Sensing Mat Dev Kits

Developer Guide

Confidential
Version 3.0

SENSING TEX, SL info@sensingtex.com | www.sensingtex.com

List of Contents

List of Tables

Abbreviation List

	Sensing Mat
Dev Kit	Development Kit
SMDK	Sensing Mat Development Kit
PC	Personal Computer
USB	Universal Serial Bus
App	Application
LED	Light Emitting Diode
CSV	Comma Separated Values
.apk	Android Application Package
API	Application Programing Interface
SPP	Standard Parallel Port
GUI	Graphical User Interface
FW	Firmware
ADC	Analog Digital Converter

1. Introduction

Sensing Mat Development Kits (Sensing Mat Dev Kits) intends to enable the usage of pressure Sensing Mat Platform and Technologies in multiple applications including, health monitoring, wellness, sports and human interaction with software among other applications.

The usage of Sensing Mat Dev Kits and other evaluation kits is the first step in the development stage. It is possible to implement and analyze different applications using Sensing Mat Dev Kits (SMDKs) because Sensing Tex provides the complete technology acquisition tools for real-time pressure map representation, analysis, and storage (hardware, firmware, communication with PC or Smartphone and Software).

The main purpose of this developer guide is to present the available tools for the technology evaluation of the SM samples and SMDK, and also to help and accelerate the development of new custom products and applications based on **Sensing Mat and Mat Dev Kits from Sensing Tex.**

The Developments kits are not products but a set of components and parts that are used as a tool during product development. Warranty terms and conditions are available in our Website.

2. Installation of Sensing Tex Demo and Analytics Software

Sensing Mat Development Kits can be connected to a PC or a Smartphone, acquisition modules can connect via USB or Bluetooth. Only a demo software on Windows based PC software is provided.

PC System Requirements:

Please use this software in a computer which the following recommended features:

Intel Core® i5, Windows® 10, 4 GB RAM, USB, Bluetooth® connectivity.

Using a system with lower features may cause a malfunction of the software.

Windows Software requirements:

- Operative System, Windows 7 or later versions
- USB free ports
- Bluetooth connectivity (if it is required a wireless link between SMDK and PC)
- SMDK driver installation.

The Sensing Mat Software installer will be installing in companion with the Sensing Mat Software:

1. The required drivers (For proper hardware configuration)
2. The libraries of .NET,
3. Microsoft Database Engine,

The installation wizard will run automatically during the installation procedure another three installation procedures for each one of the described elements in the list below.

Follow the installer wizard during all the installation procedure.

2.1. Windows Software

2.1.1. USB Serial COM first time port identification

CONNECTION WITH PC THROUGH USB

1 Turn ON the SMDK module, then you should see the LED indicator blinking. It means the device is ON and it has no Bluetooth connection.

2 Connect the micro USB textile cable provided to the SMDK acquisition module.

3 Open the Windows Device Manager and check for the PORT (COM and LTP) devices, expand the list and check if there is a "Teensy USB Serial (COM #)" device. The # stands for the number that your operative system has assigned to the SMDK device,

4 Use the COM # port with the Sensing Tex Software in order to establish the serial communication and read pressure maps.

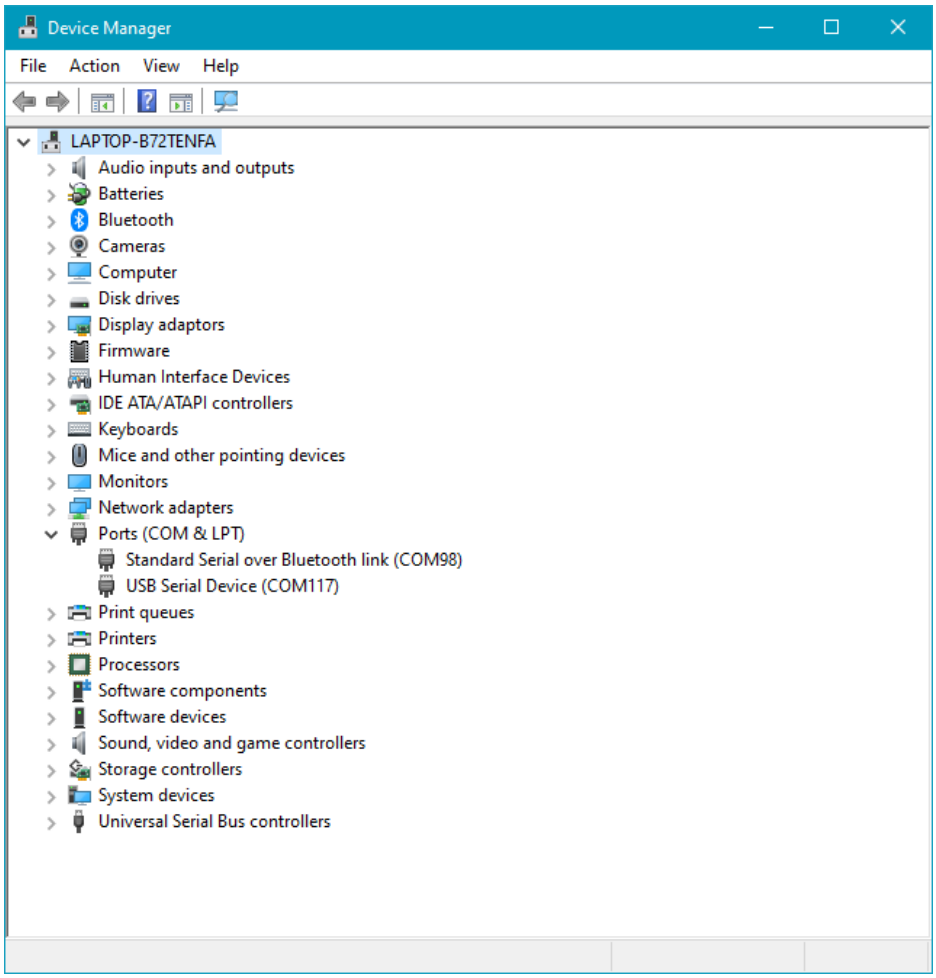


Figure 1. COM port identification through the Windows Device Manager

USB Connectivity verification

Open the Windows Device manager and expand the Ports (COM & LTP), the SMDK 05 corresponds to the "Teensy USB Serial (COM#), or "USB Serial Device", # stands for the number of the Serial Port that the operative system has assigned. In the left image example, the COM 3 has been assigned.

For future management of COM number of each port, the Sensing Mat Software has features to manage and tag the COM ports, using the "Serial Port Configuration" tool accessible through the button: 

2.1.2. Bluetooth first time pairing and connection

CONNECTION WITH PC BY BLUETOOTH

1) Turn ON the SMDK05 module, then you should see the LED indicator blinking. It means the device is ON and it has no Bluetooth established connection. If the LED signal is not blinking it means that the battery is discharged, please charge it before connecting with the USB textile Cable provided.

2) Open the Bluetooth device manager and look for a device with the name "PST_SDK_05_XXX" (XXX stands for a serialized number for each SMDK) please see the adhesive stacked to the module.

Figure 2. Pairing Bluetooth devices

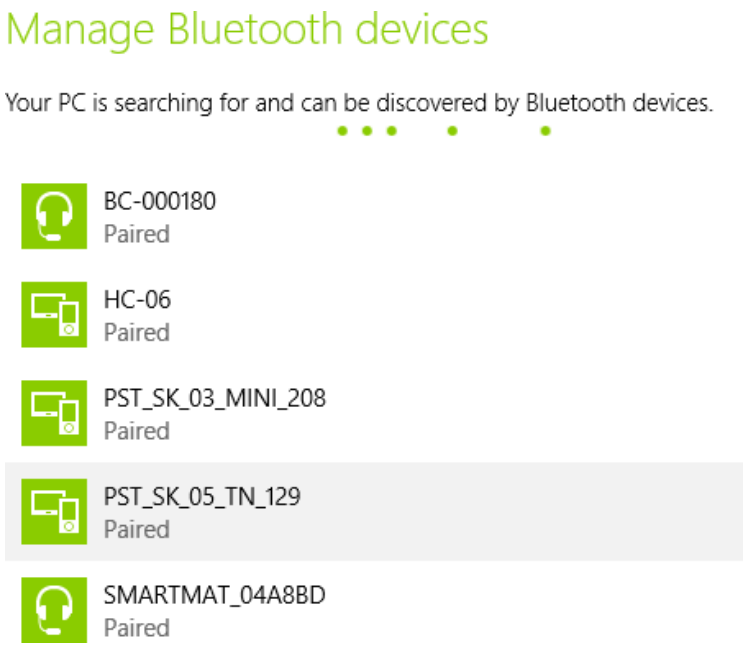


Figure 3. Pairing Bluetooth Devices

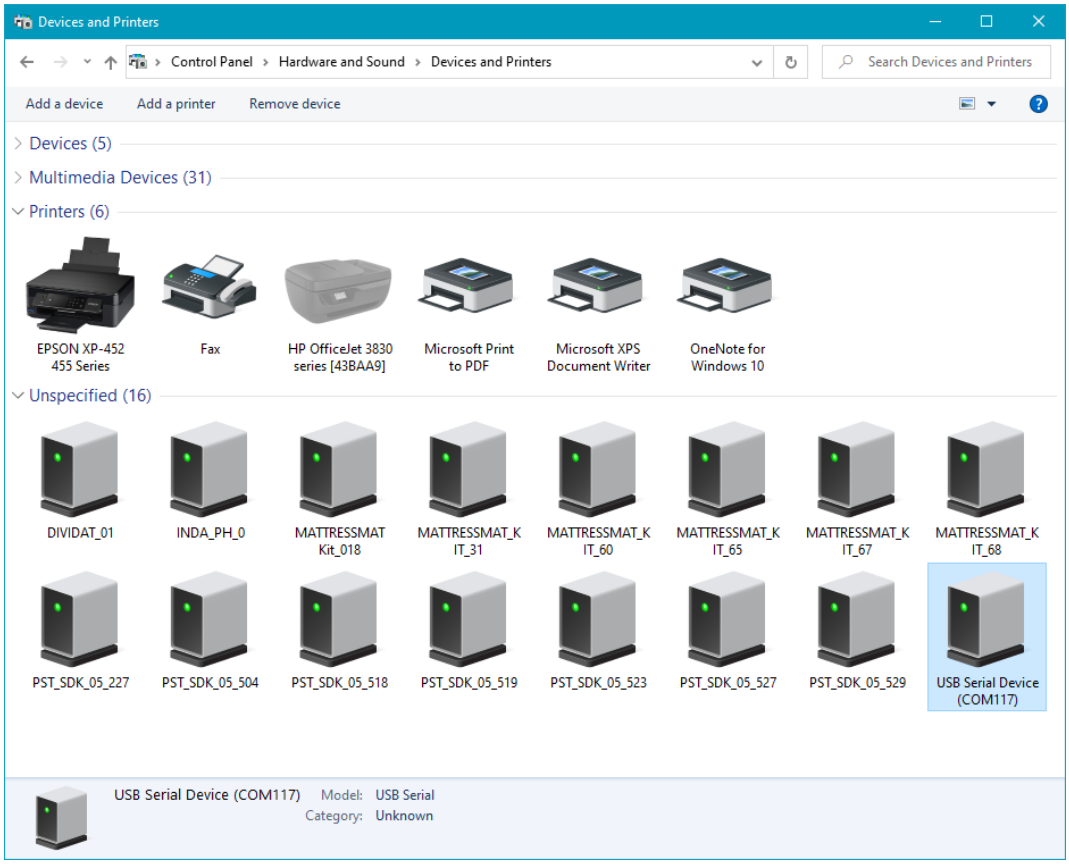


Figure 4. Devices and Printers to Identify COM port

3) Pair with the Bluetooth device "SM_SK_05_TN_XX" using the password: "1234".

2.1.3. Bluetooth Serial COM first time port identification

1) Right-click on the Bluetooth icon, in the notification area of the Windows taskbar, then select Bluetooth Settings.

2) Click on the COM Ports tab and find the Outgoing COM port associated to the "PST_SDK_05_TN_XXX ", this Bluetooth port associated with the SMDK will be different than the USB serial port COM number, in the following example, the operative system assigned the COM number 15 to the Bluetooth interface with the SMDK.

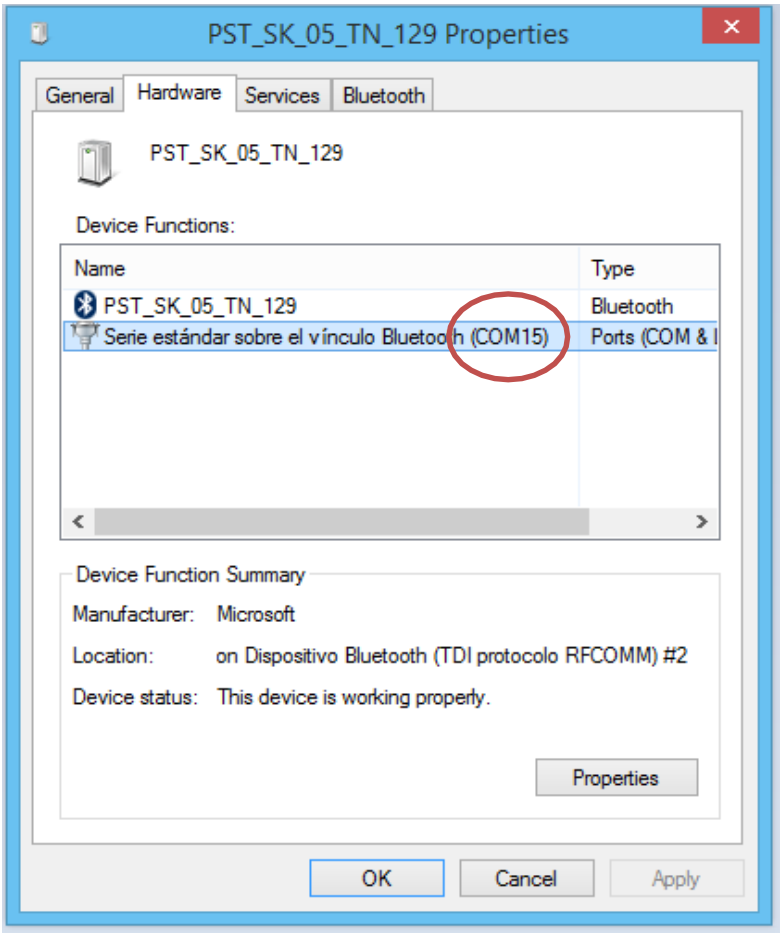


Figure 5. Bluetooth COM Port Identification Trough Device Properties

3) You must use this COM# port with the Sensing Tex Software in order to establish the serial communication and read pressure maps.

2.1.4. Windows Software Installation

The Sensing Mat Analytics software, or the Sensing Mat Software versions can be installed wizard installers provided by Sensing Tex. Each installer is contained in file, after downloading this file, execute the installer with administrator rights.

The user can follow the installation procedure, the following screenshots show an installation example procedure:

Figure 6. Sensing Mat Demo Software Installation Wizard

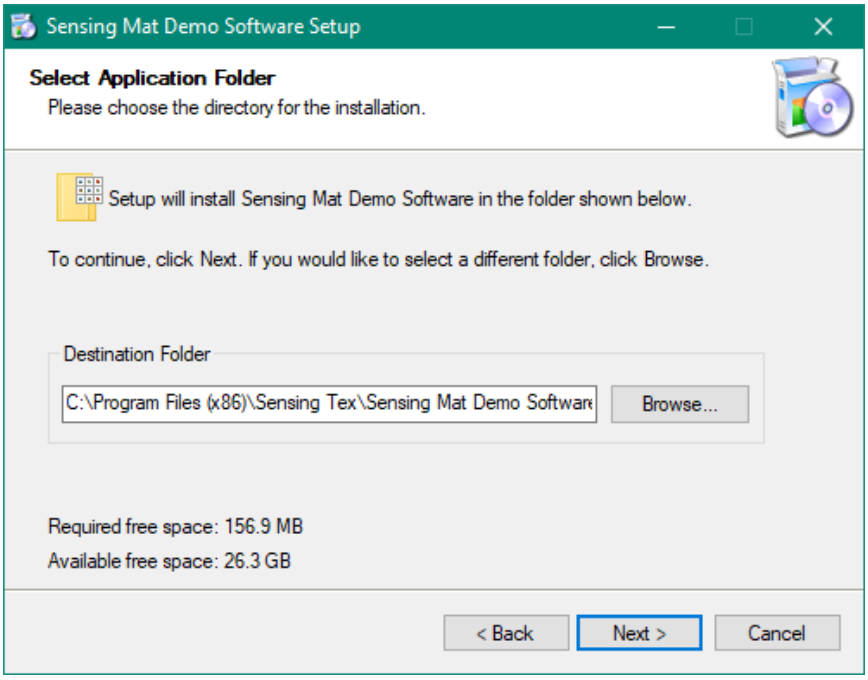


Figure 7. Default location of the files

The user can choose a different folder, in this case, it is recommended to select a folder that has "Administrator Rights", and this will allow the software to create new files when software records pressure maps.

⚠ **Note:**

It is common to install, or have installed previously the .NET Framework in PC, so in the case that the PC has already installed the .NET Framework 4.5.2 or newer versions it will prompt a Warning message notifying that it is already installed. The user may close this warning and continue with the installer.

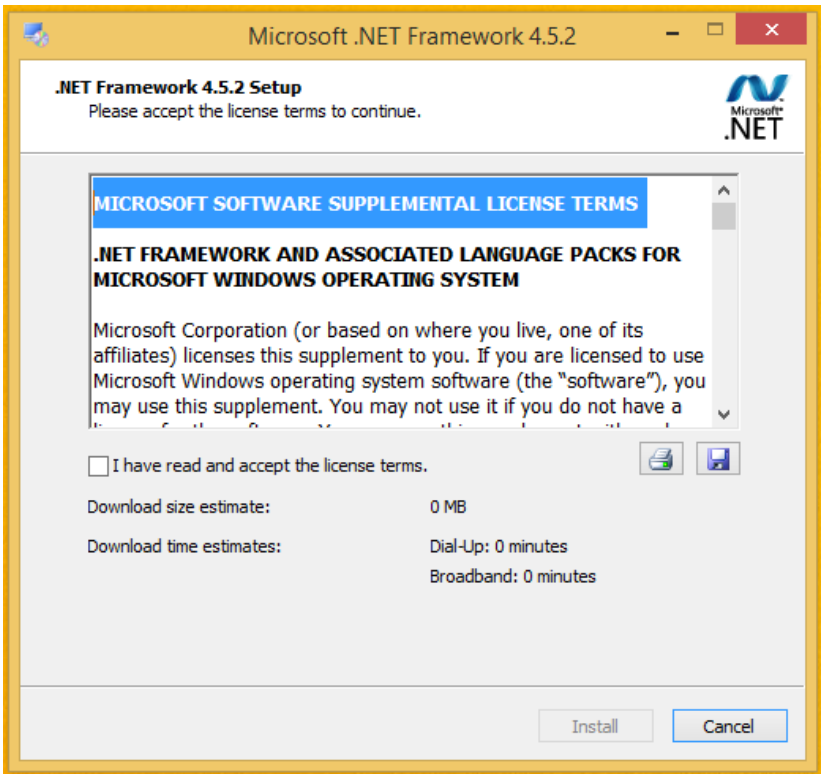


Figure 8. Microsoft .NET Installation

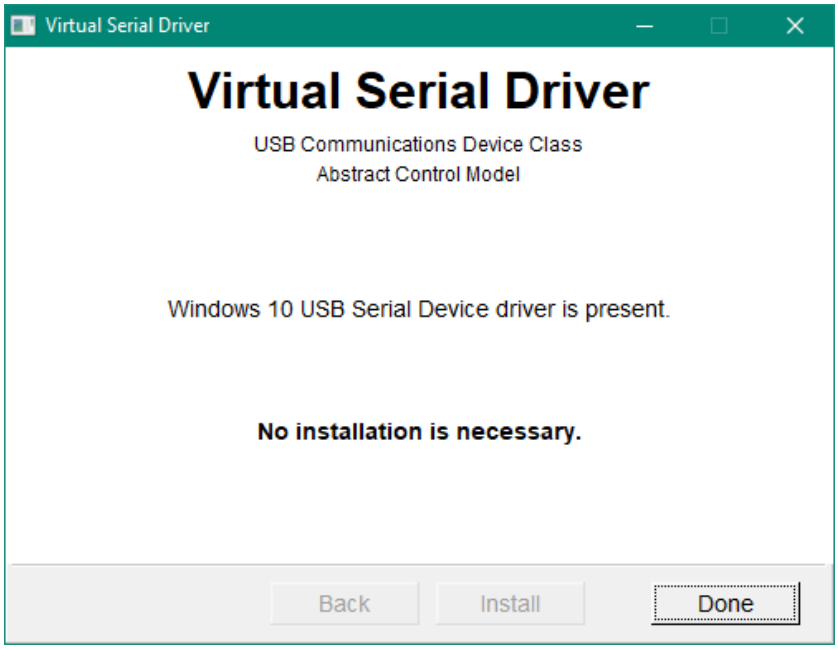


Figure 9. Virtual Serial Driver installation

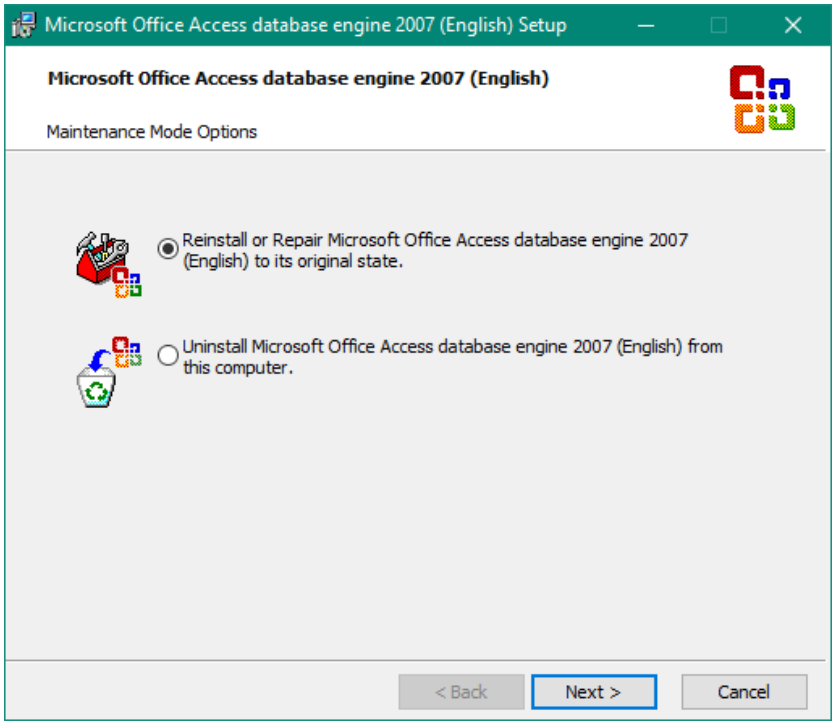


Figure 10. Microsoft Database Engine Installation

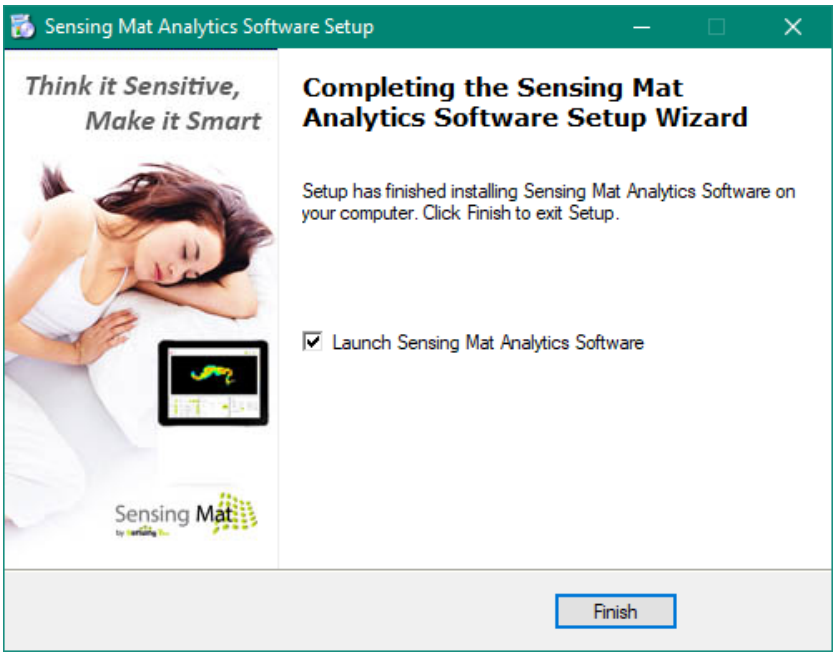


Figure 11. Sensing Mat Software Setup Finishing

2.1.5. Location and format of generated files

The software will be creating a folder inside your User, and Documents folder, with the name: "Sensing Mat Demo Software", inside this folder, all the pressure map sessions files and calibrations will be stored.

C:\Users\"USERNAME"\Documents\Sensing Mat Demo Software

...\Sensing Mat Demo Software\Recordings
...\Sensing Mat Demo Software\Calibrations

The pressure map sessions will be recorded in .JSON format, and the Calibrations will also be stored in .JSON format. Single captures for pressure maps could be stored in *.jpg, *.bmp or *.gif image files formats.

3. Demo Software & App User Guides

SOFTWARE READY TO DEVELOP NEW APPLICATIONS

Sensing Tex Apps allow direct data acquisition, pressure map representation and pressure map analysis from pressure data sensed by our **Sensing Tex Sensing Mat** technologies. It is recommended to explore the Sensing Tex technology capabilities in order to be able to develop new applications.

This software includes basic features like pressure map representation with configurable pressure-color scale, pressure map data export into .JSON files. But also advanced tools for analysis of pressure maps such as recording of pressure map sessions, and pressure map session player in order to enable the record and analysis of pressure map sessions.

Sensing Tex provide a software tool that allow developers to analyze the data coming from multiple pressure mat matrixes, and then eventually develop their own software. The communication protocol is described in the section 5 of this document.

3.1. Windows Sensing Tex Demo Software User Guide

Start the main Sensing Tex Demo Software by double click the Application "SensingTex_SDKv#.exe". This first window will allow the selection of different Sensing Tex Sensor and SMDKs, and it also allows multiple sensor acquisition in parallel. By default, the installer creates a shortcut in the Desktop, and an entry in the Windows start menu.

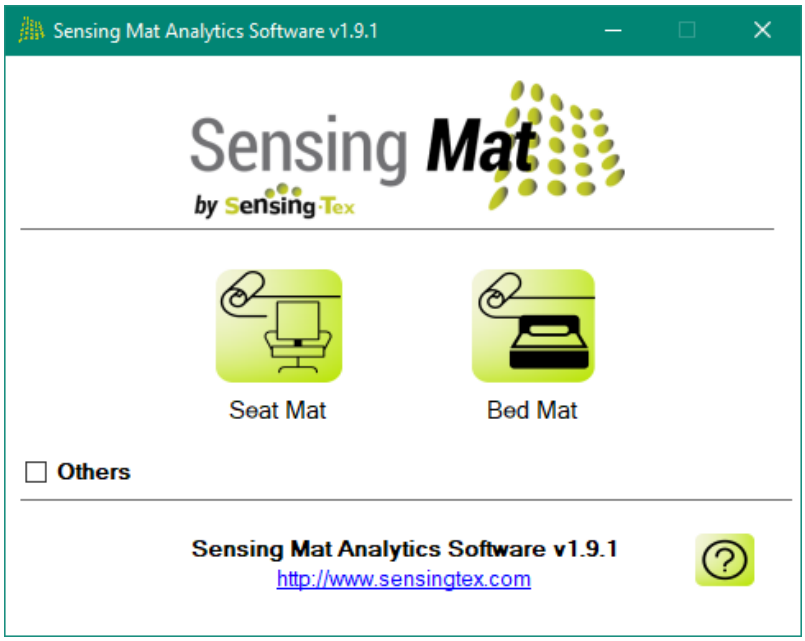


Figure 12. Sensing Mat Analytics Software Main window

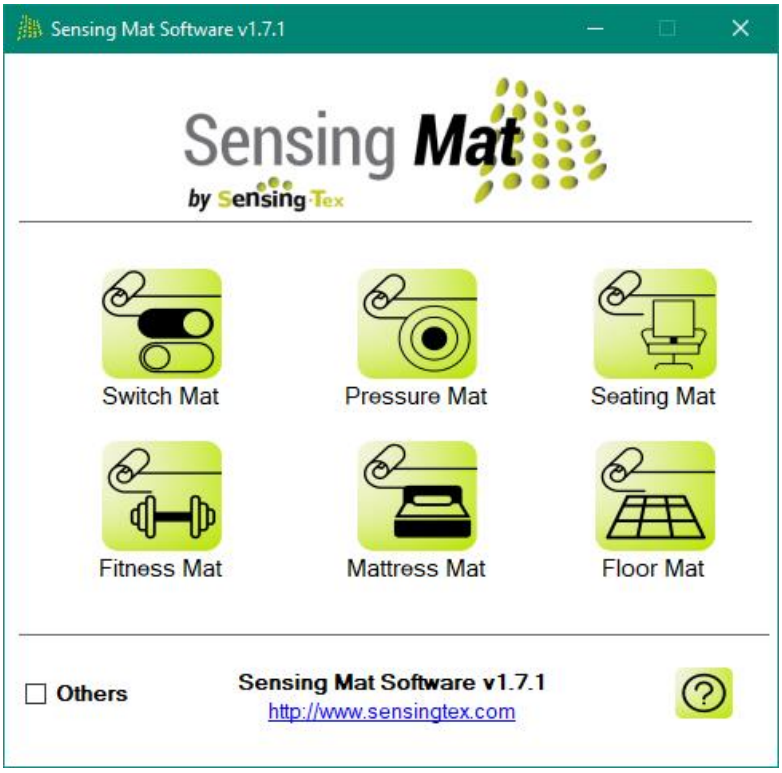


Figure 13. Sensing Mat Software main window

3.1.1. Sensing Mat Software Versions

Sensing Tex offers a wide variety of market applications based on its **Sensing Mat Platform**: Sensing Mat Analytics or Sensing Mat Software, can capture the pressure maps measured with any SM Sensor, user may choose in the SM Sensors area which Sensor will connect to the SMDK.

Seat Mat and Bed Mat platforms should be used with the Sensing Mat Analytics Software, which integrate Analytics module that implement multiple statistic calculations over the pressure map data.

Other development Kits like the Switch Mat Development Kit and the Pressure Mat Development Kits might be using the Sensing Mat Software.

3.2. Pressure Map Representation Window

User might select the button according to the type of sensor to be connected. Each option will automatically adjust the sensor size, and create a new window that has the representation area for the pressure map heatmap, and also other tools for the acquisition, capturing, analyzing, calibration and representation of the Pressure Sensor.

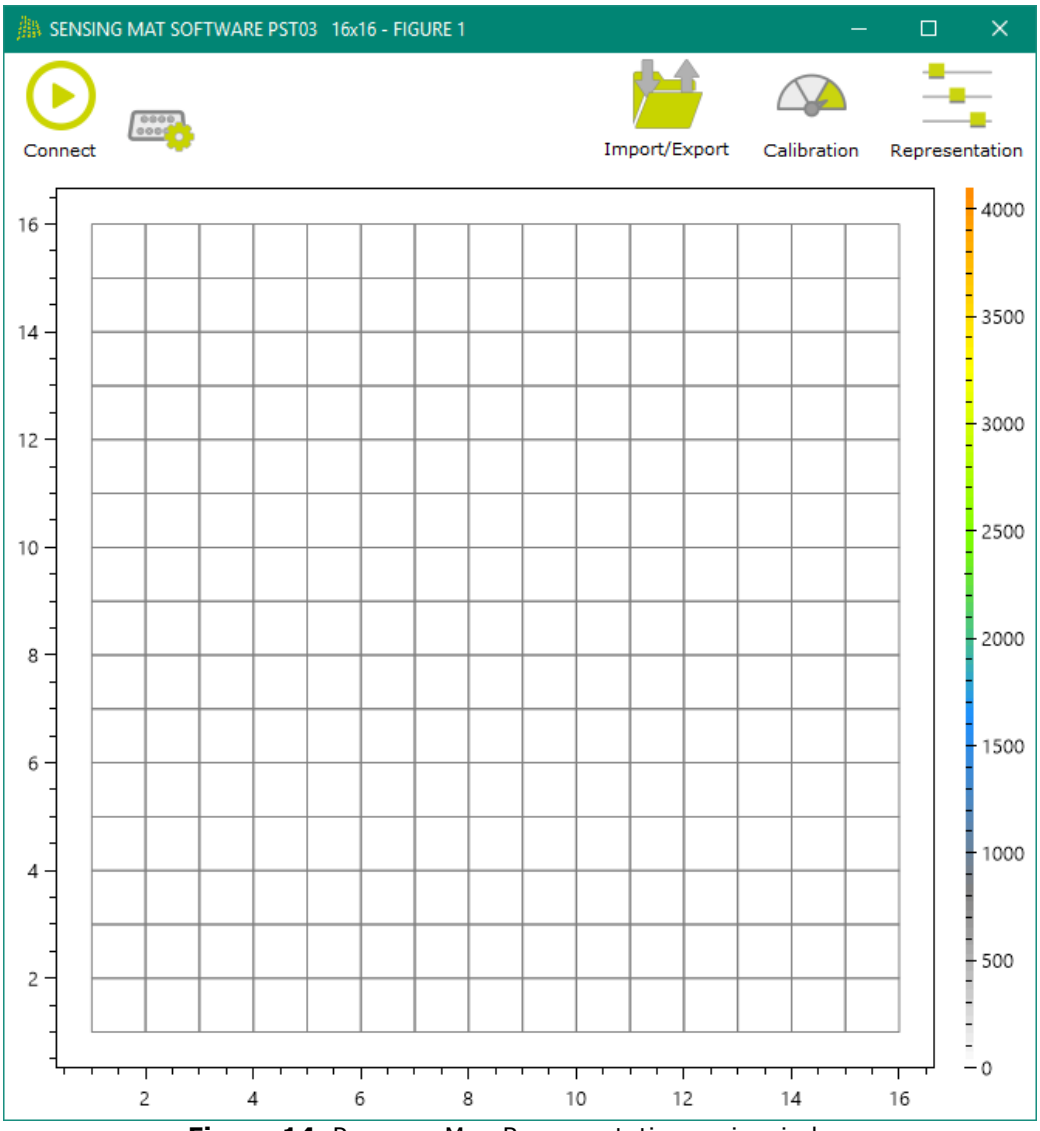


Figure 14. Pressure Map Representation main window

The upper part of the window contains the access to five group of functions of the software: Connection, Import/Export, Calibration, Analysis (Only available for the Sensing Mat Analytics Software), and Representation.

Each Pressure Map Representation window is labeled in its title with the name FIGURE #, this is useful to identify properly different windows with its correspondent Pressure Map related to the FIGURE #. The software will allow a maximum of 10 different Pressure Map Figures in parallel.

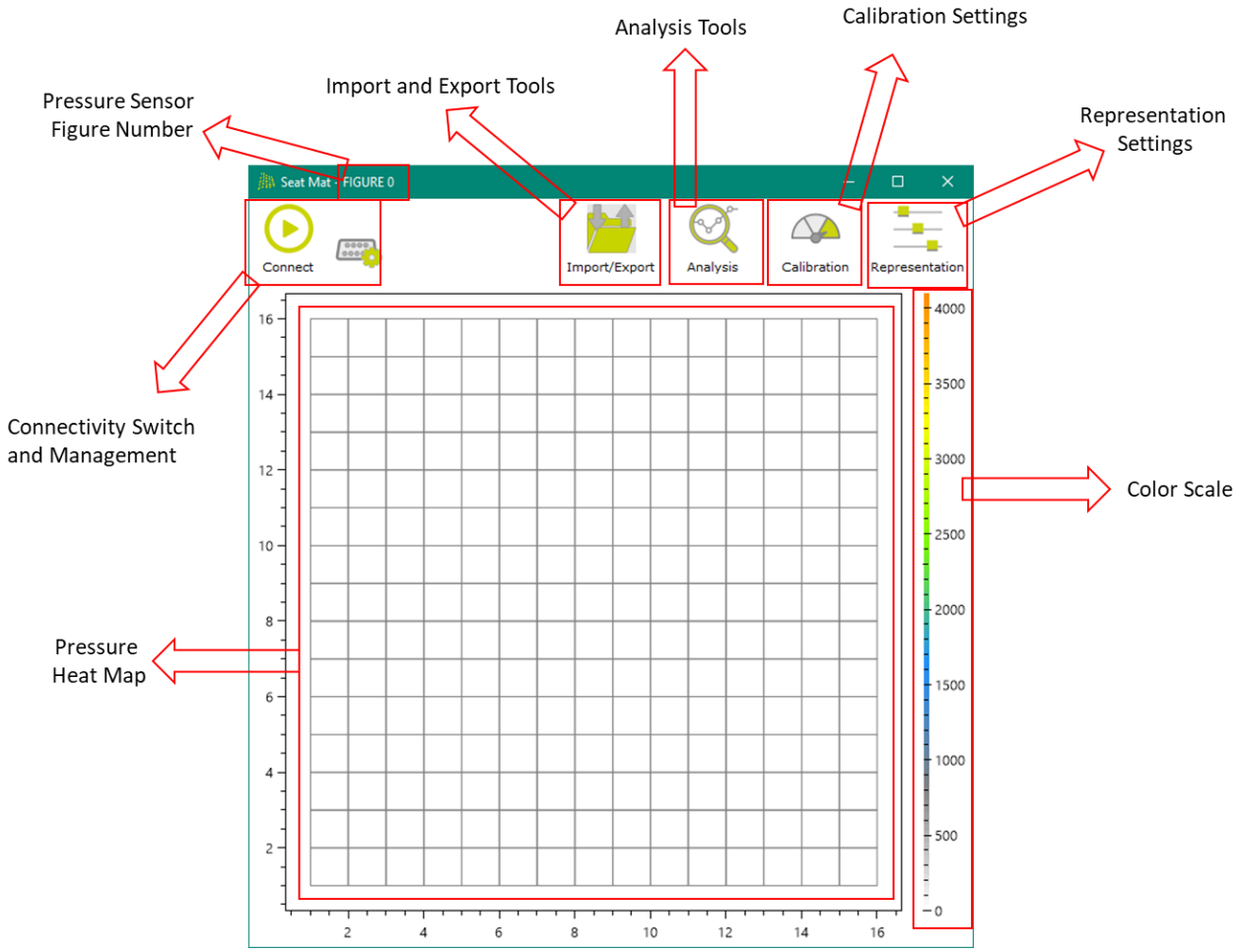


Figure 15. Diagram of different elements of the main Pressure Map main window

The previous diagram identifies all the elements composing the Pressure Map main window. The size of this window is variable, however it's important to adjust a size that meets the aspect ratio of the sensor. In the case of a square shaped sensor, it will be different than the case of a rectangular. The Pressure Heat Map area, shows a grid that correspond to the location of the pressure points. It is possible to adjust the window size using the grid as a reference to maintain a proper aspect ratio.

The basic STX DEMO SOFTWARE window has five main controls:

-  **COMMUNICATION SWITCH**: START communication with the SMDK, when the communication is not started. After the communication has been established it will change as a STOP button,

 This control can stop the communication with the SMDK. It is always recommended to STOP the communication with the SMDK before disconnecting it, or before turning OFF the SMDK.

3.2.1. Serial Port Configuration Window

The **SERIAL PORT CONFIGURATION** it's a tool that allow the listing and managing different COM ports associated to the PC, COM port could be associated trough Bluetooth or USB. This configuration window allows the user to save a particular name for each SMDK so it will be easier to manage multiple devices with the same PC.

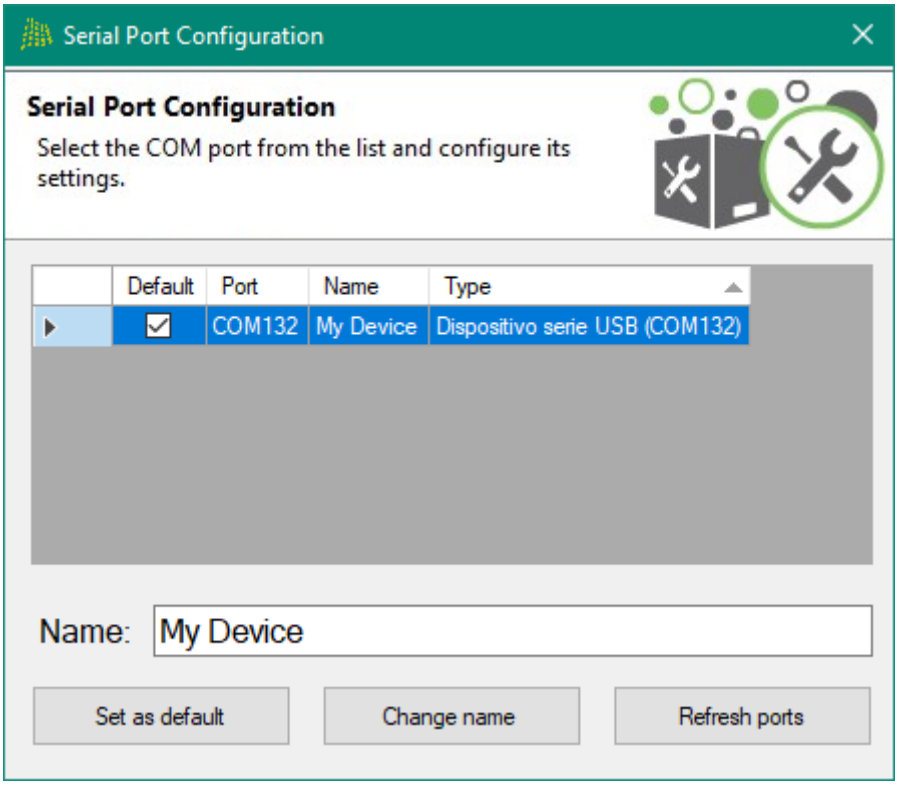


Figure 16. Serial Port Configuration window

The Serial Port Configuration window will load and list all different COM ports configured in a particular system in the case that new devices are connected when this window is already loaded, user can "**Refresh ports"** in order to list the new attached devices.

Select the device you want to link with the Pressure Map window and then click the "**Select as default"** button, this setting will be stored, and it will connect using the assigned COM port. The next time that the Sensing Mat Software is used it will recover the last used device to be connected.

3.2.2 Import and Exportation Tools Window

Import/Export

- The **Import/Export** button will open a small menu included the three main functions for exporting Pressure Map sessions and images, and also the Importation of previously recorded Pressure Map sessions.

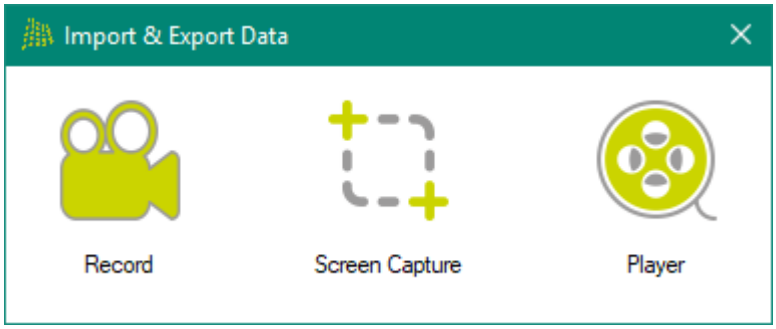


Figure 17. Import & Export Data functions

Record

- The **Record** button is used to start to store a Pressure Map Session over the time, once activated, this control will indicate that the recording started**.**

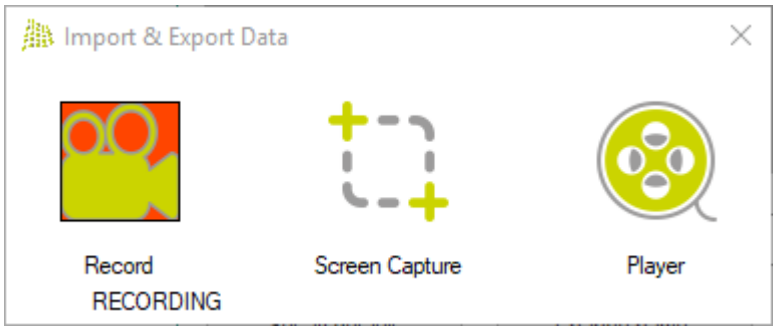


Figure 18. Import & Export Data tool when its recording a pressure map session

The pressure map session files are recorded in .JSON format, non-encoded, non-encrypted. this make them easily readable using other software sources or with the Player tool. In order to stop the Pressure map session, click again in the Red Record Button, then it will finish the session and close the .JSON file.

The name of the pressure map session files will have a name related to the timestamp corresponding to the date and time of the pressure map session.

- Screen Capture The **Screen Capture** button will capture the actual represented pressure map and save it into a Image file, once the button is clicked the image is captured, then a user form requesting the name of the image, format and location is loaded. The user might select the Image format, name and location for the Pressure Map Capture.
-

Player The **Player** allow the replay of previously acquired pressure map sessions. The information is saved as the RAW data, and then the representation and calibration settings are also saved in the Pressure Map session file. The **Player** will automatically load the same settings and then replay the pressure map sessions over the time.

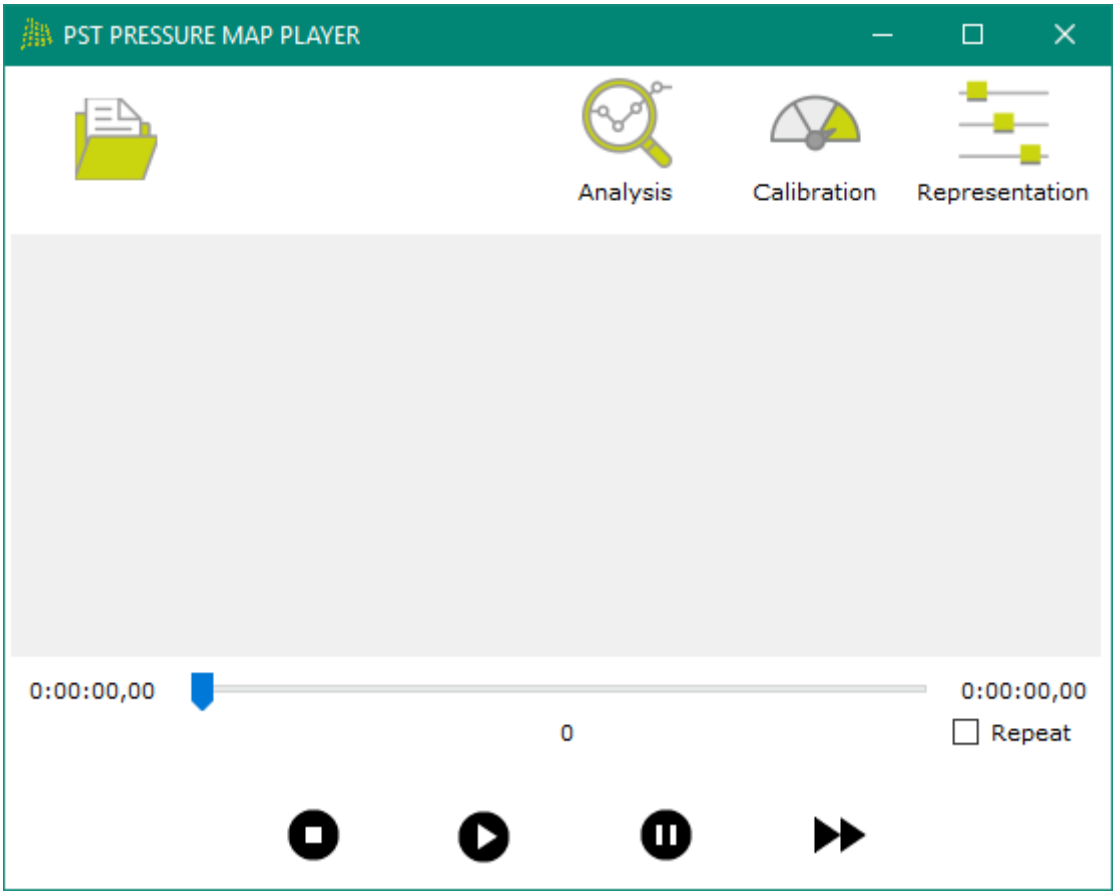


Figure 19. Pressure Map Player

Use the folder button to load the .JSON file that contains the pressure map session. The lower part of the window has the controls for the replay of the pressure map over the time:  STOP,  PLAY,  PAUSE, AND  FORWARD.

The Pressure Map Player also supports a Repeat Loop function. The lower part contains a trackbar to control the pressure map session over the time. As shown in the following example, user can control the replay of pressure map session as any standard video player. Using the progress bar and/or controls.

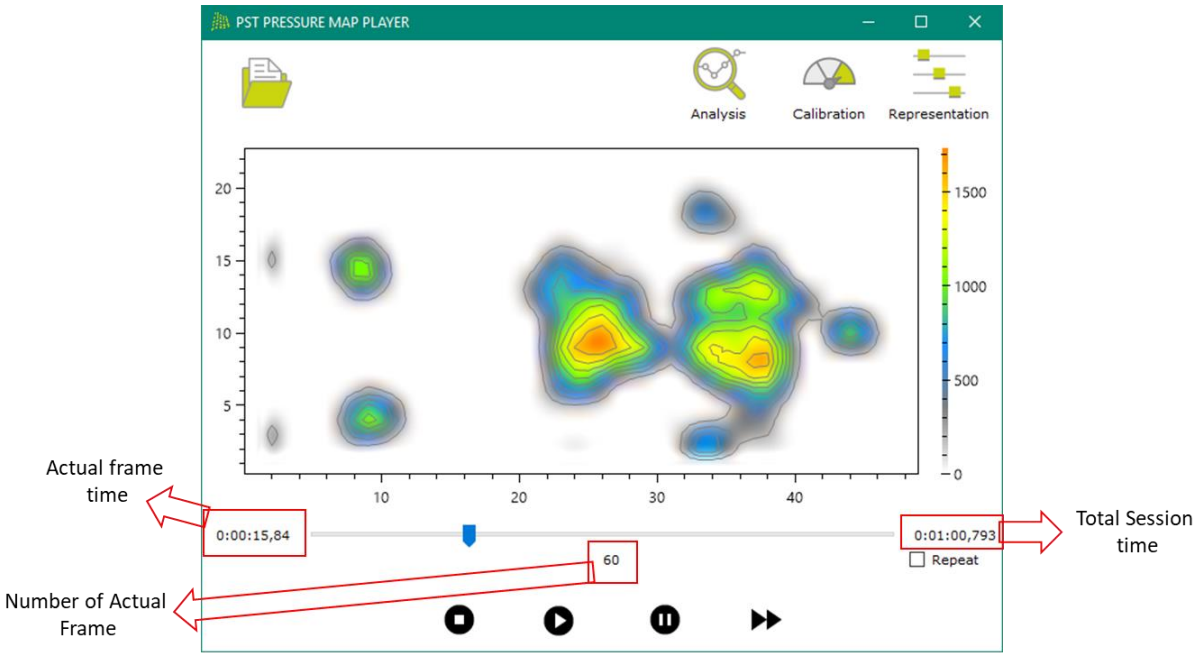


Figure 20, Example of Pressure Map Player

3.2.3 Data Analysis Window

- The **Analysis** button will load a new window that contains a form with different functions to analysis the pressure map. This form has the capability to enable or disable each statistic, also it has the feature to **Plot** each statistic over the time, and also the capability to export the statistics data over the time using .CSV format.

Each statistic in the Data analysis form have a Check Box to enable or disable. The form also has an "**All"** button that allows the user to easily enable all or disable all the statistics at the same time.

The Sensing Mat Software can represent multiple Pressure Sensors in parallel, so it's important to note that this Data Analysis form will have an association to the Pressure Map session that has been loaded from. This relation is noted by the FIGURE Number.

The Plot capability will allow the value of a selected statistic over the time with a cumulative time, it means the graph will be changing the time scale over the time to automatically fits the graph size. While the most time has passed, the more the time axis will represent.

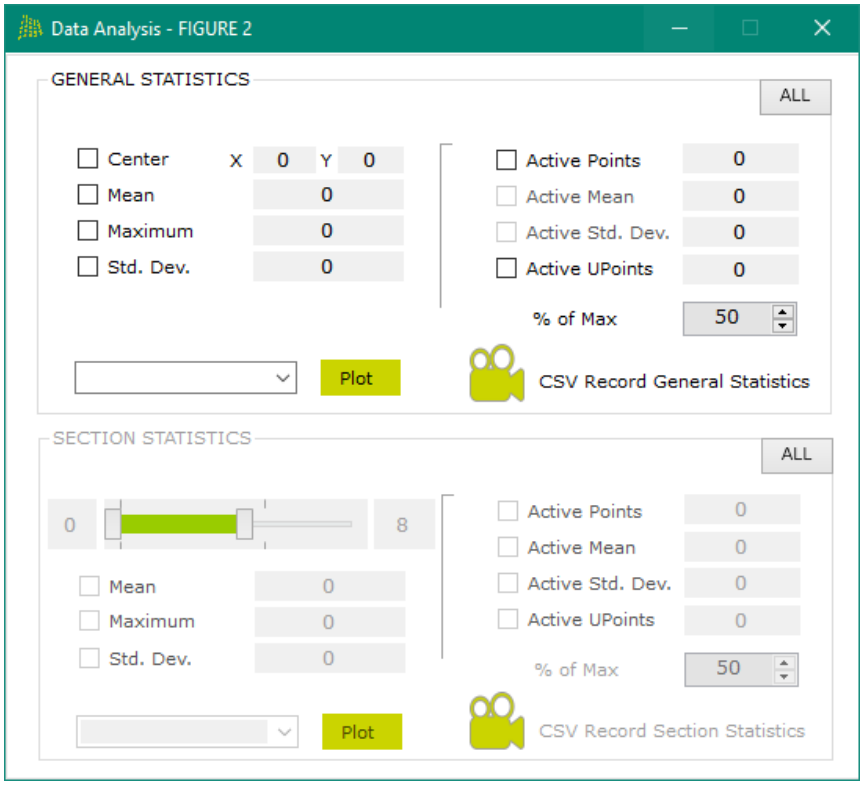


Figure 21. Data Analysis Form

Once the statistic of interest has been activated, the user can Select it from the drop list to Plot, as shown in the following example,

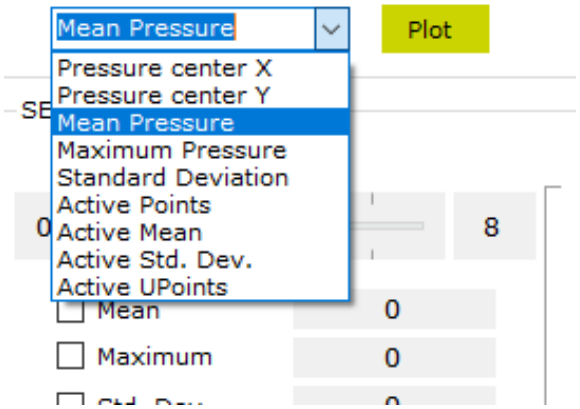


Figure 22. Drop List of Analytics to Plot

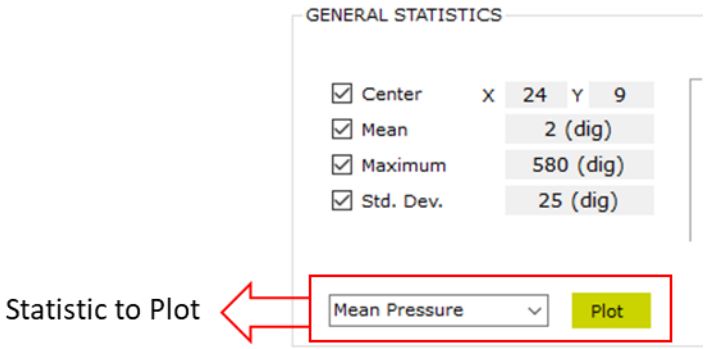


Figure 23. Plotting statistic values over the time

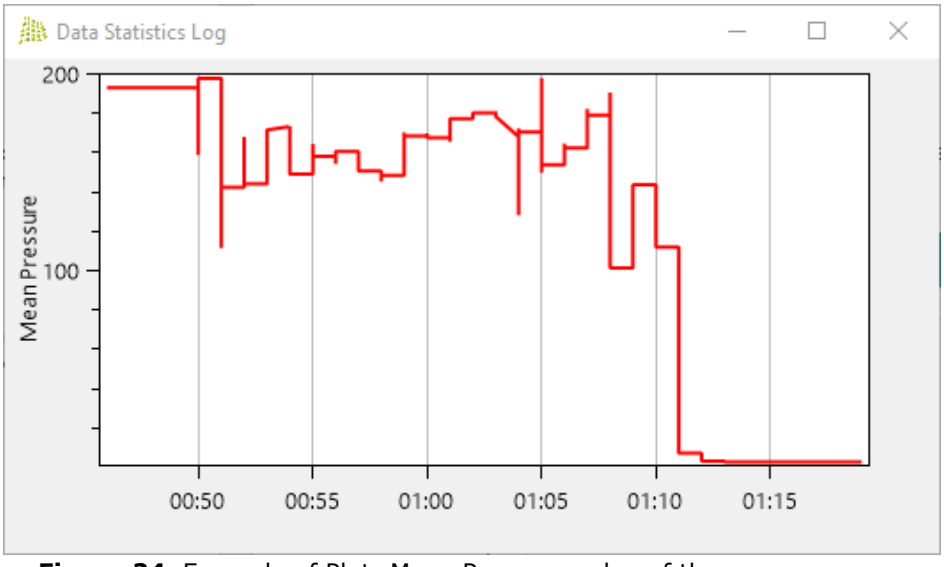


Figure 24. Example of Plot: Mean Pressure value of the pressure maps

User can create multiple Plots according to the statistic of interest, each plot has a dynamic management of the X axis over the time. It updates the Plot automatically every second.

When the time scale changes over the time, it will automatically adjust the time units

from seconds to minutes or hours.

The system has the features of plotting the dynamic behaviour of the metrics over the time, simply activate the metric desired to analyse over the time. Then use the Plot variable list in order to select it

There are two metrics lists and two Plot buttons, each one for the General and for the Section analysis; select the required unit and click Plot button. This will create a new window with the dynamic plot of the metric over the time.

The calculation is applied to all the pressure sensing elements of the full sensor. The Statistics related to the Active Points or Active Areas refers to the sensing points that has a pressure larger than the threshold. The size of the set of points will change depending on the number of Active Points.

The Active Points allow the identification of points that had a pressure larger than a defined percentage of the maximum pressure detected, this could be useful in the analysis of pressure distribution algorithms.

The Center of pressure is represented with a Cross  .

The Data Analysis form is divided in two parts, the General Statistics and the Section Statistics. General statistics will analyze the full pressure map area in order to calculate the different metrics. Section statistics will analyze a localized section of the sensor, this area can be customized using the following range selector controller:

The following table summarizes the different metrics that can be calculated using the Analysis Form, with its description.

Metric	Description
Center	Location of the X, and Y coordinates of the center of digital / center of pressure according to the pressure distribution.
Mean	Average of all the digital / pressure values
Maximum	Maximum of all the digital / pressure values
Standard Deviation	Standard Deviation of all the digital / pressure values
Active Points	Number of sensors with Digital/Pressure above the threshold
Active Mean	Average of digital / pressure values in the Active area
Active Standard Deviation	Standard Deviation of digital / pressure values in the Active area
Active Upoints	Number of sensors with Digital/Pressure above the percentage defined

CSV Record: It is possible to export the metrics data into a comma separated values file .CSV, including time stamps of each value for the two types of analysis: general or section.


CSV Record General Statistics


CSV Record Section Statistics

User can start recording the analysis data by clicking the button. The Icon will still in red color background, while it is recording the data.


CSV Record General Statistics

The file will be closed and finished properly when the user clicks again the controller and the background stays in white color.

The location of this CSV information is stored in the installation path in the folder "/CSV_STATS". The .csv file will have the format:

For General Statistics CSV Files, they have the format:

- "**SensingTexData_StatisticsyyMMdd_HHmmss.csv**" (yy stands for year, MM stands for month, dd stands for day, HH stands for hour, mm stands for minute, and ss stands for seconds.)

For Section Statistics CSV Files, they have the format:

- "**SensingTexData_Section_StatisticsyyMMdd_HHmmss.csv**" (yy stands for year, MM stands for month, dd stands for day, HH stands for hour, mm stands for minute, and ss stands for seconds.)

3.2.4 Calibration Settings Window


Calibration

The **Calibration** tool allow the user to load different calibration curves for the pressure sensor matrix. This curve could be specified in different units: mmHg, psi or g/cm^2.

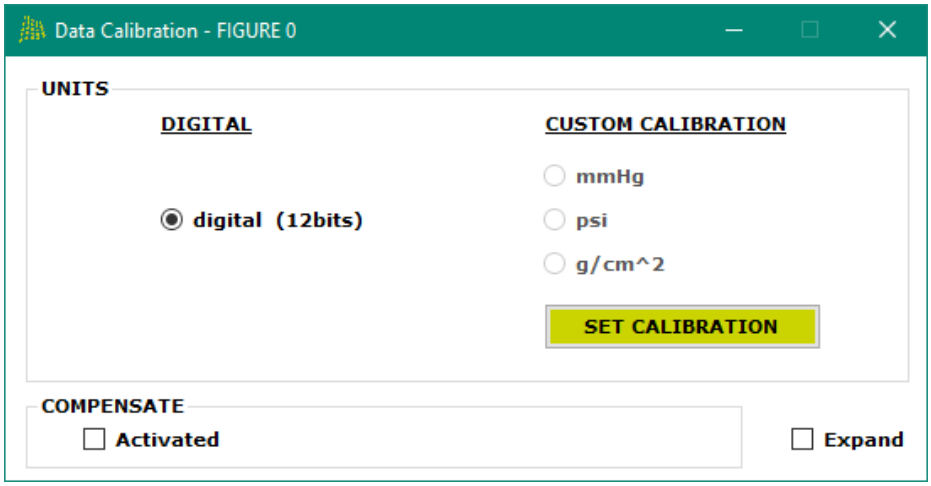


Figure 25. Data Calibration menu

The Calibration is specified in a table that correlate the Raw Data, in digital format, with pressure measurements. The table might cover the range of Raw Data values from 0 to 4095. The calibration table can be also saved and loaded in .JSON format files.

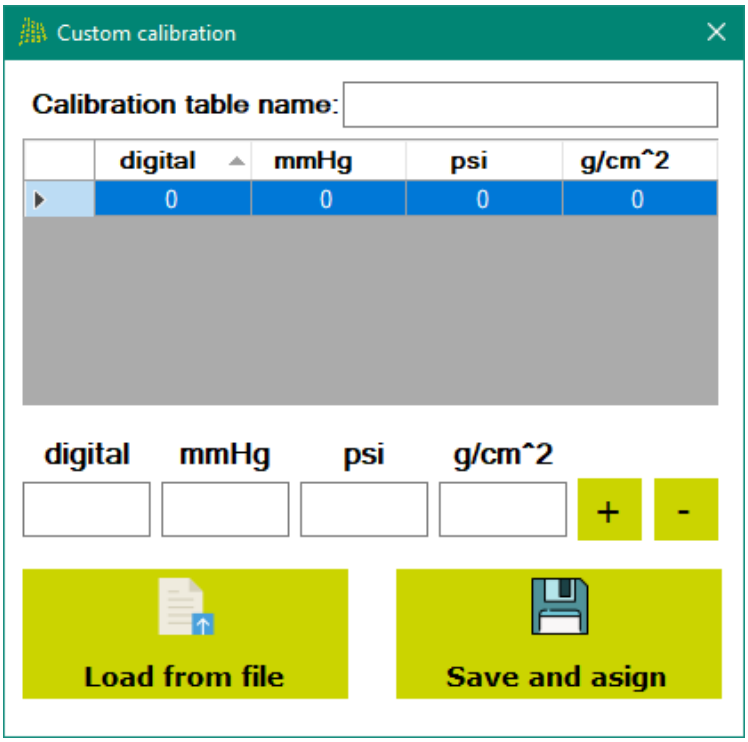
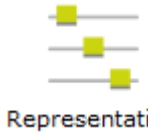


Figure 26. Calibration Table Editor

3.2.5 Data Representation Settings Window



The representation form allows the user a direct manipulation on the representation settings of the pressure maps.

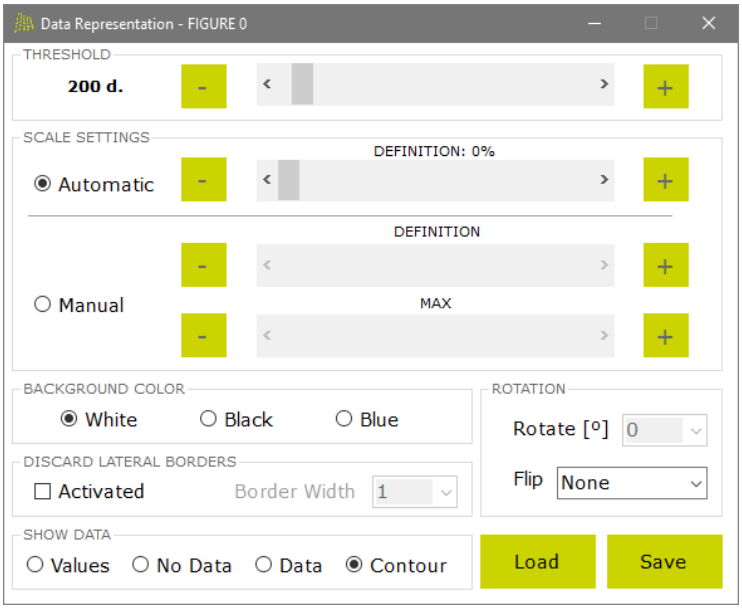


Figure 27. Data Representation Settings Editor

Threshold: This pressure value is the minimum to be represented, for certain situations there are pressure points in the lower pressure range due to the integration materials. In order to filter out these residual pressures, setting a threshold of a minimum pressure is useful. Every pressure value below the threshold will be represented as a 0.

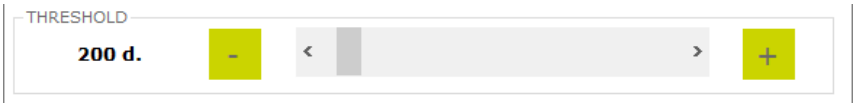


Figure 28. Threshold Editor Control

Scale settings: The relationship between colors and pressure values will correspond to these settings. As an example, the following is default color scale.

Figure 29. Dynamic or Static Color Scale

The color scale can be configured in two modes:

- **Automatic scale**, the white color corresponds to the DEFINITION. Software automatically will analyze the pressure map, and it will set the orange color to correspond with the maximum pressure value. This scale is dynamic, but it maximizes the color scale representation.

- **Manual scale**, the white color corresponds to the DEFINITION, and the orange color corresponds to the MAX fixed with the scroll bar.

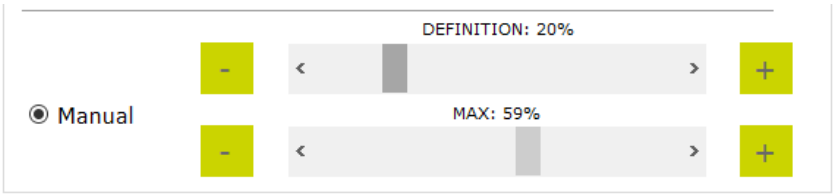


Figure 30. Static Color Scale Editor

Rotation: These two functions allow to flip horizontally and vertically the pressure map. For squared pressure maps it is also possible to specify a rotation of 90ª, 180ª or 270º.

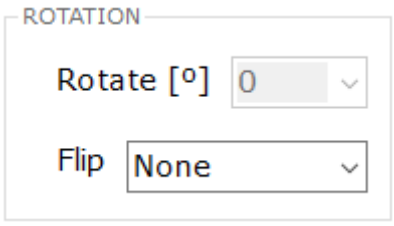


Figure 31, Rotation and Flip of pressure matrix

Background color: This setting will modify the background color of the pressure map plot, white, black or blue.

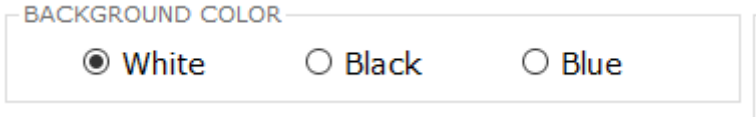


Figure 32. Background selection

Discard Lateral Borders: Some times, the bed size does not correspond with the sensor size exactly, and installation of the sensor results with folding the lateral areas of the pressure map, this constantly show pressures in the corner that are not of interest.

This feature allows the definition of a margin to discard that values. The discarded values will be assigned to 0, and they will not have any effect on the data analysis.

Figure 33. Lateral border discard

Show Data: The type of representation of the heat map can be modified using this setting. Particularly with Mattress Mat sensors, by default it is recommended to use Contour, because it has the better representation.

- **Values**: This option will represent only the numbers of pressure.

- **No Data:** Pressure data will be represented using the color scale, and interpolation inside the Heatmap, resulting in continuous surfaces of color gradients.

- **Data:** Pressure data will be represented using both: numbers and the color scale.

- **Contour:** Pressure data will be represented using the color scale, and interpolation inside the Heatmap, resulting in continuous surfaces of color gradients. Additionally, eight contour lines are used to represent the pressure value with same level.

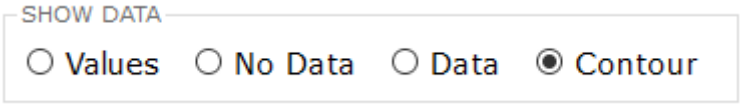


Figure 34. Type of pressure map representation

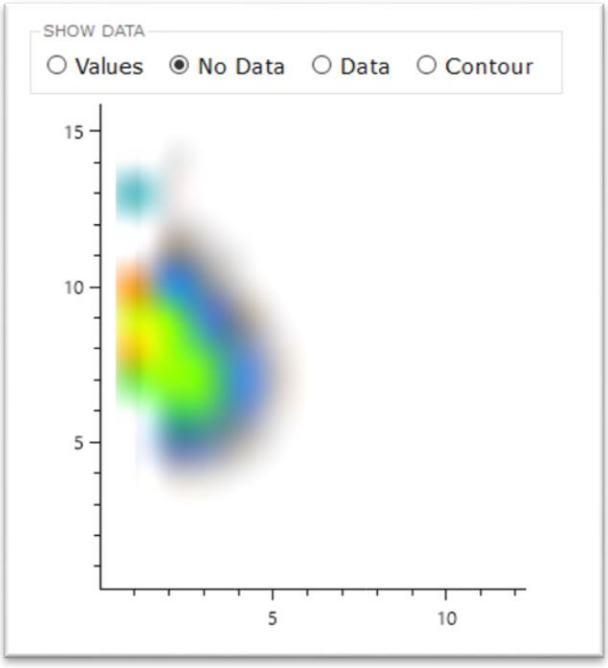


Figure 35. Example of "No Data" Show Data setting for the heatmap.

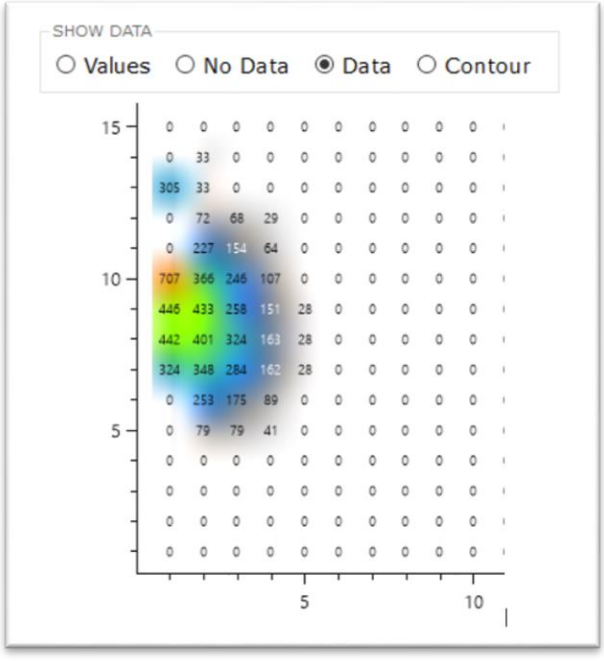


Figure 36. Example of "Data" Show Data setting for the heatmap

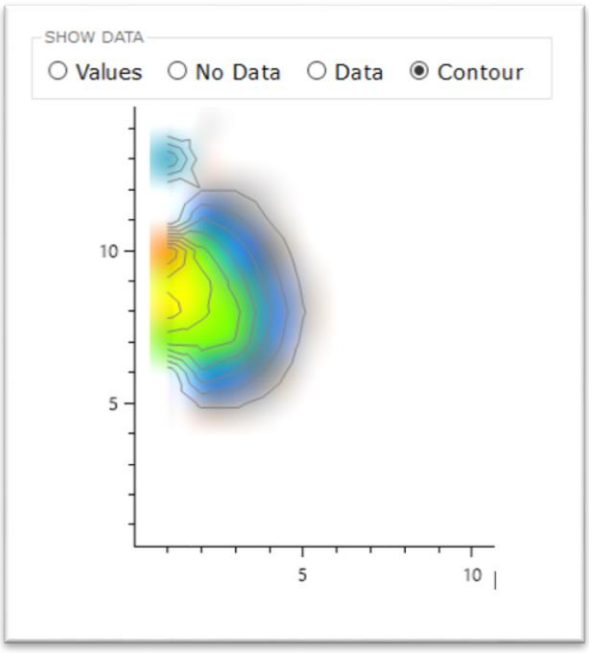


Figure 37. Example of "Contour" Show Data setting for the heatmap

Save and Load Data Representation Settings: Once the desired data representation has been configured, it is possible to save these settings into an internal .XML file, inside a folder with name "/Settings/. This Data representation configuration file is stored in the installation path of the software.

It is possible to store the settings using the "SAVE" button, and also "LOAD" previous created settings.

4. Sensing Tex Example Code

4.1. Sensing Tex Example Code for Windows (C#)

The Sensing Tex Windows Example Code is a Microsoft Visual Studio Solution that implements a basic functionality for software integration with Sensing Tex SDKs modules and SM Sensor products. It uses the Sensing Tex communication protocol for the pressure maps reading. Sensing Tex Windows Example Code contains the Serial COM ports management in order to stablish the link through the Bluetooth or USB connection. The source code is organized according to the following structure.

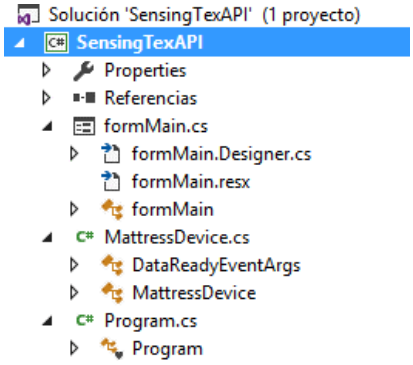


Figure 38, Sensing Tex Example Code Project

Figure 43. Sensing Tex Example Code Project

Two main subroutines of C# source code are provided in the Windows API: *MattressDevice.cs*, and *formMain.cs*. The routine *MattressDevice* has different functions in order to read the Data coming from the COM port according to the SensingTex protocol. The pressure map is stored in a dynamic variable matrix of type double called: Data[,], and the value of the pressure map is updated every time the software receives new pressure maps from the COM port.

Specific details related to the communication protocol are listed in the Communication Protocol chapter 5. The *StartDevice*() and *StopDevice()* routines are not required for actual SDKs modules. For previous generations of SDK like Premium SDK01 devices, it is required to add this two specific procedures for the communication to start and stop.

The subroutine *DataReadyEvenArgs* will detect when new pressure maps are received and updates the values for the new Data[,] pressure map. It is possible to copy the actual pressure map from this matrix, and store in another variable, then apply the processing or dynamic analysis of interest. The frequency of pressure map readings will depend on the sensor size, and the COM mean used, however for the latest SM SDK05 and a 16x16 the refresh rate of pressure map can go up to 20 maps per second.

MattressDevice.cs subroutine will construct the pressure map matrix according to the information it receives directly from the SDK module. It acts like the data receiver, and it is prepared to work correctly with the firmware implementation in SDKs. In case it receives any error of communication according to the protocol, it will retry and continue the pressure map representation.

The *formMain.cs* is the GUI for the pressure map representation, it includes the COM port connection and disconnection commands, and also it includes a basic feature for data filtering which is the Threshold value. This value will determine the minimum pressure to represent, so for example, very low random pressure values coming from noise in the electronics can be filtered by applying a threshold of 80.

The pressure is represented in two manners, one by its digital value, and by a simple color scale. Black means no pressure, blue low pressures, green a middle range of pressure and red the maximum pressure. Color scale can be customized according to the needs, the function that assigns a color according to the pressure is *colorFromValor* inside the subroutine *formMain.cs*.

The digital reading measurement is also displayed as the numeric value in the middle of each sensor representation spot. Digital values are not representing any physical unit for pressure, in order to represent pressure data a conversion procedure is required. This can be a result of a calibration procedure according to the materials used on the integration. It is also possible to use standard calibration equivalences, specified in predefined curves provided by Sensing Tex. The electronic circuit for the pressure reading and the sensor spot size can vary the digital unit pressure equivalence. The White Paper has the pressure ranges where the SM sensors behave linearly.

Particular applications may require high sensitivity for low pressure values. Sensing Tex also offers custom solutions for low noise and high sensitivity applications. Normally the SDKs may introduce noise in the very low pressure range, in the pressure map representation.

5. SDK Communication Protocol

The protocol we use to send the pressure data from our SDK is designed thinking on a quick and easy implementation of acquisition software solutions. Received data can be easily received and processed.

CONNECTIVITY
Standard SDK have Bluetooth connectivity that implements 2.1 version and SPP profile, so it can be controlled as a serial port via computer.

There is no need to interact with the SDK, it is always continuously sending information. As soon as the connection is set, you will receive information.

DATA STRUCTURE
The dataset of the entire sensor (16x16 matrix) has a fixed 564 bytes structured as follows length:

START SEQUENCE	ROW DATA 1	ROW DATA 2	ROW DATA 3	..	ROW DATA 16

START SEQUENCE

0x48	0x00	0x0A

3 bytes that sets the beginning of a dataset.

DATA ROW x

0x4D	0x10	Row id	Sensor 1	Sensor 2	Sensor 3	..	Sensor 16	0x0A

0x4D: indicates the start of a row.
0x10: indicates the number of sensor points of the line. It will always be 16 (0x10).
#id row: 0-15 byte indicating which row of the sensor is received.
Sensor x: 2 bytes pressure data. Values between 4095 (0x0FFF) and 0 (0x0000) will be received. 4095 means no pressure and 0 maximum pressure.
0x0A: indicates the end of a row.

Notice that initial and ending bytes (0x48, 0x4D, 0x0A) are ASCII codes for 'H', 'M', '\n'. It is sometimes useful for a quick "visual debugging".

EXAMPLE

Example dataset of a 16x16 sensor in hexadecimal format

```
0x48 – 0x00 – 0x0A                              //START SEQUENCE

0x4D – 0x10 – 0x00 – 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF
0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF – 0x0A

//ROW 0 INFORMATION

0x4D – 0x10 – 0x01 – 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF
0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF – 0x0A

//ROW 1 INFORMATION

0x4D – 0x10 – 0x02 – 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF
0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF – 0x0A

//ROW 2 INFORMATION

0x4D – 0x10 – 0x03 – 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF
0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF – 0x0A

//ROW 3 INFORMATION

0x4D – 0x10 – 0x04 – 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF
0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF – 0x0A

//ROW 4 INFORMATION

0x4D – 0x10 – 0x05 – 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF
0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF – 0x0A

//ROW 5 INFORMATION

0x4D – 0x10 – 0x06 – 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF
0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF – 0x0A

//ROW 6 INFORMATION

0x4D – 0x10 – 0x07 – 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF
0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF – 0x0A

//ROW 7 INFORMATION

0x4D – 0x10 – 0x08 – 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF
0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF – 0x0A

//ROW 8 INFORMATION

0x4D – 0x10 – 0x09 – 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF
0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF – 0x0A

//ROW 9 INFORMATION

0x4D – 0x10 – 0x0A – 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF
0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF – 0x0A

//ROW 10 INFORMATION

0x4D – 0x10 – 0x0B – 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF
0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF – 0x0A

//ROW 11 INFORMATION

0x4D – 0x10 – 0x0C – 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF
0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF – 0x0A

//ROW 12 INFORMATION

0x4D – 0x10 – 0x0D – 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF
0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF 0x0FFF – 0x0A
```

5.1 Initialization command to set the communication protocol

It is important to implement by software an instruction that sends an initial command from the PC or software side. Initialization command is required to be sent once the connection has been stablished, it is the 'S' ASCII character from the PC to the SMDK in order to start the communication with the device.

If the Initialization command is not sent, the format of pressure maps is different and it is not readable with this protocol, so it is a prerequisite to send the Initialization command in order to ask the SMDK to send pressure maps according to this communication protocol.

5.2 Byte ordering and parsing of the pressure data into variables

Values of maximum pressure corresponds to 4095, it will correspond to 0FFF in hexadecimal, and it is in two bytes sent as:

```
FF 0F
```

The first byte corresponds to the lower significant digits, after that the most significant digits are sent. Software may save these two bytes in different variables, and merge them in an integer variable, this operation is illustrated in the function of the provided Windows API.

Any custom software that need to acquire the data in according to this protocol may use loops to order or parse data correctly into a matrix, and each matrix of sensor spots (pressure map) for each time is sent divided by the character 'H'.

For development purposes, it is useful that the received character corresponds to the "0x4D" or asci 'M'. When software finds this, it is possible to use the next byte to check the number of lines in the matrix, because X always stands for the number of lines. After that, the following byte is the identification of the row. Software may can use a temporary variable to store each received byte and then use "if "sentences in order to parse properly all the information.

When the software gets pairs of bytes, corresponding to the pressure data. The software may reorganize the data as low significant byte first then the most significant byte, this is achieved by concatenation.

Example of concatenation in C sharp:

```
tmp = this.ReadByte();

//Read the byte then assign it to the variable:
adc_value = tmp;

//Read the following byte tmp = this.ReadByte();
adc_value |= ((int) tmp) << 8;
```

If software concatenates the bytes in the correct order and assign the result value into an INT variable you can interpret properly the pressure data.

6. Firmware modifications or updates for the SMDK

SMDK inside has a microcontroller that is programed to continually configure the ports to apply a certain voltage and measure signals from the sensor as fast as possible.

Sensing Tex can offer for certain projects or requirements customized firmware, or firmware modifications after the purchase, it implies that users may have the need to modify the firmware.

FIRMWARE UPLOAD PROCEDURE

The SM_SDK 05 is based in a microcontroller, the low-level logic that controls the behavior of the microcontroller is specified in the device firmware. Sensing Tex may introduce firmware updates or changes depending on the specific customer requirements.

⚠ **NOTE:**

In order to change the firmware, Sensing Tex provide this procedure. However, the firmware upload is a risky procedure, the SMDK 05 can be damaged if the firmware upload is abruptly interrupted or disconnected during the flash memory writing procedure.

Pre requisites:

- PC running Windows 7, 8 or 10 version.
- USB free port.
- USB-micro USB cable.
- Have installed previously the SMDK driver provided in the Dropbox link.

7. Pressure Sensor Measurement

The SMDK acquisition modules are transducers that convert the textile hardware characteristics into a digital information, this implies a conversion between real pressure into electric resistance, then a comparison between a reference and the Pressure Sensor status is transformed into a voltage difference.

The SMDK had ADC converter that could transfer this voltage difference into the digital domain. The following figure shows the different domains associated to the PST measurement.

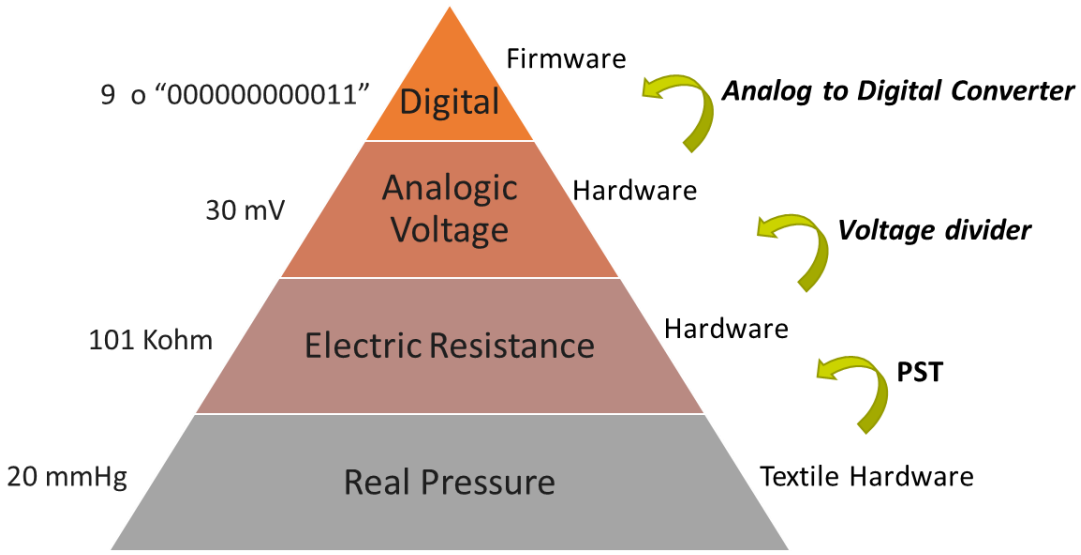


Figure 39. Pressure transduction used for PST Measurement

Sensing Mat Sensors are manufactured with printed electronic processes, it allows the construction of crossbar matrix of conductive materials over flexible substrates. The crossing areas of matrix contains the pressure sensing elements, depending on the connection used for the measurement of the impedance the circuit response can have different responses in terms of Ghosting effect but also in terms of sharing row or column interference.

This effect is also known as the sneak-path in memristor crossbar structures.

SM SDKs allow three different types of measurement configuration:
1) Standard
2) Premium
3) Mix

7.1 Standard measurement

Recommended for: Dynamic pressure applications and shape analysis, where the pressure accuracy is not critical.

The SMDK allow the measurement of each channel without disconnecting other parallel channels. This kind of measurement reduces drastically the Ghosting effect. The standard type of measurement is used by default in all the SMDK. However, as a counterpart non desired effect occur when multiple sensors are pressed at the same time, the pressure values are decreased because the sharing row sensors decrease the current and divide it between the shared pressed elements.

This sharing current losses can be compensated using a software algorithm that consider the measurements of all the matrix and depending on how many sharing elements are being pressed it compensates de pressure measurement. This compensation algorithm is explained in the section 8.

Ghosting effect: It is a known effect that makes the illusion to measure fake spots when three sensor points are pressed with sharing row between two of them, and sharing column between two of them, when Ghosting effect is not corrected, the cross-bar matrix creates this non-desired effect.

Ghosting Effect examples: The following 10x10 pressure maps are being pressed only in three points, if the conditions of sharing column and row occur between these three points, the Ghosting effect occurs. The points pressed are marked with green color, and the red color is a measurement not related to pressure.

Example a:

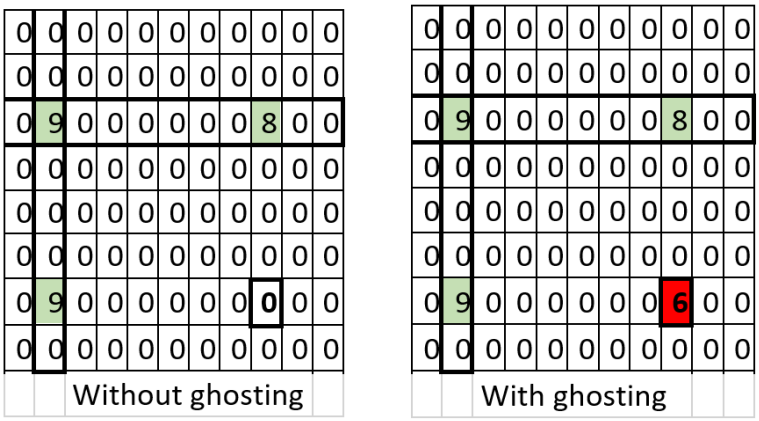


Figure 40. Ghosting Effect Example a

Example b:

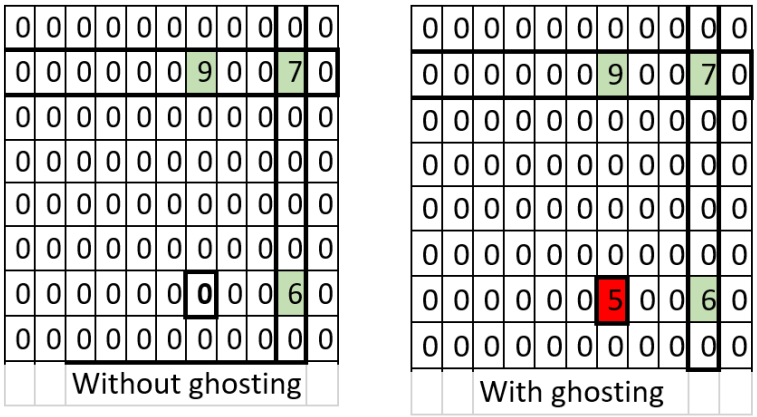


Figure 41. Ghosting Effect example b

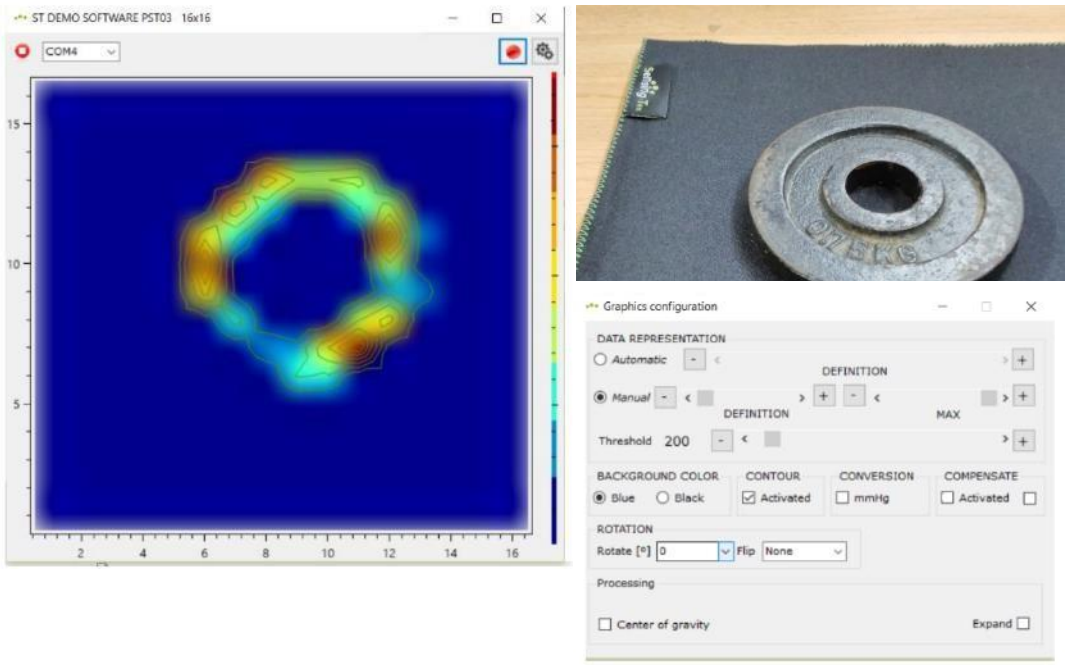


Figure 42. Example of pressure mat no-compensation

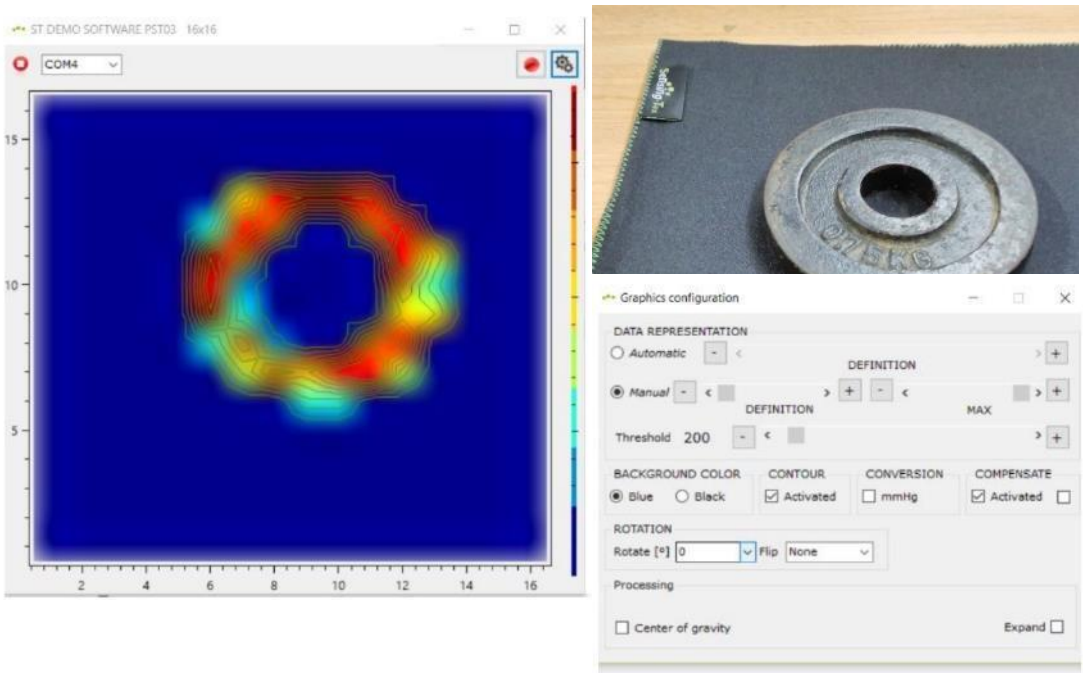


Figure 43. Example pressure map with compensation

7.2 Premium measurement

Recommended for: High pressure accuracy required applications, with fast response, when the shape analysis is not critical and Ghosting effect does not affect or can be compensated.

In order to avoid correlation between adjacent sensing elements, the SDK can measure each matrix element disconnecting the other elements from the matrix. This makes the measurements to rely directly only in the elements being pressed, and independent of sharing row measurements.

This approach is recommended for applications that require high pressure accuracy, because the measurements are absolute. The Ghosting effect is not mitigated by this approach, so the disadvantage of this approach is large non-desired results in the measurements due the Ghosting effect.

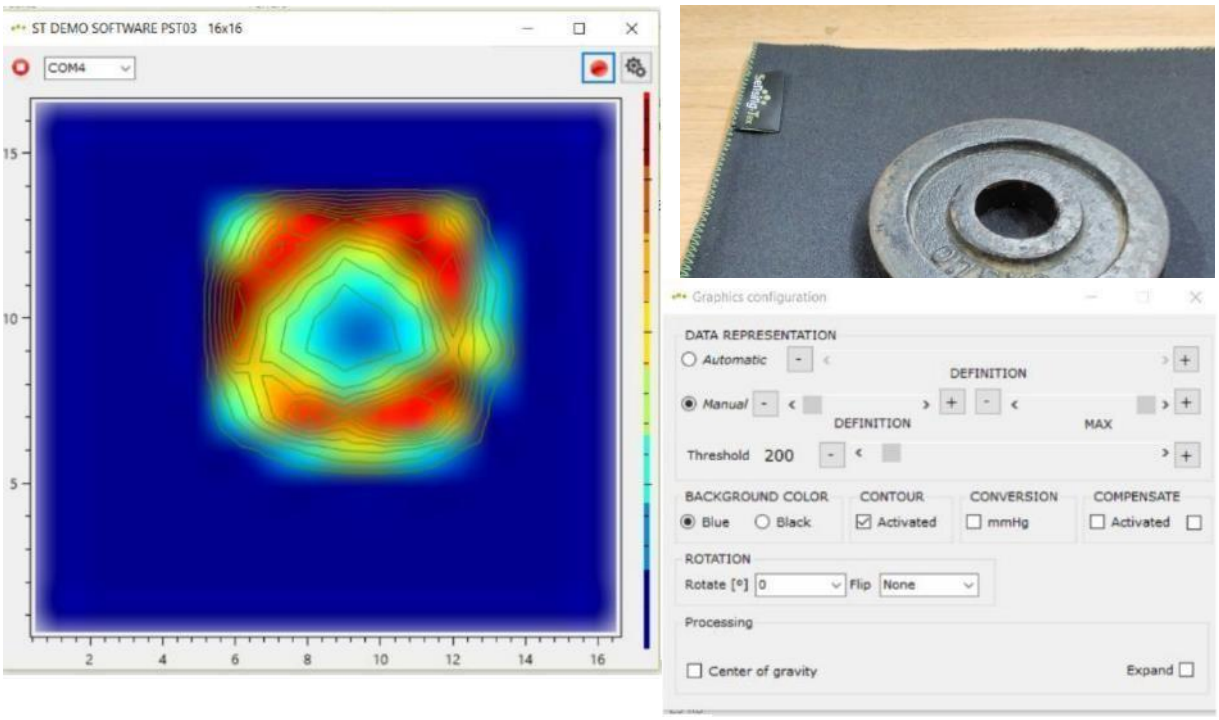


Figure 44. Example pressure map premium measurement

7.3 Mix measurement

Recommended for: Dynamic pressure applications and shape analysis, where acquisition rate is not critical but the pressure accuracy is important.

Using this approach, the SDK is capable to measure two different pressure maps, the first one with standard measurement, and the second one with premium measurement. By filtering the Premium pressure map using the results of the standard pressure map it is possible to mix the advantages of both types of measurements.

Pressure maps obtained by Mix measurement mode will have absolute pressure measurements with a drastic Ghosting reduction. The disadvantage of this measurement mode is that it requires the measurement of two pressure map and a

filtering processes in the SDK microcontroller. This reduces the speed of the acquisition system, and is not recommended for dynamic applications that require fast as possible measurements.

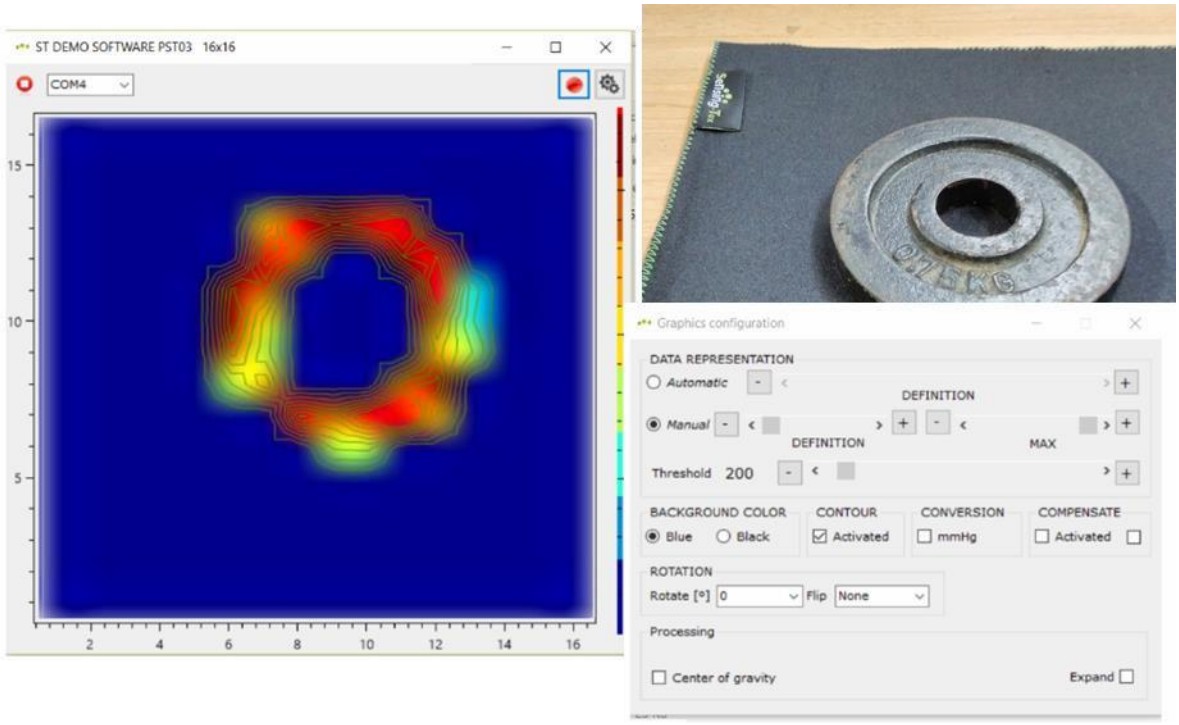


Figure 45. Example Pressure Map Mix FW

6.2. Firmware modification

1. Run the software SM_SDK_05_Firmware_Upload.exe

This software will have the following window:

Figure 46. FW modification/updating

2. Once the window is ready, press the OPEN HEX FILE button with  icon, or selecting the option OPEN HEX FILE from the File menu bar. Locate the .HEX file you need to upload and click Open.

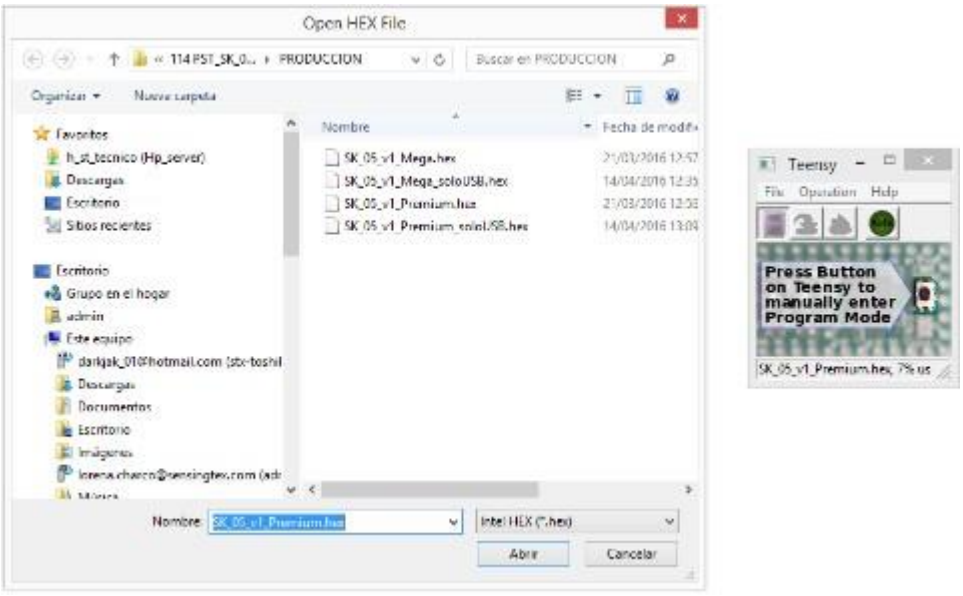


Figure 47. HEX File selection

3. Press the AUTO button, the icon must change from the OFF appearance  to the ON  .

Figure 48. Press button to charge FW

4. Open in a windows explorer window the Firmware Uploader folder. Navigate and find the executable "Teensy-reboot.exe". Visualize both windows, the explorer and the Firmware uploader at the same time, like in this example.

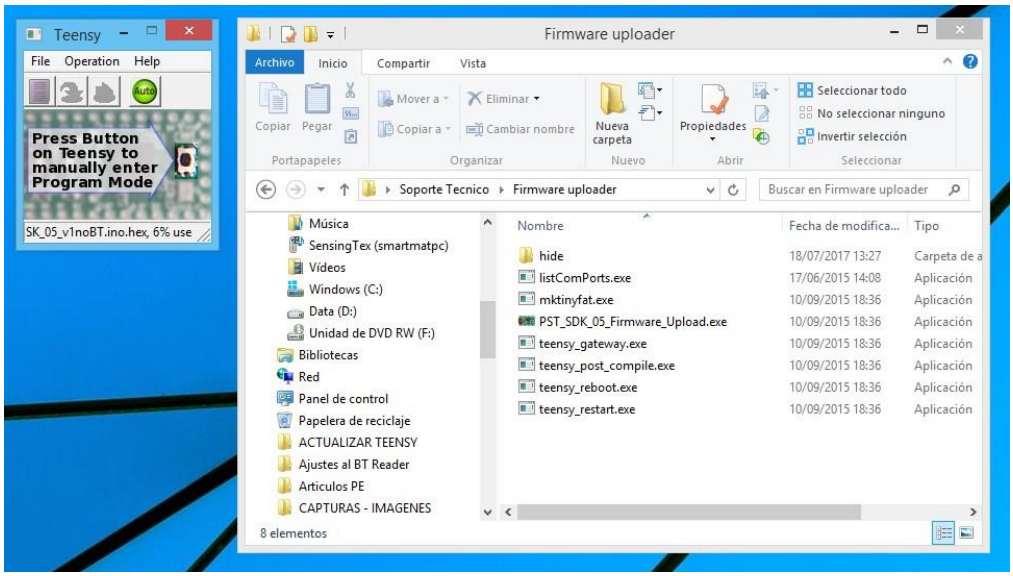


Figure 49. Firmware Uploader folder

5. Run the program "SM_SDK_05_Firmware_Upload.exe", this will prompt a command line window. This window has black command line with no text.

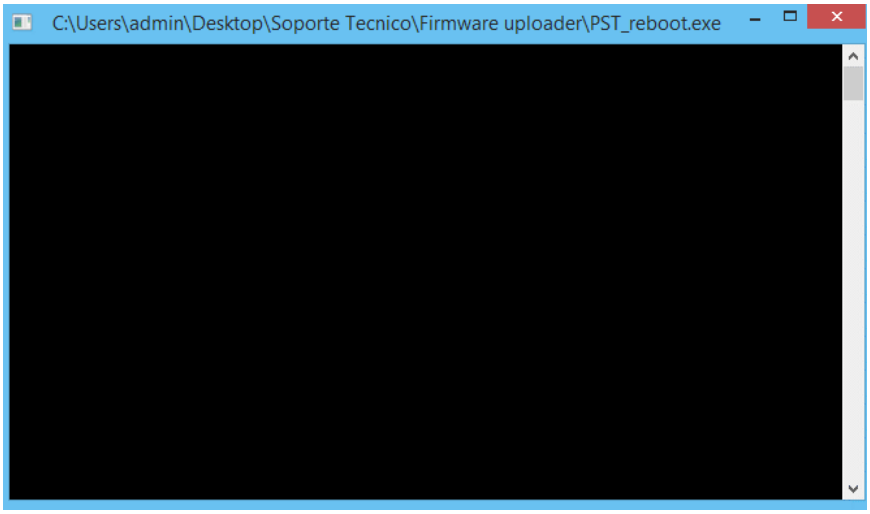


Figure 50. Command screen

At the same time the window of the Firmware Uploader window will display a progress bar indicating the flash memory writing procedure, this is a fast procedure.

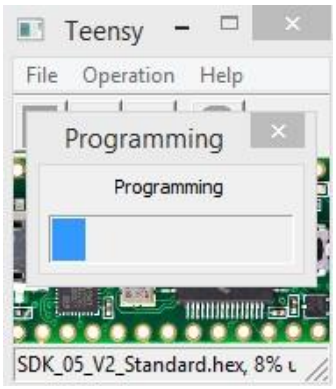


Figure 51. Programming progress bar

The Firmware Uploader window will display a growing status bar, and after that it will display the message **"REBOOT OK".** This message indicates that the firmware has been successfully uploaded.

Figure 52. Upload confirmation

6.3. Software compensation for Standard type measurement

Standard type of measurement decreases the ghosting effect, but it has also a side effect: when measuring a specific sensor point, all others points pressed in the same column will affect its measure by reducing its value. We call this *sharing column effect*.

6.3.1 Shared Column Compensation

All measurements are inside the digital range of the ADC, by default SMDK uses 12 bits range, in order to compensate properly, it is important to compensate according to the range.

The following compensation rule could reduce the shared row voltage drop due to the crossbar topology of the Pressure Sensor.

Given a pressure sensor matrix with i index for Rows, and j index for Columns, the system can measure individually all the locations over the matrix for the voltage measurement $v(i,j)$, an acquisition module with voltage divider principle used to measure the resistance of a sensor element, given a reference component R_{fix}.

$$V_{NumCol}(j) = V_{ADC_{3.3V}} - \sum_{i=0}^{Rows} v(i,j)$$

$$R'(i,j) = \frac{R_{fix} \cdot V_{NumCol}(j)}{v(i,j)}$$

$$v_{comp}(i,j) = \frac{V_{ADC_{3.3V}} \cdot R_{fix}}{R_{fix} + R'(i,j)}$$

The typical values for the a standard SMDK will be $V_{ADC_{3.3V}} = 4095$ and $R_{fix} = 1000\Omega$. But it may be modified under specific custom made circuits

The compensation rule will consist on measuring all the matrix, and then calculate V_{NumCol} for all the columns, then it is possible to apply the compensation rule for each $v(i,j)$. At the end of the compensation, it is possible to use the $v_{comp}(i,j)$ values for all the pressure matrix.

6.3.2 GPIO Impedance Compensation

The SMDK aims to measure pressure while in the transduction principle there is impedance measurement involved. This implies that there are additional effects that could strongly modify the measurements due to impedance modifications of the comparator circuit.

The impedance of the senor elements is proportional to the pressure, and the sensor elements interconnection, connector and peripherals are normally known and could be characterized. This impedance effects could be typically modeled as two different main effects:

1. Conductive tracks impedance.
2. General Input Output port impedance.

It is possible to compensate the conductive tracks impedance in the case of very large sensors where the impedance of interconnection traces for sensor elements could vary its impedance introducing more than 10 ohms in traces. For small sensors, the effect of interconnect impedance lower than 3 ohms is neglectable.

The impedance of General Input Output ports used to acquire the pressure map sensors. This effect could be compensated by passing to the impedance domain the pressure matrix, then count the number of active sensor elements in the same Column N_{Active} and subtract the equivalent impedance

$$R(i,j) = R(i,j) - R_{GPIO} \cdot N_{Active}$$

The microcontrollers used in the SMDK had an equivalent $R_{GPIO} = 30\Omega$

All of these techniques are focused on compensating effects of the electronic module to measure the right resistance on each single sensor element within a matrix topology

7. Pressure measurement units

The SMSDK has an acquisition electronic module that measure the impedance of each single pressure sensor spot in the SM matrix. In order to reduce the calculations inside the SDK microcontroller, the unit conversion is delegated to higher processing levels in the software side.

The acquired data is sent on a 12-bit digital scale, according to the hardware ADC resolution, older versions of SDK has only 10-bit resolution. These digital values have a correspondence with resistance and pressure values.

7.1. Conductance Vs Pressure of SM Series

This paragraph contains a description of the Sensing Mat piezoresisitive features through experiments.

The first experiment was carried out to analyze the relation between conductance and pressure for a pseudo dynamic test, the Piezo Fabric Q8 itself and a mustimeter to read directly the changes in the resistance vs pressure.

Piezo Fabric Q8 has been the standard materials used for all of the Development kits up-to-date but new Piezomaterials: Piezolayers: Pseudoplastics and fabrics as far as ink piezomaterials printable solution may be customized thanks to the expertise of Sensing Tex Engineering team.

7.1.1. Single Point Calibration Curves SM Series Piezo Fabric Tech 1.# Standard solution integrated on development kits (excluding Mattress Mat Dev Kit)

These SM sensors have a circular pressure sensitive element distributed over the matrixes, with a diameter of 10 mm. The next table and graph shows the behavior of our Piezo Fabric Q8 when submitted to pressure on a pseudo-statical test

- Sensor Spot Size: 10mm diameter round shape
- Type of conductivity: vertical
- Composition: Q8 peizoresistive fabric
- Sensor Part Number: SM01-Q8

Weight [gf]	Pressure [gf*cm^{-2}]	Pressure [mmHg]	Resistance [Ω]	Conductance [S]
10	12.74	9.37	454000	2.20E-06
20	25.48	18.74	101375	9.86E-06
30	38.22	28.11	19787	5.05E-05
40	50.96	37.48	5067	1.97E-04
50	63.69	46.85	3575	2.80E-04
60	76.43	56.22	2276	4.39E-04
70	89.17	65.59	1659	6.03E-04
80	101.91	74.96	1515	6.60E-04
90	114.65	84.33	936	1.07E-03
100	127.39	93.70	909	1.10E-03
120	152.87	112.44	626	1.60E-03
140	178.34	131.18	492	2.03E-03
160	203.82	149.92	476	2.10E-03
180	229.30	168.66	372	2.69E-03
200	254.78	187.40	311	3.22E-03
220	280.25	206.14	308	3.25E-03
240	305.73	224.88	307	3.26E-03
260	331.21	243.62	241	4.15E-03
280	356.69	262.36	201	4.98E-03
300	382.17	281.11	233	4.29E-03
345	439.49	323.27	185	5.41E-03
385	490.45	360.75	154	6.49E-03
425	541.40	398.23	129	7.75E-03
445	566.88	416.97	115	8.70E-03
485	617.83	454.45	112	8.93E-03
525	668.79	491.93	96	1.04E-02
565	719.75	529.42	101	9.90E-03

Table 1. Conductance vs Pressure SM01-Q8

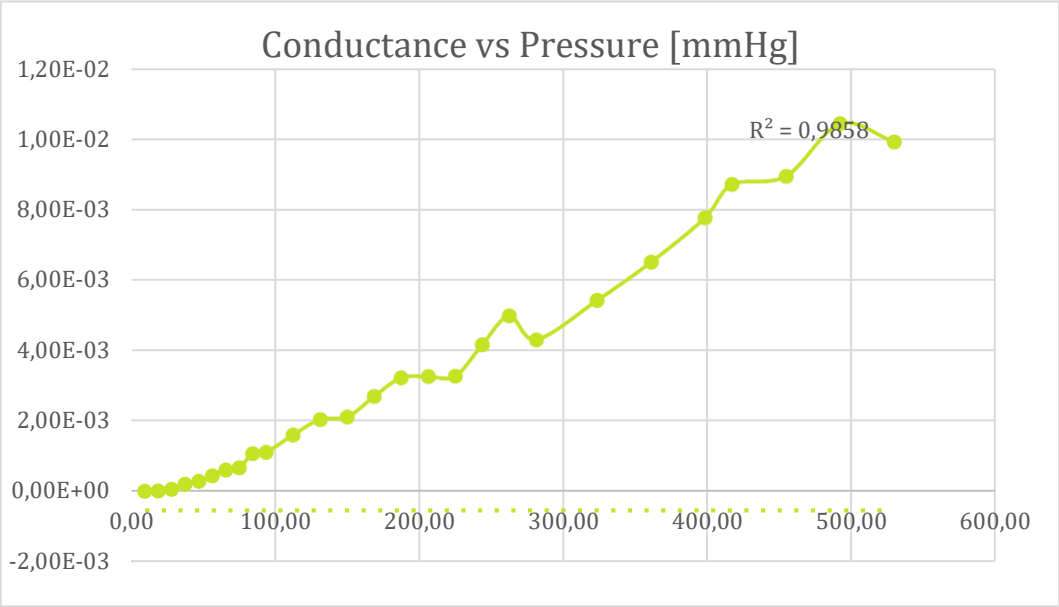


Figure 53. Conductance vs Pressure SM01_Q8

7.1.2. Single Point Calibration Curves new SM Series Piezo Ink Tech 3.# Custom Samples

The piezo ink was analyzed with a SM01 that has the piezo ink printed on both sides.

- Sensor Spot Size: 10mm diameter round shape
- Type of conductivity: Vertical
- Composition PiezoInk: 40% B23 + 60% B24. The piezoresistive ink was applied on both printed layers.
- Sensor Part Number: SM01-PI-B2340B2460-B

Weight [gf]	Pressure [gf*cm^{-2}]	Pressure [mmHg]	Resistance [Ω]	Conductance [S]
85	108.28	79.65	72438.5	1.38E-05
185	235.67	173.35	25940	3.86E-05
285	363.06	267.05	20019	5.00E-05
385	490.45	360.75	16300	6.13E-05
485	617.83	454.45	12700	7.87E-05
585	745.22	548.16	11950	8.37E-05
685	872.61	641.86	10550	9.48E-05
785	1000.00	735.56	9050	1.10E-04
885	1127.39	829.26	8526.5	1.17E-04
985	1254.78	922.96	8364.25	1.20E-04

Table 2. Resistance vs Pressure. Piezoresistive sensor SM01-PI-B2340B2460-B

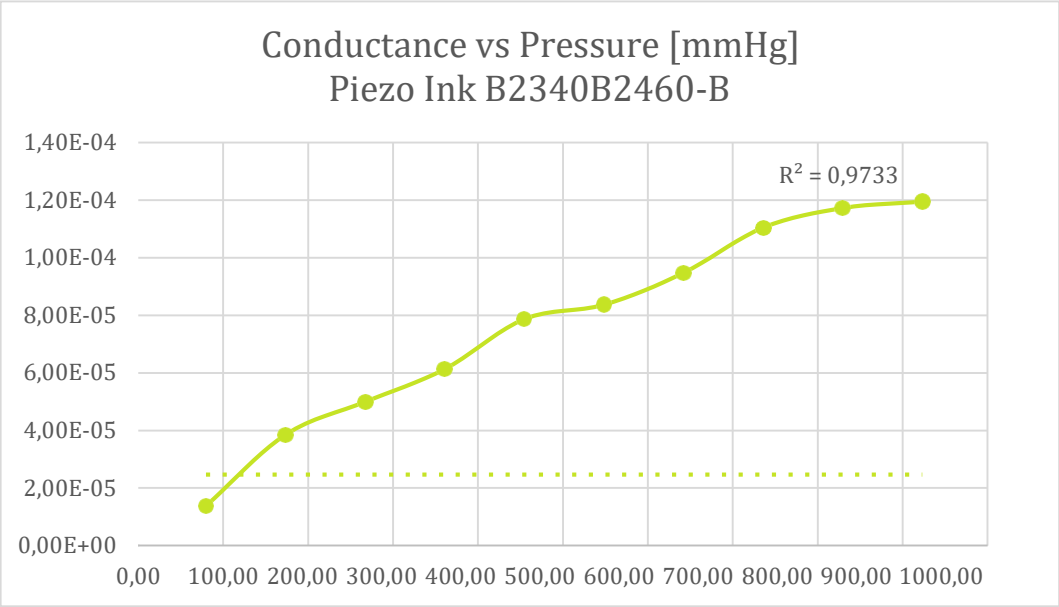


Figure 54. Conductance vs Pressure Piezo Ink

7.2. Single Point Calibration Curves for the Mattress Mat Dev Kit

This test has been carried out with a single sensor element of the Mattress Mat Dev Kit:

- Sensor Spot Size: 22.5 mm diameter round shape
- Type of conductivity: Vertical
- Composition: Q8 peizoresistive fabric
- Sensor Part Number: SMMM01-Q8

The units of the acquisition modules are voltage measurements from an ADC circuit.

Weight (g)	Pressure [gm/cm^2]	Pressure [mmHg]	Resistance [Ohm] 5 min	Conductance [S]	Voltage [V]	Digital Data
70	18.42	13.55	1507.00	6.64E-04	1,32	1633
80	21.05	15.49	1210.00	8.26E-04	1,49	1853
90	23.68	17.42	997.80	1.00E-03	1,65	2050
100	26.32	19.36	848.30	1.18E-03	1,79	2216
120	31.58	23.23	701.40	1.43E-03	1,94	2407
140	36.84	27.10	589.40	1.70E-03	2,08	2576
160	42.11	30.97	517.91	1.93E-03	2,17	2698
260	68.42	50.33	352.70	2.84E-03	2,44	3027
360	94.74	69.68	266.85	3.75E-03	2,60	3232
460	121.05	89.04	241.85	4.13E-03	2,66	3297
560	147.37	108.40	239.45	4.18E-03	2,74	3406

Table 3. Pressure and Digital Measurement correlation static behavior

The Table 3 contains pressure acquisition data for a wide range of pressures between 13mmHg up to 110mmHg. The values are for the static behavior, in order to isolate the drift from the piezo resistive element, the resistivity measurement is considered after 5 minutes of pressing the sensor.

White paper gives details on the drift of this type of sensor, and in case that more dynamic application, another range of calibration is required and different dynamic responses of resistivity result from the sensor.

The SM has two main pressure ranges that allow a correlation between the resistance and the applied pressure, Figure 59 show the Low pressure range from 13mmHg up to 110mmHg.

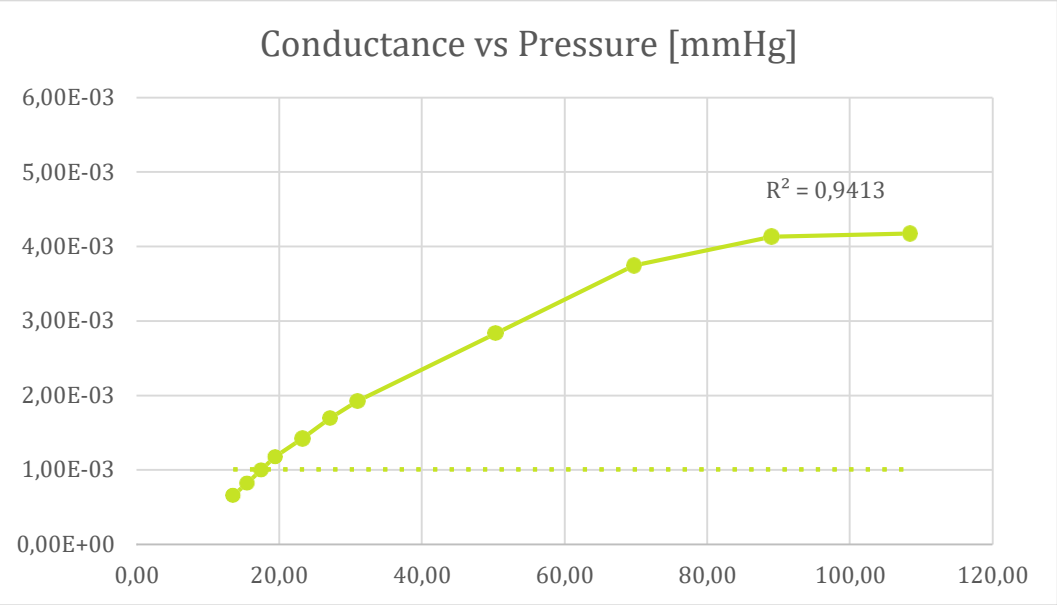


Figure 55. Low Pressure Range (25mmHg to 200mmHg)

7.3. Calibration Curves for the Fitness Mat Dev Kit

This test has been carried out with a single sensor element of the Fitness Mat Dev Kit:

- Sensor Spot Size: 14 x 16 mm square lateral conductivity shape
- Type of conductivity: Lateral
- Composition: Q8 peizoresistive fabric
- Sensor Part Number: SMFM01-Q8

Weight (g)	Pressure [gm/cm^2]	Pressure [mmHg]	Resistance [Ohm] 5 min	Conductance [S]	Voltage [V]	Digital Data
70	18.42	13.55	1507.00	6.64E-04	1,32	1633
80	21.05	15.49	1210.00	8.26E-04	1,49	1853
90	23.68	17.42	997.80	1.00E-03	1,65	2050
100	26.32	19.36	848.30	1.18E-03	1,79	2216
120	31.58	23.23	701.40	1.43E-03	1,94	2407
140	36.84	27.10	589.40	1.70E-03	2,08	2576
160	42.11	30.97	517.91	1.93E-03	2,17	2698
260	68.42	50.33	352.70	2.84E-03	2,44	3027
360	94.74	69.68	266.85	3.75E-03	2,60	3232
460	121.05	89.04	241.85	4.13E-03	2,66	3297
560	147.37	108.40	239.45	4.18E-03	2,74	3406

Table 4. Pressure and Digital Measurement correlation static behavior

The Table 4 contains pressure acquisition data for a wide range of pressures between 13mmHg up to 110mmHg. The values are for the static behavior, in order to isolate the drift from the piezo resistive element, the resistivity measurement is considered after 5 minutes of pressing the sensor.

White paper gives details on the drift of this type of sensor, and in the case that more dynamic application, another range of calibration is required and different dynamic responses of resistivity result from the sensor.

The SM has two main pressure ranges that allow a correlation between the resistance and the applied pressure, Figure 60 show the Low pressure range from 13mmHg up to 110mmHg. For pressure values larger than 110mmHg consider Fig 61, however it has saturation regime.

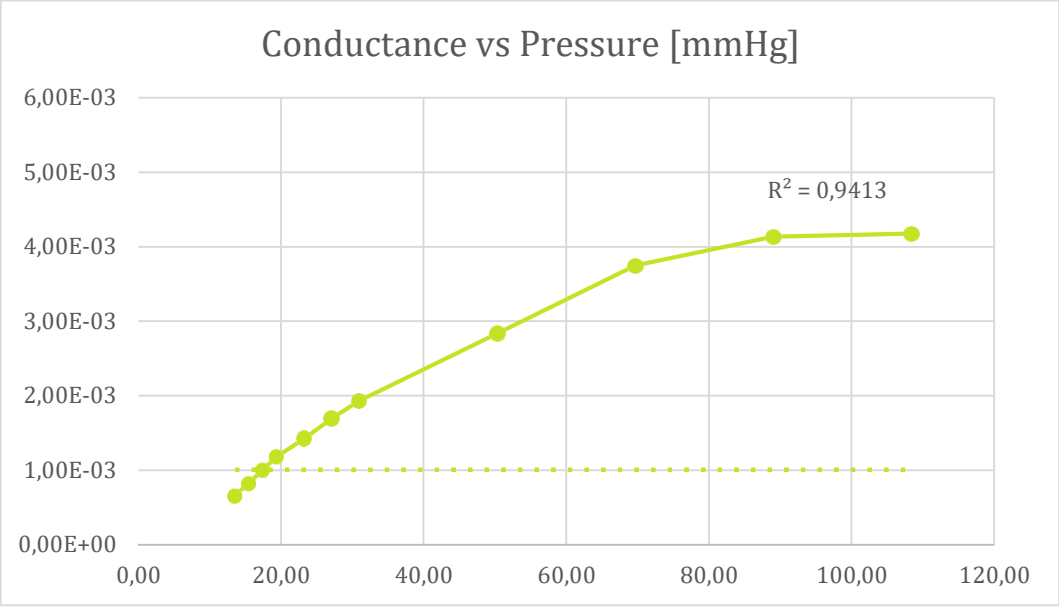


Figure 56. Low pressure range (25mmHg up to 200 mmHg)

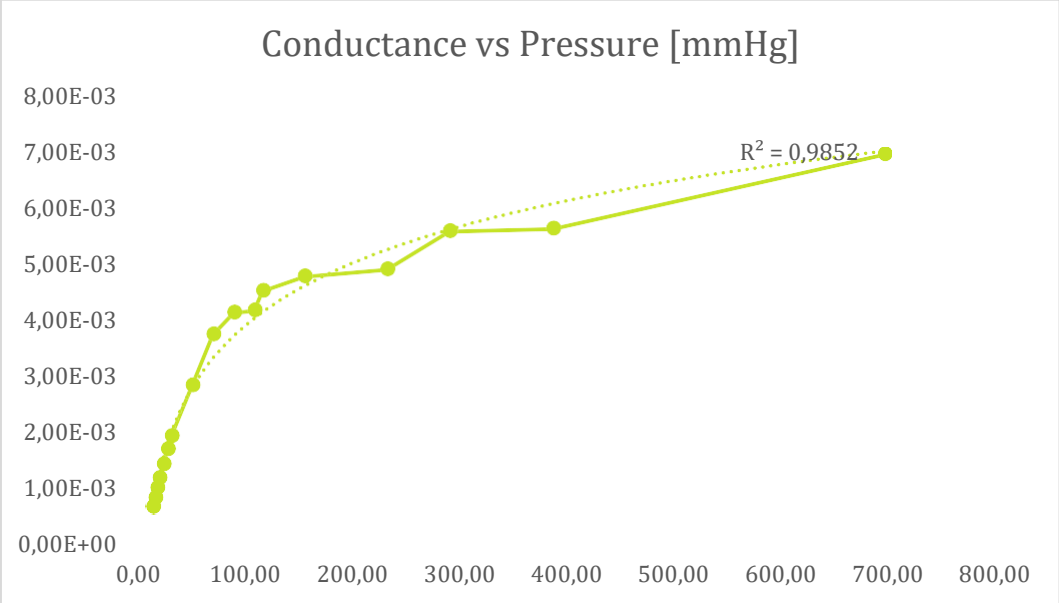


Figure 57. Full Range of pressure resistance vs applied pressure

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SM Sensors are resistive force sensors, based on a textile technology that's allow the correlation between applied pressure and resistance. SM SDK are acquisition modules that can measure the resistance of multiple SM single sensors or SM matrixes of different sizes, and represent them in a Pressure Map.

The Seating Mat Dev Kit sensor is composed of a cross bar matrix sensor with a size of 16x16 sensitive circular piezo-resistive spots with a diameter of 10 mm distributed uniformly over all the mat.

The units of the acquisition modules are voltage measurements from an ADC circuit.

Weight [gf]	Pressure [gf*cm^{-2}]	Pressure [mmHg]	Resistance [Ω]	Conductance [S]
10	12.74	9.37	454000	2.20E-06
20	25.48	18.74	101375	9.86E-06
30	38.22	28.11	19787	5.05E-05
40	50.96	37.48	5067	1.97E-04
50	63.69	46.85	3575	2.80E-04
60	76.43	56.22	2276	4.39E-04
70	89.17	65.59	1659	6.03E-04
80	101.91	74.96	1515	6.60E-04
90	114.65	84.33	936	1.07E-03
100	127.39	93.70	909	1.10E-03
120	152.87	112.44	626	1.60E-03
140	178.34	131.18	492	2.03E-03
160	203.82	149.92	476	2.10E-03
180	229.30	168.66	372	2.69E-03
200	254.78	187.40	311	3.22E-03
220	280.25	206.14	308	3.25E-03
240	305.73	224.88	307	3.26E-03
260	331.21	243.62	241	4.15E-03
280	356.69	262.36	201	4.98E-03
300	382.17	281.11	233	4.29E-03
345	439.49	323.27	185	5.41E-03
385	490.45	360.75	154	6.49E-03
425	541.40	398.23	129	7.75E-03
445	566.88	416.97	115	8.70E-03
485	617.83	454.45	112	8.93E-03
525	668.79	491.93	96	1.04E-02
565	719.75	529.42	101	9.90E-03

Table 1. Conductance vs Pressure Piezo Fabric

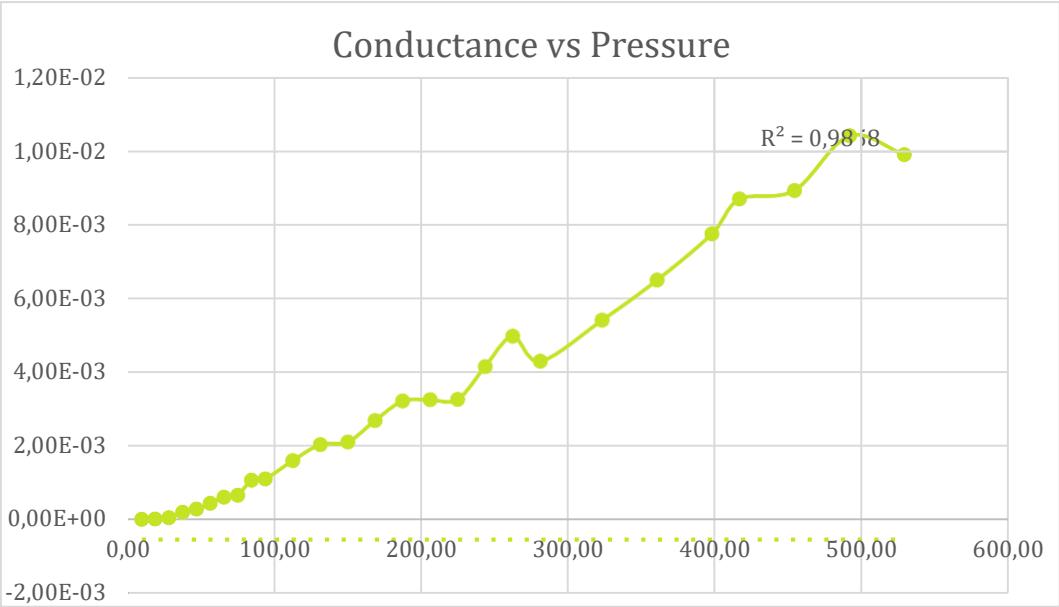

Figure 58. Conductance vs. Pressure Piezo Fabric

7.4. Conductance Vs Digital Values SDK05

Acquisition Circuit Technical Data

Sensing Mat Development Kit uses a voltage divider circuit, by default it has 1Kohm resistor divider that is connecter in series with the SM sensor. The measurement is done by ADC acquisition, then the voltage divider makes the voltage signal to be directly dependant on the applied pressure.

SM Sensors are resistive force sensors, based on a textile technology that's allow the correlation between applied pressure and resistance. SMSDK are acquisition modules that can measure the resistance of multiple SM single sensors or SM matrixes of different sizes, and represent them in a Pressure Map.

The units of the acquisition modules are voltage measurements from an ADC circuit.

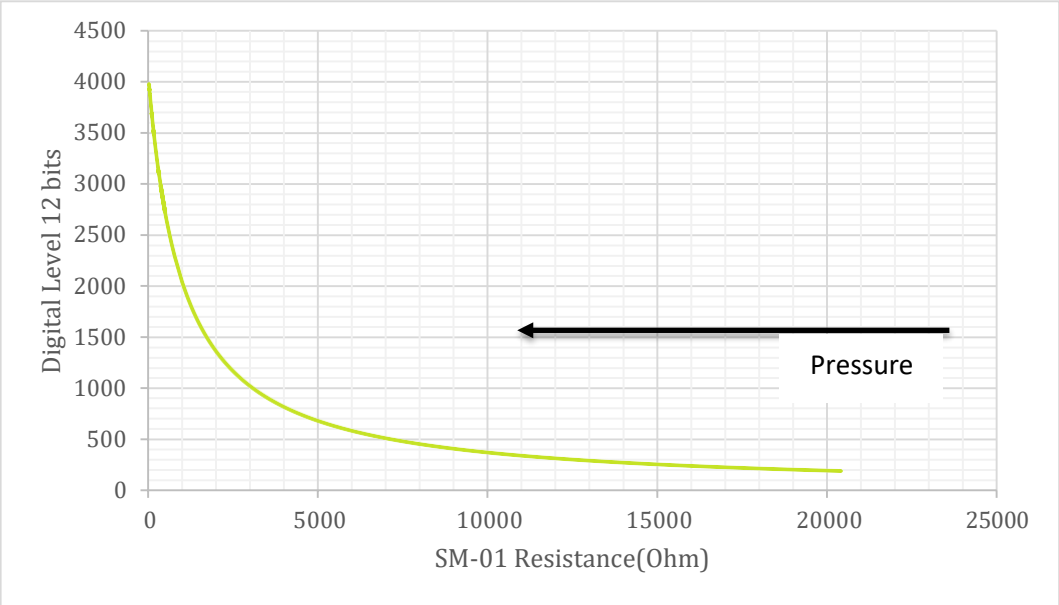

Figure 59. Resistance Measurement with SMDK Acquisition Module

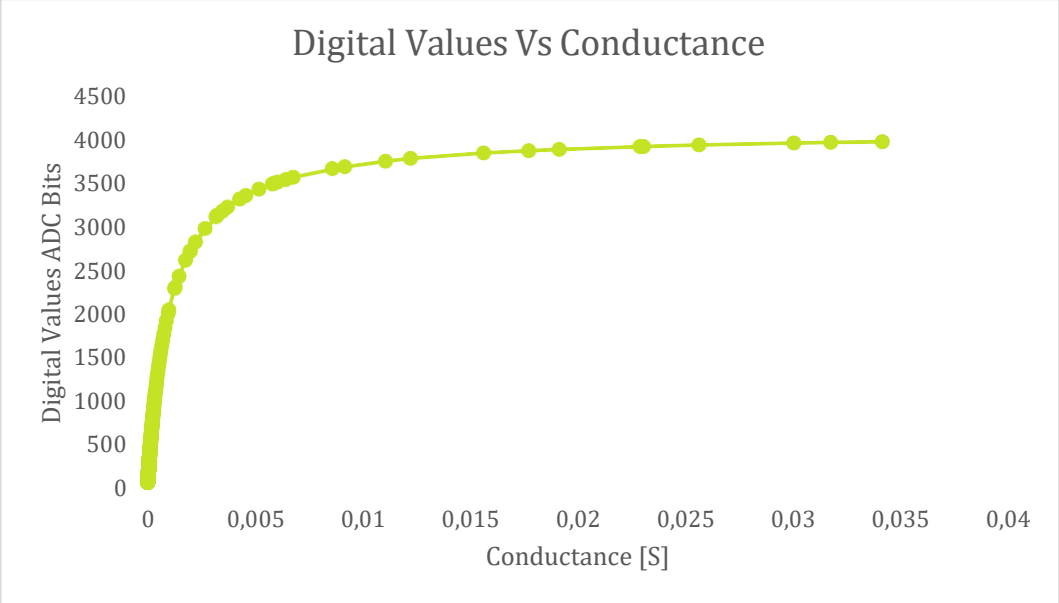

Figure 60. Conductance vs Digital Values ADC

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