testing and general demonstration of sensor operation.

This GUI can be found on the Contactile USB flash drive which was shipped with the Development Kit. The executable file is located in the folder ‘Visualisation Software’ in the root directory.

For further information, refer to the document PTSVIS_B1.3_MAN_JAN21.

6.2 C++ Library

A C++ Library is provided which converts the raw photodiode readings into calibrated 3D displacement and 3D force signals for each of the sensing pillars, and global 3D force and 3D torque for the entire sensor array, for up to two sensors. The library also contains algorithms which can detect incipient slip (in the absence of torque) and subsequently estimate the coefficient of static friction.

The C++ Library can be found on the Contactile USB flash drive which was shipped with the Development Kit. The files are located in the folder ‘C++ Library’ in the root directory.

For further information, refer to the document PTSC++_B1.3_MAN_JAN21.

7 Maintenance

7.1 General

For most applications, there are no parts that need to be replaced during normal operation.

Sensors must be kept free of excessive dust, debris, and moisture. Debris and dust should be kept from accumulating on or in the sensor(s).

7.2 Silicone

Periodic inspection of the condition of the silicone of the sensor is recommended.

During normal use, the silicone surface finish may become dull - this is normal.

If the silicone appears worn or there are signs of damage, the silicone may need to be replaced and the sensor recalibrated. Contact Contactile for options on replacing the silicone and recalibration.

7.3 Cabling and Connectors

In industrial-like applications that continuously or frequently move the system's cabling, you should periodically check the cable jacket for signs of wear.

Damage to the outer jacketing of the sensor cable could enable moisture or water to enter an otherwise sealed sensor. Ensure the cable jacketing is in good condition to prevent sensor damage.

The sensor cables are not designed to be frequently connected and disconnected. To avoid damage to the sensor cables and sensor ports, avoid frequently connecting and disconnecting the sensor(s) from the Communications Hub.

The sensor cables and connectors are not designed to be user serviceable. Contact Contactile for options on repairing or replacing cables and connectors.

7.4 Periodic calibration

Periodic calibration of the sensor and its electronics is required to maintain accuracy and resolution. We recommend annual recalibrations, especially for applications that frequently cycle the loads applied to the sensor. Contact Contactile for options on recalibration.

8 Terms and conditions of sale

Liability

1. To the full extent permitted by law, Contactile is not liable for any damages incurred, including any consequential damages, as a result of the provision of products, services, data, reports, or information provided herein or as part of the provided services. This includes without limitation any loss of production, damage to person or property, loss in investment, caused either directly or indirectly by Contactile. The Purchaser agrees to indemnify Contactile and its agents, and keep Contactile indemnified against all such claims, including but not limited to all financial losses, loss of income, charges, expenses, law suits, liabilities, fees, or costs.
2. Where Contactile acts as an agent on behalf of the Purchaser with other contractors, manufacturer's or suppliers, Contactile accepts no responsibility for the performance of said third-parties, and the Purchaser indemnifies Contactile from any obligation or liability relating to their performance.
3. The Purchaser acknowledges that despite best efforts by developers, no product is free of defects (or bugs). As such, Contactile does not imply that its work product, or the work product from its suppliers, will be defect free. Contactile shall not be liable for any damages relating to said defects.
4. All liability limitations that form part of this agreement survives the completion or termination of this agreement in perpetuity.

Intellectual Property

5. Intellectual property created during the course of this agreement shall remain the property of Contactile until all outstanding fees have been paid by the Purchaser after project completion. The Purchaser is liable for all costs associated with the maintenance and transfer of intellectual property from Contactile to The Purchaser. The Purchaser also agrees to attribute recognition of authorship to Contactile as reasonably requested by Contactile, including but not limited to design registrations and patents. Once all outstanding fees have been paid after project completion, ownership of all intellectual property created as part of this Agreement will be transferred from Contactile to The Purchaser.
6. Contactile and its agents may use existing intellectual property to facilitate lower project costs, such as open-source and publicly-available source code, or source code already developed by Contactile or its agents. In return, the Purchaser will grant Contactile a perpetual and royalty-free license to use the intellectual property generated as part of this agreement for use in projects that are not commercially competitive to The Purchaser's products or services.
7. Contactile will take reasonable care to check that all intellectual property used in the execution of products or services to the Purchaser is available for perpetual royalty-free use by the Purchaser, however Contactile will not be liable for any damages if intellectual property encumbrances are later discovered.
8. Some information provided to The Purchaser may be confidential to Contactile or a third party. Contactile will notify and/or mark such information as confidential. The Purchaser will treat this information as confidential, and will not disclose it to third-parties without prior agreement from Contactile.
9. For designs developed by Contactile known to the public, the Purchaser grants Contactile rights to reference products that include these designs, using company and product name, as well as images, for Contactile's use in its marketing portfolio.

Jurisdiction

10. This agreement is governed by the laws of New South Wales Australia. The Purchaser waives any rights it may have to select an alternative governing jurisdiction.
11. If any part of this agreement is not-enforceable by New South Wales law, only the un-enforceable part or parts of this agreement will become invalid, and the remainder of the agreement will remain in full-effect to the maximum extent permissible by law.