# contactile

# PapillArray Tactile Sensor Development Kit (Beta v1.3)

## Installation and Operation Manual

**Document #:** PTSDK_B1.3_MAN_JAN21

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## Foreword

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## 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.
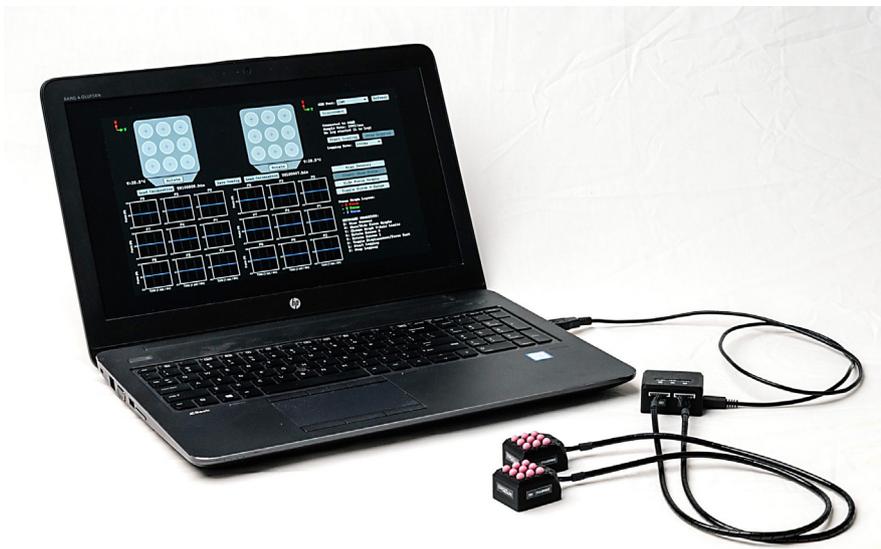


Figure 1.1 – The PapillArray Tactile Sensor Development Kit (Beta v1.3). Laptop not included.

This document contains the installation and operation manual for the PapillArray Tactile Sensor Development Kit (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   Getting started

## 3.1   Introduction

This section describes the contents of the PapillArray Tactile Sensor Development Kit (Beta v1.3). Installation is covered in Section 4.

## 3.2   Unpacking

Check the shipping box and components for damage during shipping. Any damage should be reported to Contactile Pty Ltd.

Check the packing list for omissions. Standard components of the Development Kit are:
- 2x PapillArray Tactile Sensor (Beta v1.3)
- 1x PapillArray Tactile Sensor Communications Hub (Beta v1.3)
- 2x Sensor cable (Beta v1.3)
- 1x USB cable
- Contactile USB flash drive

Additional components may include:
- Additional PapillArray Tactile Sensor (Beta v1.3)
- Additional PapillArray Tactile Sensor Communications Hub (Beta v1.3)

## 3.3   Development Kit Components

### 3.3.1   PapillArray Tactile Sensor (Beta v1.3)

The PapillArray Tactile Sensor (Beta v1.3) is a sensor array that 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. Figure 3.1 shows the PapillArray Tactile Sensor (Beta v1.3).



Figure 3.1 – The PapillArray Tactile Sensor (Beta v1.3)

To ensure proper operation, the IP rating of the sensor must match or exceed the sensor's environment. Unless otherwise specified, a sensor has no special IP protection. In this case, the sensor may be used only in benign environments with no dust or debris and no liquids or spray.

For detailed specifications of the sensor, refer to PapillArray Tactile Sensor (Beta v1.3) Specification (Document # PTS_B1.3_SPEC_JAN21).

### 3.3.2   PapillArray Tactile Sensor Communications Hub (Beta v1.3)

The PapillArray Tactile Sensor Communications Hub (Beta v1.3) 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. The Communications Hub also supplies power to up to two PapillArray Tactile Sensors (Beta v1.3) over the same single USB cable used for communications. Figure 3.2 shows the PapillArray Tactile Sensor Communications Hub (Beta v1.3).



Figure 3.2 – The PapillArray Tactile Sensor Communications Hub (Beta v1.3)

Before proceeding to installation, please read the PapillArray Tactile Sensor Communications Hub (Beta v1.3) Specification (Document # PTSCH_B1.3_SPEC_JAN21).

### 3.3.3   Sensor Cable (Beta v1.3)

The sensor cable connects a PapillArray Tactile Sensor (Beta v1.3) to the PapillArray Tactile Sensor Communications Hub (Beta v1.3).  The sensor cable is shown in Figure 3.3.



Figure 3.3 – The Sensor Cable (Beta v1.3)

NOTE: The sensor cable comprises part of the calibrated sensor. Changing the length or type of the cable can affect the calibration. Check with Contactile when making cabling changes to ensure your system's calibration will not be affected.

### 3.3.4   USB Cable (Beta v1.3)

The Development Kit comes with a standard 1 m long USB 2.0 cable for connecting the PapillArray Tactile Sensor Communications Hub to a PC (for power and communications). The USB cable is shown in Figure 3.4.



Figure 3.4 – The USB cable

### 3.3.5   Contactile USB Flash Drive

The Development Kit comes with a Contactile USB flash drive containing manuals, sensor calibration files, visualisation software, and a C++ Library. The USB flash drive is shown in Figure 3.5.



Figure 3.5 – The Contactile USB Flash Drive

A summary of the contents of the USB flash drive are described in Table 3.1. For a full folder and file list of the contents of the USB flash drive, see Document #PTSDK_B1.3_USBCONTENTS_JAN21 in the root folder of the USB flash drive.

Table 3.1 – Contents of Contactile USB flash drive

| Folder Name | Description of Contents | More Information |
|---|---|---|
| Manuals | PTS_B1.3_SPEC_JAN21 | Specifications for the PapillArray Tactile Sensor (Beta v1.3) |
| | PTSCH_B1.3_SPEC_JAN21 | Specifications for the PapillArray Tactile Sensor Communications Hub (Beta v1.3) |
| | PTSDK_B1.3_MAN_JAN21 | Operation manual for the development kit (this document) |
| | PTSVIS_B1.3_MAN_JAN21 | Operation manual for the PapillArray Tactile Sensor Visualisation Software (Beta v1.3) |
| | PTSC++_B1.3_MAN_JAN21 | Operation manual for the PapillArray Tactile Sensor C++ Library (Beta v1.3) |
| Calibration Files | A binary calibration file for each sensor with a name matching the serial number of the sensor. | These files contain the data required for decoding the raw sensor signals into calibrated measurements of displacement and force in SI units. |
| Visualisation Software | Java GUI for 50 Hz real-time visualisation and logging of displacement and force | See Document #PTSVIS_B1.3_MAN_JAN21 |
| C++ Library | C++ Library for 1 kHz real-time displacement, force, torque, slip and friction decoding and logging | See Document #PTSC++_B1.3_MAN_JAN21 |

# 4   Installation

## 4.1   Precautions

Before attempting to mount or connect the PapillArray Tactile Sensor or the Communications Hub, the user must ensure they have read the following documents:
- PapillArray Tactile Sensor (Beta v1.3) Specification (Document # PTS_B1.3_SPEC_JAN21)
- PapillArray Tactile Sensor Communications Hub (Beta v1.3) Specification (Document # PTSCH_B1.3_SPEC_JAN21.

These documents contain details of specifications as well as safety information to prevent damage to the sensor and Communications Hub.

## 4.2   Mounting the sensor

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

Mount the sensor(s) to a structure with sufficient mechanical strength. Not doing so can lead to suboptimal performance. The sensor can be mounted using the bolt pattern provided – See Document # PTS_B1.3_SPEC_JAN21.

## 4.3   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. The Communications Hub can be mounted using the bolt pattern provided – See Document # PTSCH_B1.3_SPEC_JAN21.

## 4.4   Connecting the sensor(s) and Communications Hub

**CAUTION**: Do not stress or over bend the sensor cable, especially where it is attached to the sensor. Sharp bends must be avoided as they can damage the cable and sensor and will void the warranty.

**CAUTION**: Be careful not to crush the sensor cable by over-tightening tie wraps or walking on the cable, since this may damage the cable.

**CAUTION**: Do not attempt to disconnect sensor cables by pulling on the cable itself; this can damage your system.

Each sensor is connected to the Communications Hub via a sensor cable. The sensor cable is connected to the Communications Hub into one of the sensor ports (labelled SEN0 and SEN1). Make note of the serial number of the sensor connected in each of the sensor ports on the

communications hub as the calibration files for the sensors must match for accurate decoded sensor readings.

The sensor cable must be routed so that it is not stressed, pulled, kinked, cut, or otherwise damaged throughout the full range of motion. If the desired application results in the cable rubbing, then use a loose plastic spiral wrap for protection.

## 4.5 Powering up the Communications Hub and sensors

**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.

After connecting the sensor/s and the Communications Hub, connect the USB cable between the Communications Hub and a PC. The LED labelled PWR on the Communications Hub should turn green, and subsequently, the LED labelled HUB should flash green. For more information about the LED indicator panel on the communications hub, refer to the PapillArray Tactile Sensor Communications Hub Specification (Document #PTSCH_B1.3_SPEC_JAN21).

## 4.6 Interfacing the Communications Hub to a PC

**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.

After powering up the Communications Hub through, the PC that is connected can be used to read the data being transmitted by the Communications Hub, either via the same USB connection, or via a second USB connection to the micro-USB port labelled MNTR.

The 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 *5 Software and algorithms*).

# 5   Software and algorithms

## 5.1   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.

## 5.2   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.

# 6   Maintenance

## 6.1   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).

## 6.2   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.

## 6.3   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.

## 6.4   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.

# 7 Terms and conditions of sale

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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.

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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.