SensorMatrixLAB

Software for printed Sensor Matrices

User Guide

Full Edition

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Software version:	5.2.x	
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	Rev 1.0.1	(DevKit)
	Rev 1.16	(Passive Matrix)
Supported device firmware:	7.4.x	(Universal Matrix)
	0.5.x	(Devkit)

FLEXOO

Impressum

Flexoo GmbH
Speyerer Str. 4
69115 Heidelberg
Germany
www.flexoo.de

Customer Support

Phone: +49 (0) 6221-54 19 100
Fax: +49 (0) 6221-54 19 110
Email: support@flexoo.de

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1 Introduction

This document is an integral part of the SensorMatrixLAB Software.
To ensure proper operation and full functionality of this product, read this manual carefully and completely before taking any action related to the use of this program.

1.1 How to Use This Manual

This manual provides the necessary information about the purpose, system requirements and settings needed to install, run, and effectively use SensorMatrixLAB software.

1.2 Typographic Conventions Used in This Document

In this user guide, certain words and phrases are distinguished by special formatting:

- Keywords and important information are highlighted in bold (e.g., **NOTE:** this is some important information).
- Software interface texts referenced in this manual are highlighted in italics (e.g., Use the *Apply* button to save the size).

2 Safety Instructions and Recommendations

These instructions facilitate the safe and efficient use of the product and should be available to the operator at the user site at any time. Failure to follow these instructions may result in errors in the functioning of the program and in the incorrect processing and storage of data.

2.1 User Qualifications and Intended Use

This software is intended for the specific purpose as described. It may only be used by users with at least a basic IT knowledge, and only with the equipment and under the operating conditions described in this documentation.

The user is fully responsible for the consequences resulting from the use of the product beyond its intended use and the safety rules described in this manual.

2.2 General Software Safety Instructions

To ensure effective and safe use of SensorMatrixLAB software:

- Always install the latest operating system updates.
- Clear the cache in your Internet browser(s) regularly.
- Keep your anti-virus software up to date.

3 Overview and Requirements

The SensorMatrixLAB software is a Microsoft Windows application for visualizing and processing data from Flexoo's pressure sensor matrices.

The software supports the following key features:

- Advanced data visualization
- High-speed data acquisition and playback
- API access to sensor data
- Communication interfaces: USB Serial, Wi-Fi, Ethernet
- Support for custom printed sensor matrices and different hardware types
- Advanced hardware configuration (including standalone operation via CAN/RS232)
- Sensor calibration (including individual calibration of sensors in a matrix)
- Full support of proprietary protocols

3.1 Hardware Requirements

Unless otherwise specified, these minimum hardware requirements apply to all installation options:

- Flexoo’s hardware (electronics) with the latest firmware version
- Flexoo’s printed sensor matrix.
- Windows-based personal computer with x86/x64 processor
- USB port with USB-to-serial driver installed.
- Optional: Internet connection for automated updates
- Optional: Local network connection via Ethernet (for ETH connectivity)

Minimum PC requirements:

- Intel I5/Ryzen 3
- Windows 10 operating system
- Integrated Intel HD Graphics cards with OpenGl version 3.3 support
- Up to 30 Mb free disk storage
- 300Mb RAM
- Virtual COM port driver can be required on some PCs to work with a measurement board via USB

3.2 Software Requirements

The software requires the following conditions to function properly:

1. Microsoft Windows 10 or higher
2. **Microsoft .NET Framework 6.0.x**
3. The latest version of a web browser (Mozilla Firefox, Google Chrome, or Microsoft Edge)
4. Microsoft Excel (2016 or later)

4 Installation and Maintenance

4.1 Software Installation

To install the SensorMatrixLAB software on your PC, run the provided installer executable and follow the installation instructions.

NOTE: SensorMatrixLAB does not require a local user to have administrator privileges on the computer to install or use the software. However, administrator privileges may be required to use the auto-discovery feature for ethernet connection.

4.2 Software Activation

Once installed, the software has to be activated.

1. Run the software
2. Read and confirm the license agreement
3. Copy your license UID to the clipboard (**Figure 1:** Activation window).

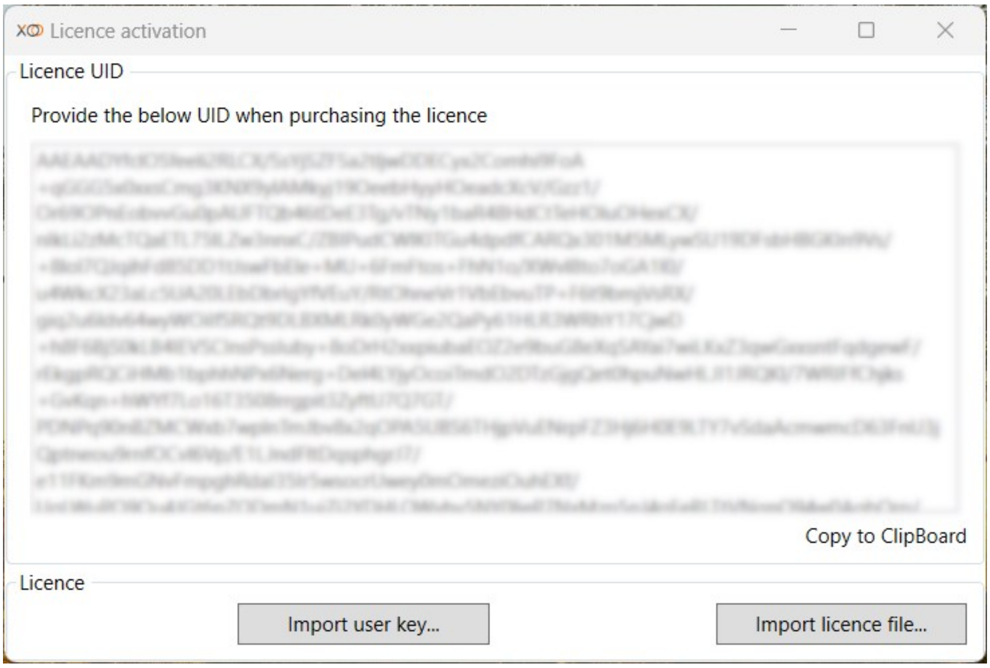


Figure 1: *Activation window*

4. Send the UID including your company's name and order number to support@flexoo.de
5. You will receive two files for activation:
   - A user key file (KEY)
   - A license file (LIC)
6. To activate the program import both files (**Figure 1:** Activation window)
7. If all operations have been performed correctly, you will see the following confirmation.

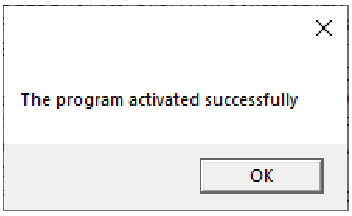


Figure 2: *Activation confirmation*

✓ Congratulations, your license activation is complete! If you start the software, the main window should appear.

4.3 Update

To update SensorMatrixLAB to a newer version:

1. Reinstall the current version from your PC.
2. Request activation files for a new software version.
3. Proceed with the activation as described above.

5 User Interface

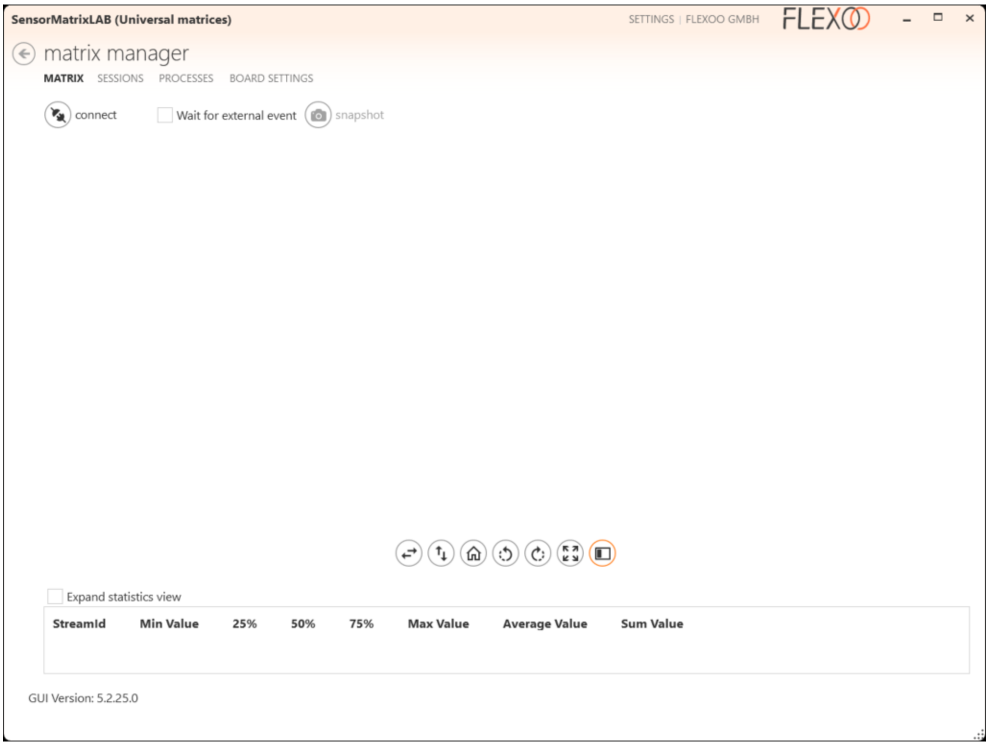


Figure 3: *SensorMatrixLAB start screen (Universal Matrix).*

Figure 4: *SensorMatrixLAB start screen (Devkit).*

Figure 3 & **Figure 4** shows the main window of the SensorMatrixLAB software after startup. The different sections of the main window are described from top to bottom:

1. *SETTINGS* (left to the Flexoo logo) refer to the global settings of the application. For detailed information on the settings and each menu, see the global settings section (**section 6**).
2. Tabs (below *matrix manager*) allows switching between several core features of the application. For more information, see the (**section 7)**:
   - *MATRIX*: main view for matrix visualization
   - *SESSIONS:* export and visualization of previously captured measurement sessions
   - *PROCESSES:* information about ongoing processes
   - *BOARD SETTINGS (Universal Matrix Only):* read, modify, and upload board parameters and settings.
   - *ADVANCED DEVICE SETTINGS (DevKit Only):* read, modify, and upload advanced board parameters.

6 Global Settings

Global settings related to the application and hardware connection can be changed under *SETTINGS* in the upper right corner of the application window.

NOTE: The *SETTINGS* button will disappear if a measurement session is running. Make sure that the device is disconnected to change the global settings.

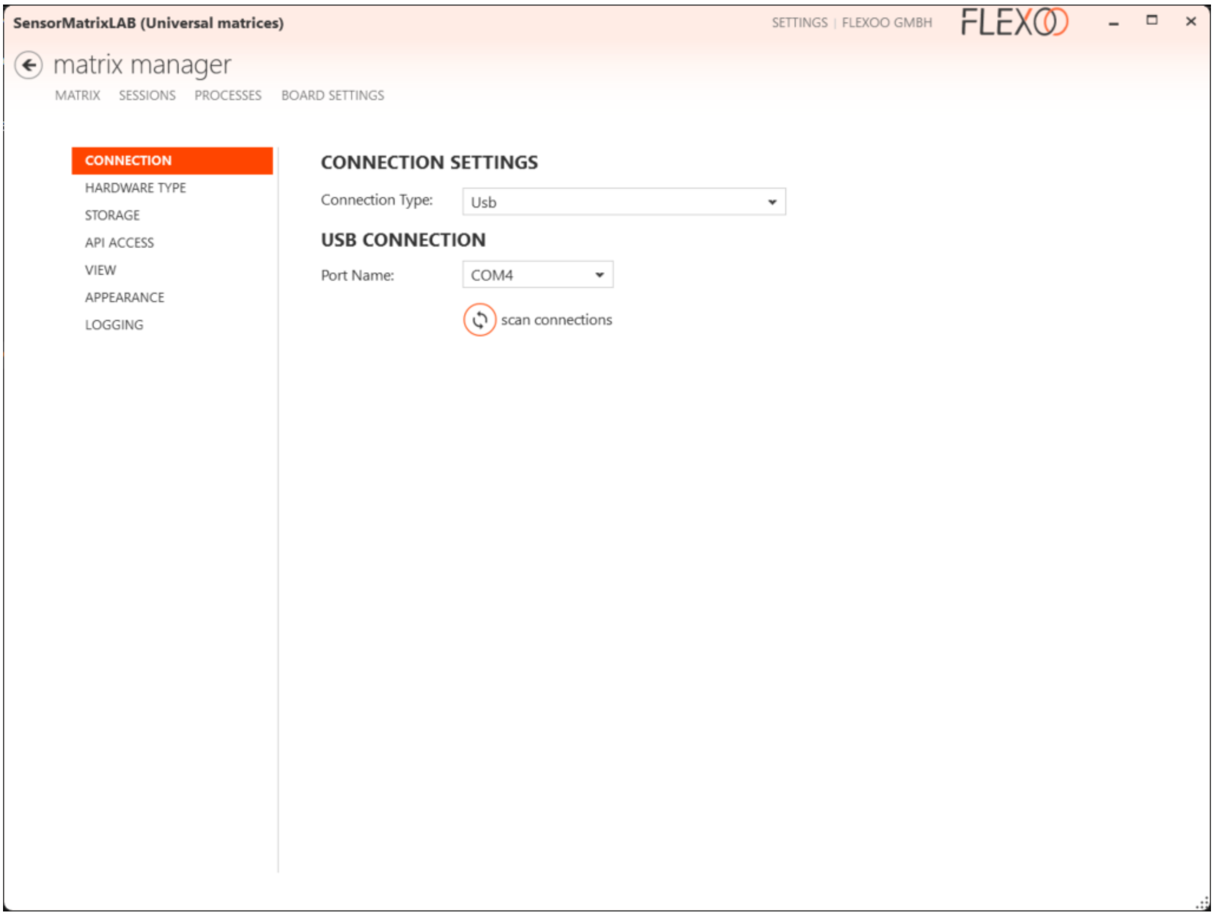


Figure 5: *SensorMatrixLAB – Settings (Universal Matrix)*

Figure 5 gives an overview of the *SETTINGS* window. The subsections are described in the following. For Devkit, the tab Frame processing is added.

6.1 Connection

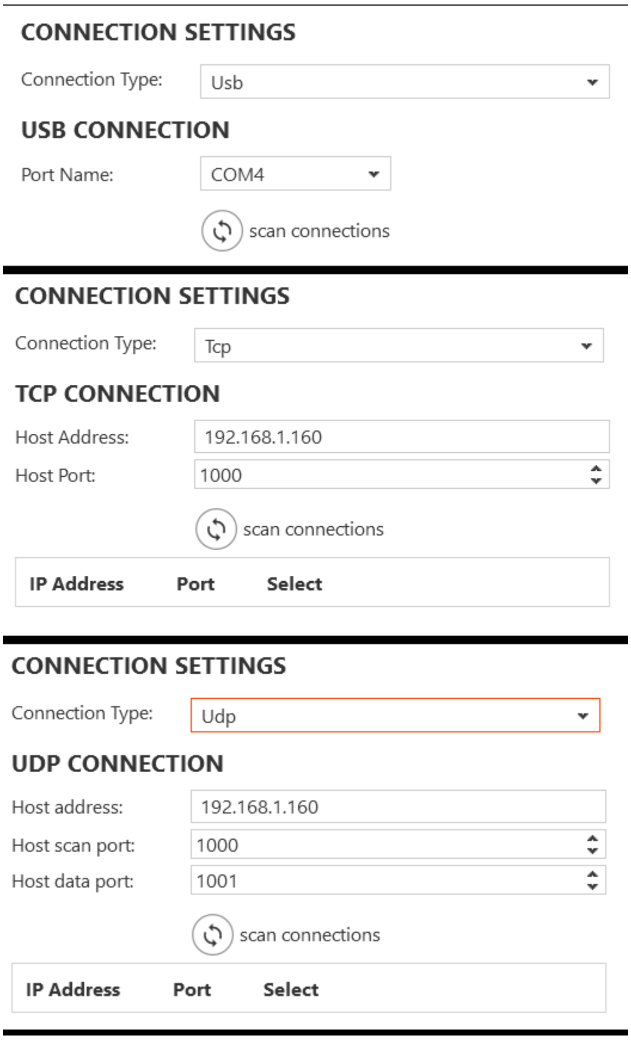


Figure 6: *CONNECTION SETTINGS for USB, TCP and UDP*

This subsection allows you to select and specify the connection interface, either USB, TCP or UDP. For USB, the corresponding COM port must be chosen. For TCP and UDP it is required to specify the IP address and port of the device. Use the *scan connections* button to search for possible connections.

NOTE: Not all hardware support TCP/UDP. Please refer to your hardware manual for more information.

NOTE: The *scan connections* button for TCP/UDP might require running the application with admin rights.

6.2 Frame Processing (Devkit only)

Figure 7: *Frame processing settings*

Per default the complete device's readout resolution is visualized in the application. Usually, the connected sensor covers a resolution smaller than this. In addition, depending on the sensor layout, the arrangement of the readout does not correspond to the sensor matrix layout.

To reduce the amount of data and correct the arrangement, a sensor matrix specific JSON file can be loaded to the application. This frame conversion file can be uploaded using the *load new* button. After that it is selectable in the dropdown menu.

6.3 Hardware Type

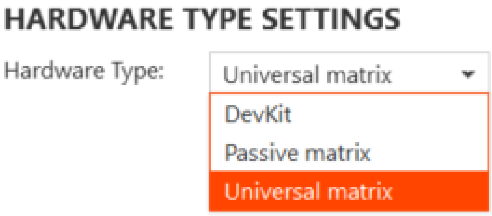


Figure 8: *HARDWARE TYPE Settings*

Depending on your order, several hardware types might be able to select. Choose the connected device from the dropdown menu. Typically, only one hardware type is selectable.

NOTE: If you are interested in the different hardware types and their capabilities, please visit www.Flexoo.de.

6.4 File Storage

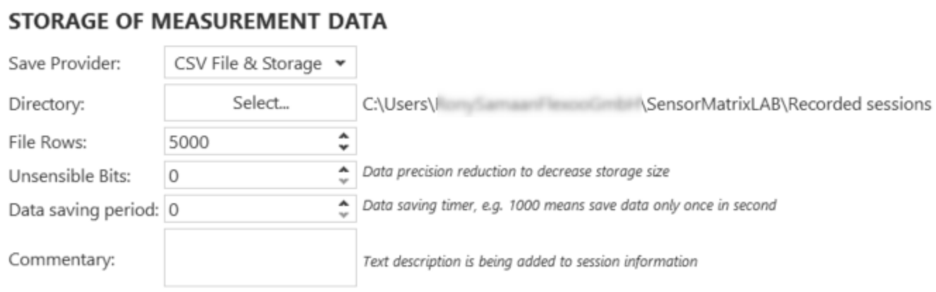


Figure 9: *STORAGE settings*

The *STORAGE* subsection allows to save a session in two ways: *CSV file* (CSV) or *Storage* (DB). These modes can be selected under the *Save Provider* option. During a measurement, the data is written in the selected format to the directory specified.

In addition to the data, a session.txt or session.db file is generated to encapsulate important session information, including any specified Commentary. Additionally, a FilterSettings.txt file is created, detailing the applied filter settings and the types of filters used when applicable.

NOTE: Make sure that a valid directory is specified.

6.4.1 CSV file type

The data in CSV files is arranged in the following format:

Column	1	2	3	4 and following
Description	Time Stamp (in ms)	Sample Number	CAN Time Stamp (if configured)	Data of sensor pixel

Each row corresponds to a single matrix snapshot. The two-dimensional matrix data is flattened and starts at the fourth column. The *File Rows* setting allows to change the maximum amount of CSV file rows before a new file is created.

The CSV file storage requires a lot of CPU resources compared to the DB file type, as the data needs to be converted before it can be written in real time.

6.4.2 DB file type

The database (DB) files provide a smaller sized storage option. Those files can be read, visualized, and exported to CSV in the *SESSIONS* tab (section 7.2).

To reduce the file size even more, the *Unsensible Bits* option can be used. It specifies a tolerance window a sensor's readout must leave before a new value is stored. E.g., setting this option to 3 requires a value to change by at least 8 (2^3) before a new value is saved. This is particularly useful for long-term measurements.

6.5 API Access

Figure 10: *API Access settings*

The API ACCESS subsection provides several options to access the measurement data stream outside SensorMatrixLAB. Three APIs are provided:

- *Image Hub*
- *Json Hub*

6.5.1 Image Hub

To enable this mode, use the *Image Hub* setting.

Specifications:

- The matrix state is generated as a PNG image on demand for incoming HTTP requests.
- Images can be loaded using the HTTP GET request via the selected *Image Host Port*.
- The data format is the same as for Folder Hub.
- Try to access in a web browser via http://localhost:<SELECTED_PORT>/
(e.g., http://localhost:5000/)

6.5.2 Json Hub

To enable this mode, use the *Json Hub* setting.

Specifications:

- The matrix state is generated as a JSON file on-demand for incoming HTTP requests.
- The data can be loaded by third-party software using the HTTP GET request through the selected *JSON Host Port*.
- The matrix data is given in two-dimensional form as a listed list.
- Use the *send timestamp* checkbox to include the measurement start time and timestamp since measurement start in ms.
- Try to access in a web browser via http://localhost:<SELECTED_PORT>/
(e.g., http://localhost:5001/)


```
{"StartTime":"30-08-2023
20:51:26","CurrentFrameTimestamp":10157.0,"FrameData":[[0,0,0,1,0,0,0,0,0,0
,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,1,0],[0,0,0,1,0,0,1,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
,0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,1
,0,0,0,0],[0,0,0,0,0,0,0,0,1,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,1,0,1,0,0,0,0,0]
,[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0],[1,0,0,0
```

```
,1,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0
,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,1,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,
0,1,0,0,0,0],[1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
,0],[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,
0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0],[0,0,0,0,0,0,0
,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0],[1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,1,0,0,0,
0,0,0],[0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0],[1
,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,1,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0
,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
,0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
0,1,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0]
,[0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0]]}
```


Figure 11: Example of a JSON file containing 32x32 matrix data including time stamp.

6.6 View Color Palette

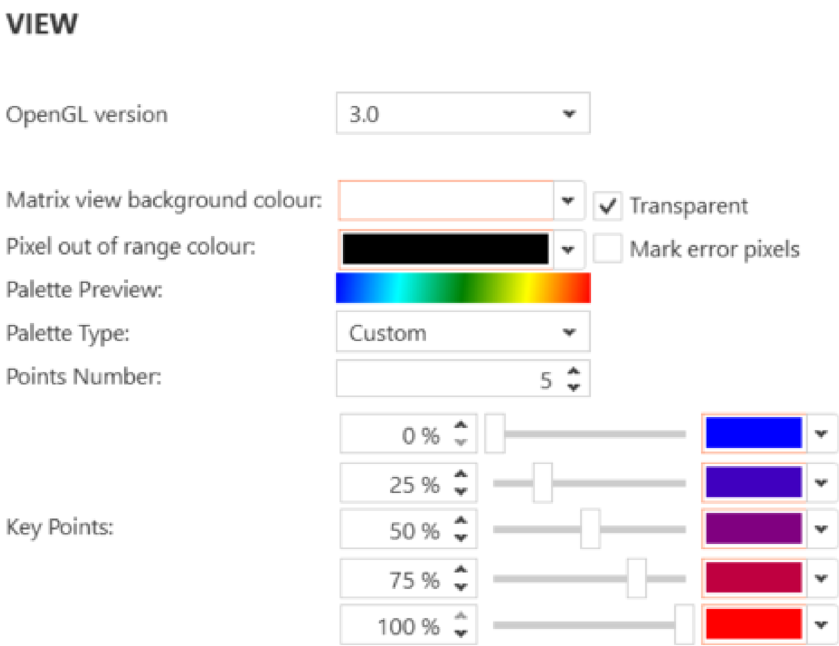


***Figure 12:** VIEW Settings*

The *VIEW* section allows you to select and configure a color map for data display. A variety of predefined color palettes are provided. In addition, a customized color palette can be configured (**Figure 12**).

The *Transparent* checkbox will apply a transparent background to the matrix view.
The *Mark Error Pixels* option will highlight pixels that are out of range using the selected color.

6.7 Application Style

The Application Style tab allows you to customize the appearance of the software to match your preferences. From this tab, you can:

Palette: Choose from a variety of color schemes to personalize the look of the application.

Theme Selection: Switch between **Light** and **Dark** modes to adjust the brightness of the interface.

Font Size: Adjust the **font size** to improve readability. You can choose between different sizes depending on your preference, from small to large.

This section gives you the flexibility to adjust the interface to suit your comfort and style.

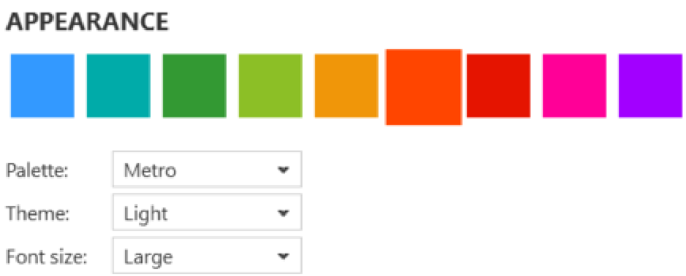


Figure 13: APPEARANCE *Settings*

6.8 Logging

The Logging tab features a button that opens a console, enabling users to view logs at different levels. The available log levels include Error, Warning, Info, Debug, and Verbose. Each level offers increasing detail for in-depth analysis and troubleshooting.

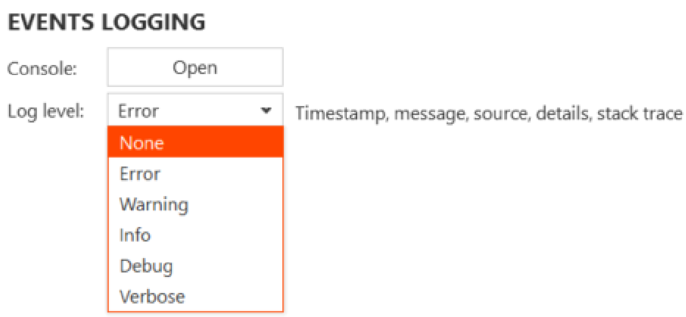


Figure 14: *Events Logging*

- None: No logging is performed. No log files are generated, and no messages appear in the console. Use this setting if you want to completely disable logging.
- Error (Default): Records critical information about errors. Each log entry includes:
  - Time of the event.
  - Description of the error.
  - The module in which the error occurred.

    - Event details (if available).
    - Error depth (shows how many modules were involved and what was affected).
- Warning: Captures minimal information, A brief description of the issue.
- Info: Provides all details from the Warning level, plus the name of the module that generated the error message. This level is useful for tracking general system information.
- Debug: Designed for developers. Like the Error level but includes additional testing points for in-depth debugging. It can be enabled or disabled during application compilation and is not recommended for end users due to the excessive detail it provides.
- Verbose: Builds on the Error level, adding even more detailed descriptions of errors. This log level is recommended for crucial situations where the default Error logging doesn't provide enough information for troubleshooting.

7 Tabs

7.1 Matrix

This window controls the measurement to the connected device and provides various options to modify the live measurement presentation. In the following, its features are described from top to bottom (**Figure 15**).

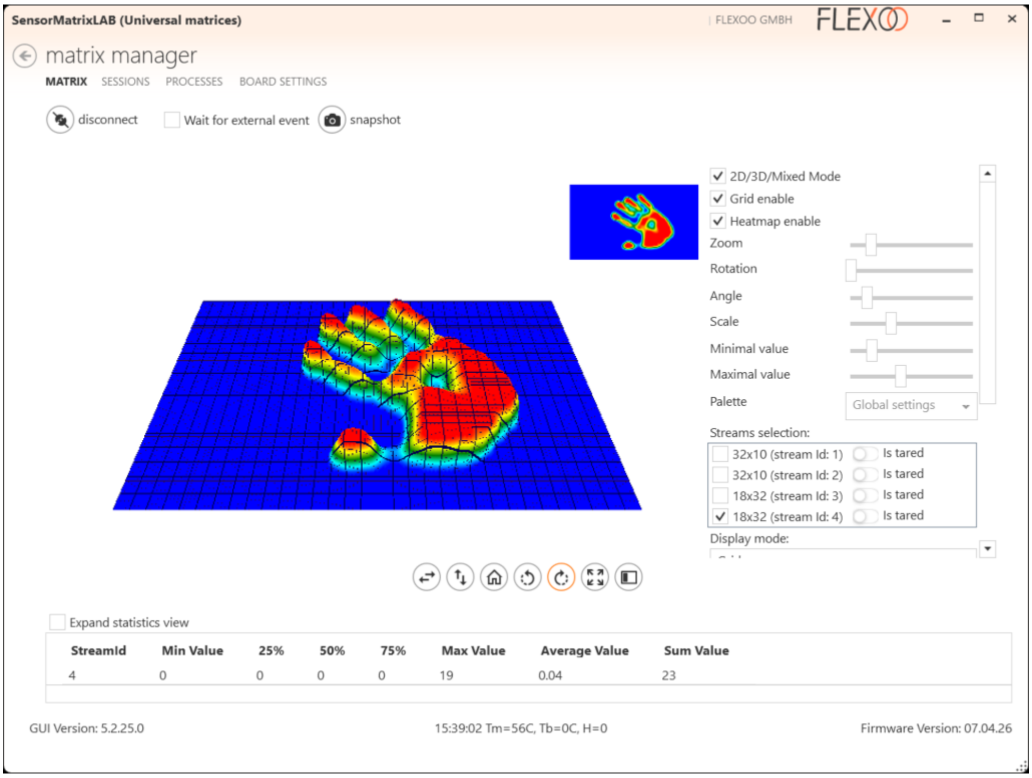


Figure 15: *MATRIX tab*

7.1.1 Control Buttons

The *connect/disconnect* button establishes a connection the device using the interface specified in the connection settings (section 6.1). After a connection is established, the *snapshot* button can be used to capture a screenshot of the current measurement visualization. To stop the current measurement session the *connect/disconnect* must be clicked again.

The *external trigger* check box is used for starting a scan session when a signal is received from an external device. A more detailed explanation can be found in the PMU's Hardware Manuel **section 6.7 Triggering.**

7.1.2 Device Settings (Devkit only)

The device settings are stored in the non-volatile memory of the hardware and the same settings are used to control the device via all supported interfaces (e.g., CAN, ETH).

NOTE: To update the device configuration, an existing connection to the hardware is required and the session must be stopped.

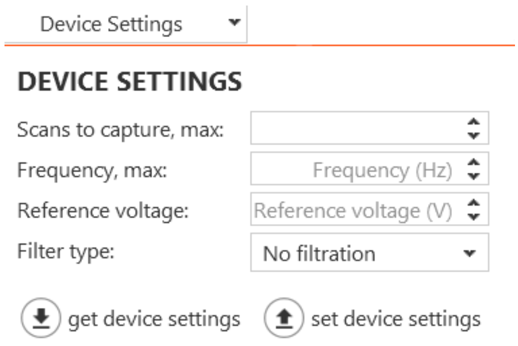


Figure 16: *Device settings window*

If the USB connection to the board is established successfully, the board settings can be changed in the *MATRIX* window under *Device Settings*.

The *Device Settings window* shown in **Figure 16** contains several options:

- The *get device settings* button loads the current settings from the board, *set device settings* sends the user's input to the board.
- *Scans to capture, max* allows you to limit the number of captured images per session. When this number is reached, the session will be stopped. If this value is set to 0 (default), the session is not limited and can only be stopped using the *disconnect* button.
- *Frequency max* describes the upper limit for the measurement frequency of a session in Hz (samples per second). If this value is set to 0, the measurement will be performed at the maximum frequency possible for the current hardware and sensor matrix.
  NOTE: Some hardware does not support frequency limit. Refer to the hardware datasheet for more information.
- *Reference voltage* allows you to set a reference voltage value on the board. In general, the higher the reference, the higher the sensitivity of the sensor system to external stimulus. It is recommended to start measurements with a low reference voltage and to increase it if necessary. The unit of this value is Volts.
- *Filter type* allows you to apply time-domain filtering to live sensor data. This means that each matrix pixel is filtered as a function of time, independent of other pixels. The filter parameter can be set in the *ADVANCED DEVICE SETTINGS* tab (section 7.4).
  NOTE: Not all hardware supports live filtering. Please refer to your hardware manual for more information.

7.1.3 Matrix View

The matrix view provides a variety of features to visualize the measured data in real time. A detailed description of the matrix view can be found in the Visualization section (**section 8**).

7.1.4 Software and Firmware Version

The current software version is displayed in the bottom right of the *MATRIX* window. If a connection to the device is established and a measurement running, the device's firmware version is displayed in the bottom right of the window.

7.2 Sessions

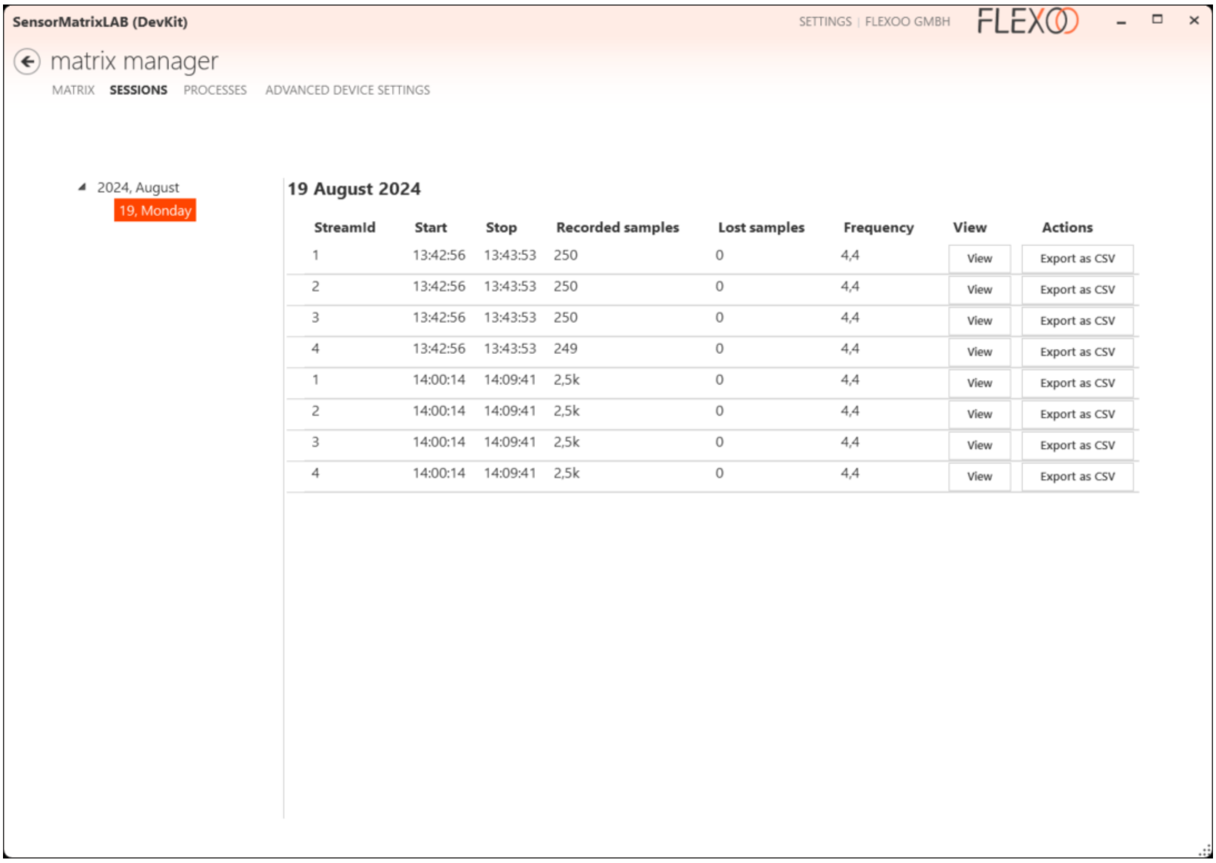


Figure 17: *SESSIONS window*

The *SESSIONS* window allows to review and export previous measurement sessions. Recordings are categorized by date and time of the measurement session. In addition, the number of recorded samples and the measurement frequency is displayed.

Lost samples describe the number of samples that have been lost during transmission. This might exclusively happen for USB connection, as a broken data package will not lead to a request for another one. However, the number of lost packages is typically very low.

NOTE: Only sessions saved in database format are displayed.

Note: Only sessions saved in the *STORAGE directory* are shown. To show different files, switch the directory (**section 6.4**).

Clicking on the *View* button will lead to the session view window which provides two tabs (*MATRIX* and *INFO*).

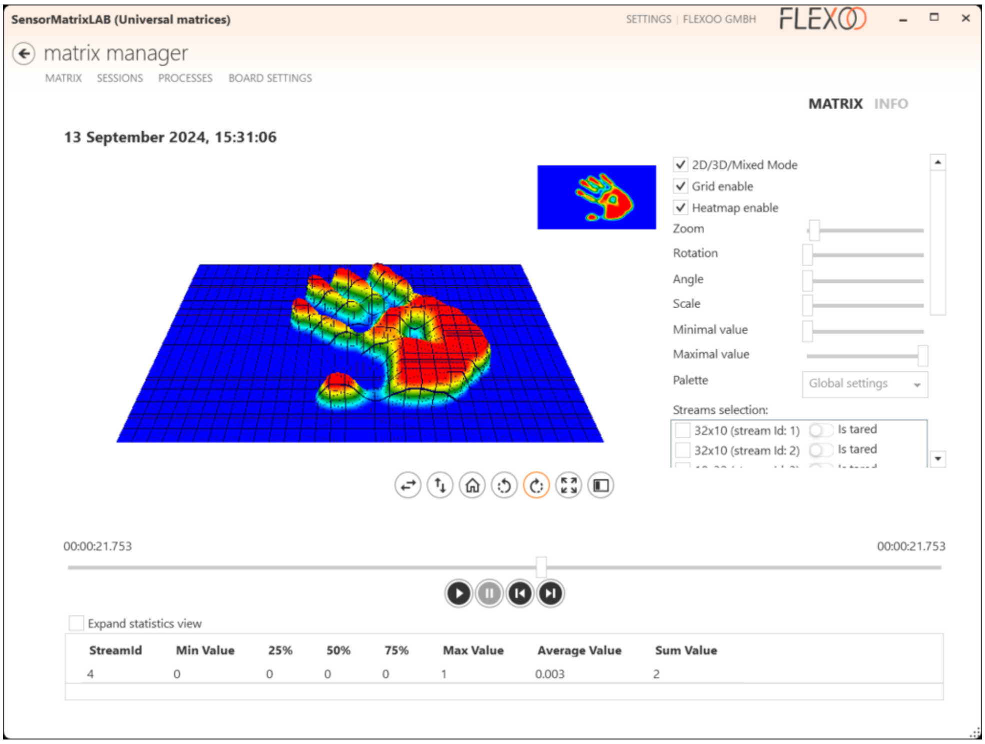


Figure 18: *Session view MATRIX window showing the pressure distribution of a foot.*

Figure 18 shows the *MATRIX* tab for a selected measurement session. It shares all visualization features with the live data view. Please see **section 8** for more information. In addition, a data player is provided to select specific samples or automate the data play.

SESSION INFO

StreamId:	1	2	3	4
Start time:	8/19/2024 1:42:56 PM	8/19/2024 1:42:56 PM	8/19/2024 1:42:56 PM	8/19/2024 1:42:56 PM
Stop time:	8/19/2024 1:43:53 PM	8/19/2024 1:43:53 PM	8/19/2024 1:43:53 PM	8/19/2024 1:43:53 PM
Session Time, ms:	57275	57314	57323	57203
Recorded Samples:	250	250	250	249
Lost Samples:	0	0	0	0
Session Frequency:	4,36	4,36	4,36	4,35
Data framerate with data losses:	4,36	4,36	4,36	4,35
Data resolution bits:	12	12	12	12

SESSION SETTINGS

Frame processing feature:	No PC side frame processing has been used	No PC side frame processing has been used	No PC side frame processing has been used	No PC side frame processing has been used
Frame width:	32	32	29	20
Frame height:	10	10	17	64
Settings Frequency:	0,00	0,00	0,00	0,00
Reference voltage, V:	3,00	2,50	2,50	2,50
Number Of Samples:	0	0	0	0

GERERAL SESSION INFORMATION

Hardware type:	UniversalMatrix
Firmware Version:	07.04.26
GUI Version:	5.2.22.0
Unsensible bits:	0

Figure 19: *Session view INFO window*

The INFO tab provides the meta data of the selected measurement session for each stream, like frame size, measurement frequency, etc. (**Figure 19**).

7.3 Processes

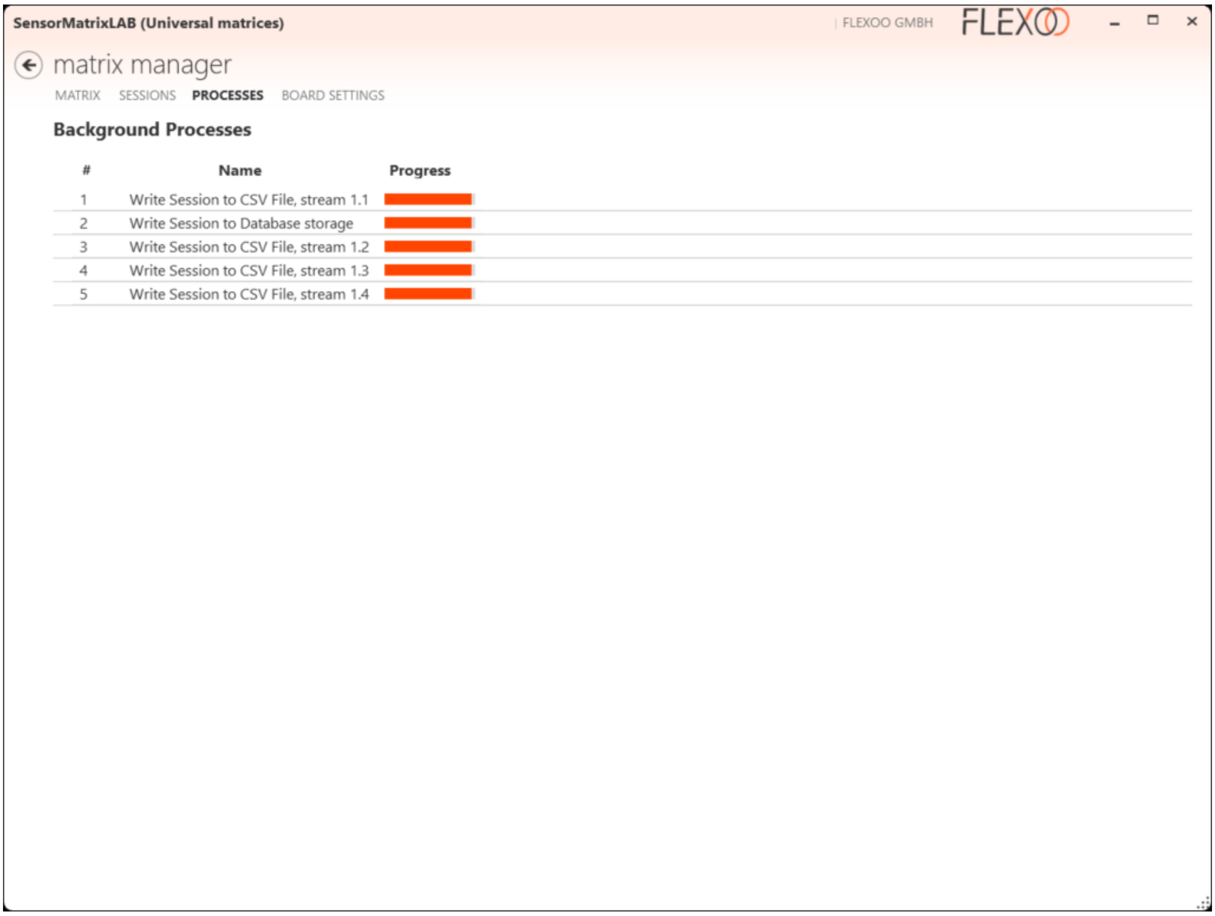


Figure 20: *PROCESSES window*

This tab contains a list of running subprocesses, such as CSV and database file writing. A progress bar shows the subprocess' progress.

NOTE: The performance of file writing subprocesses can be affected by the accessibility of the save destination. In case of file writing subprocesses adding up, consider selecting a different directory in the *STORAGE* settings **(6.4)**.

7.4 Advanced Device Settings (Devkit only)

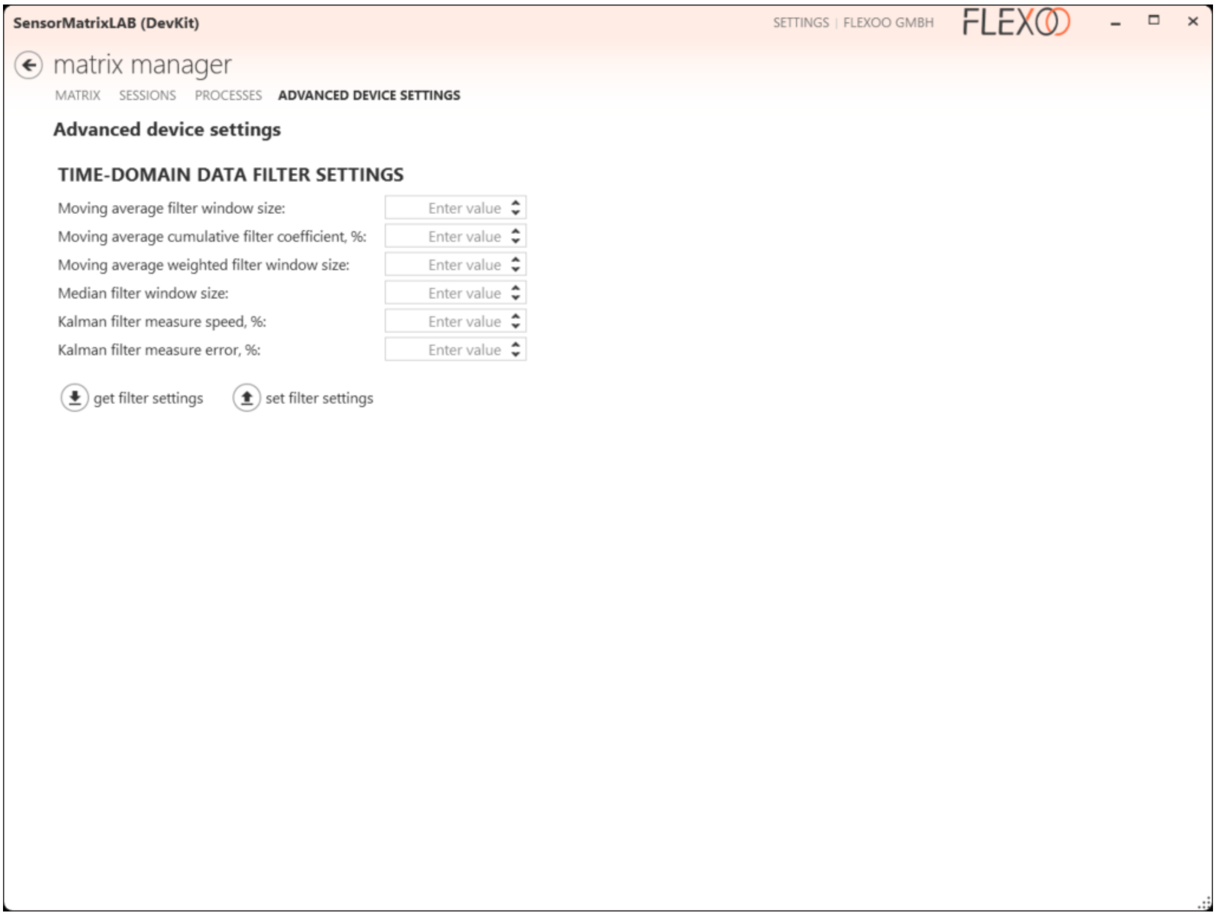


Figure 21: *ADVANCED DEVICE SETTINGS window*

Figure 21 shows the *ADVANCED DEVICE SETTINGS* tab. It provides additional on-board features which are described in detail in the following subsections.

7.4.1 Time Filter Settings

In this section, the on-board time domain filtering of the sensor data can be enabled and configured. This reduces measurement noises and delivers a steady output. Filter computation is performed for each pixel individually.

A detailed description about the filters and their configuration is given in section 9.1.

7.5 Board Settings (Universal matrix only)

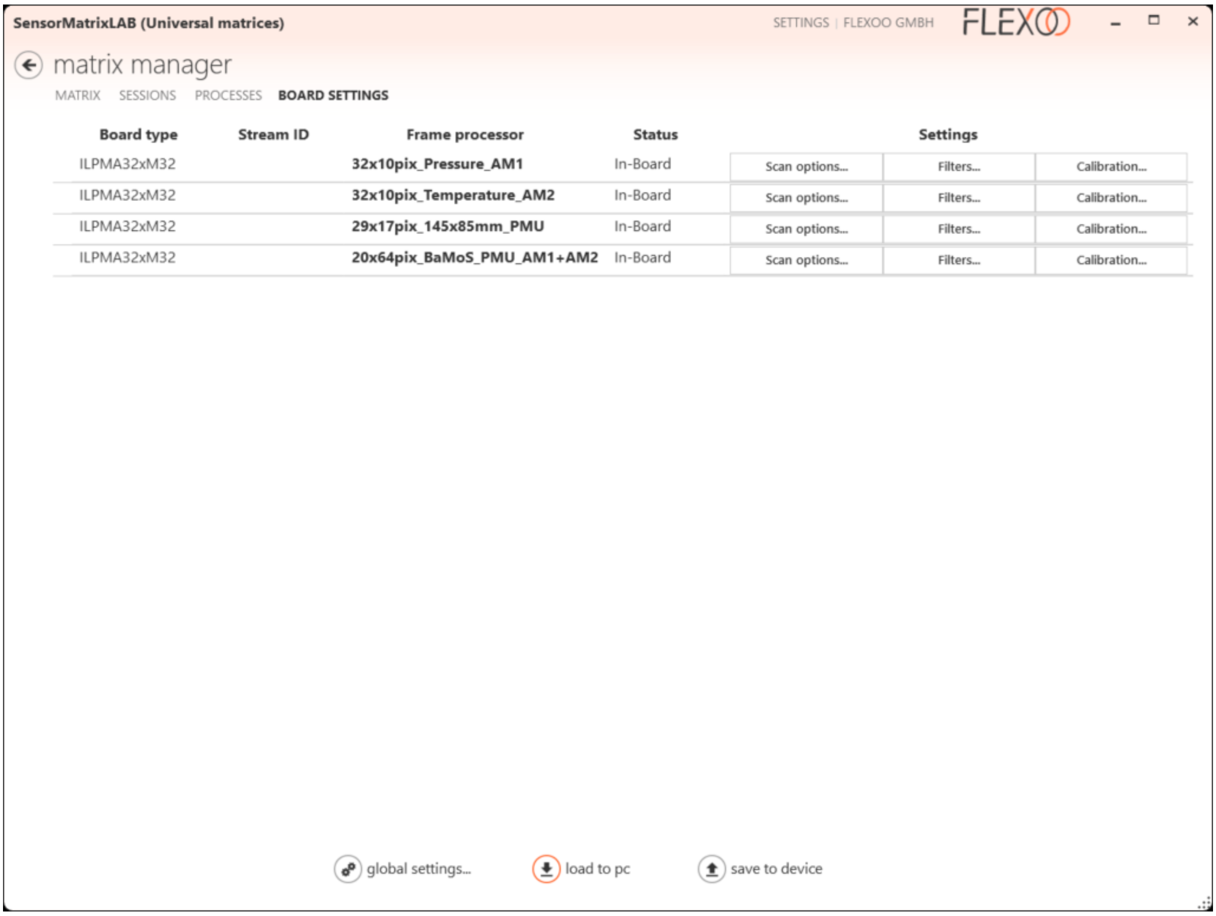


Figure 22: *BOARD SETTINGS window*

The board settings are stored in the non-volatile memory of the hardware and the same settings are used on all supported interfaces (e.g., CAN, ETH). Several streams can be configured for a single board. Those streams can read different (or same) readout regions with different settings (e.g., reference voltage, frequency). The stream information is stored on a MicroSD card applied to the PMU board (see the hardware manual for more information).

NOTE: To read and update the device's stream configurations, an existing connection to the hardware is required and the session must be stopped.

Use the *load to pc button* to read the stream configurations of the connected device. This process might take a while. Afterwards, all streams available are displayed in the *BOARD SETTINGS* window (**Figure 22**). After some changes have been made, they can be written to the device using the *save to device button*.

NOTE: Some changes might require the board to restart. In this case, if the *connect* button is pressed, the board will restart automatically. Wait until the device's LED is blinking green and try to connect again.

In the following, all settings will be explained in detail.

7.5.1 Global Device Settings

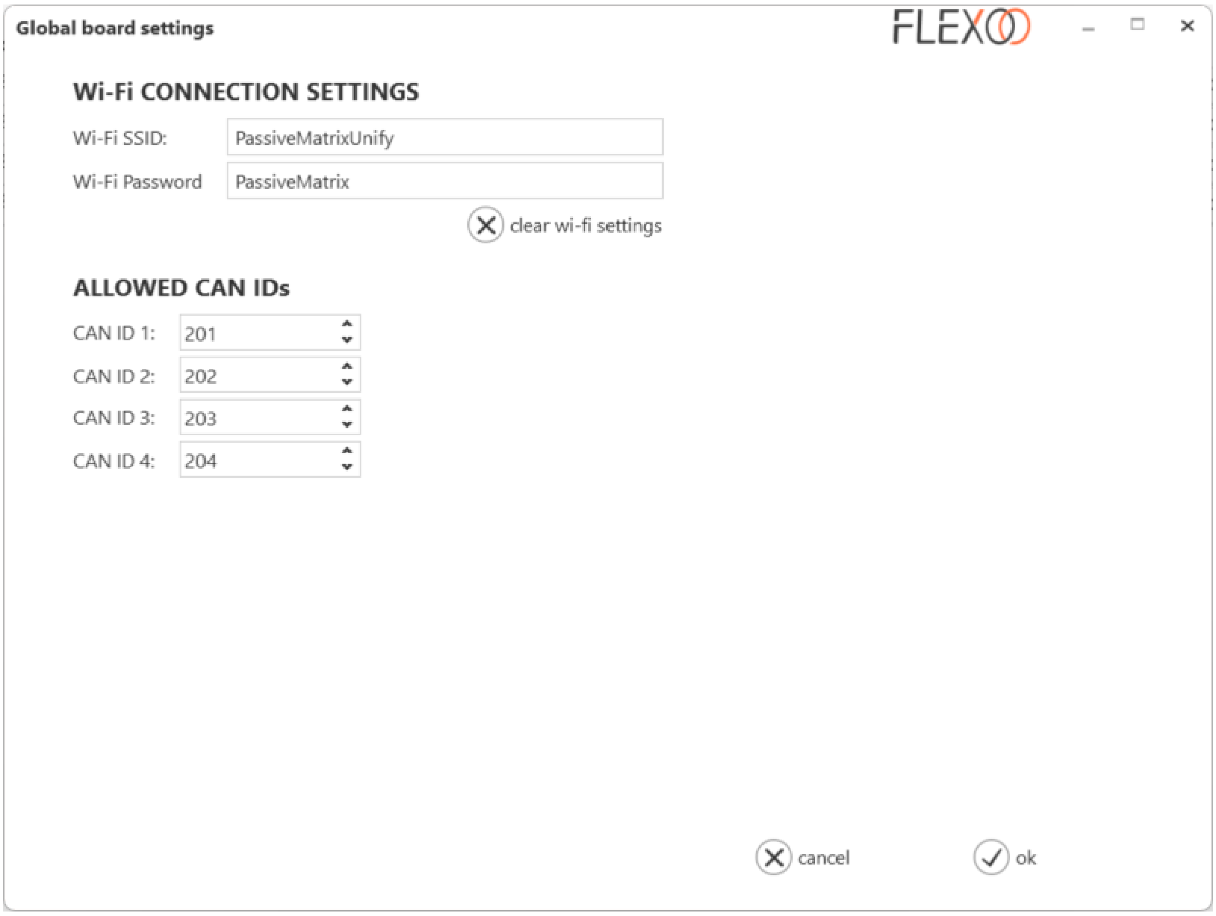


Figure 23: *Global board settings window*

Click the *global settings* button on the device settings window (**Figure 22**) to open the global board settings window (**Figure 23**). This window contains non stream specific board parameters. For Wi-Fi functionality the SSID and password can be set in the *Wi-Fi CONNECTION SETTINGS* section. If the CAN interface is used, the *ALLOWED CAN IDs* specify up to four CAN IDs from whom the board will accept commands.

NOTE: For additional information regarding the CAN interface, please see the hardware manual.

7.5.2 In-Board Frame Processing

In the device settings window (**Figure 22**), for each stream a frame processor is declared. This frame processor specifies the readout region according to the selected sensor matrix. The frame processing information is stored on the MicroSD card and is typically pre-configured according to the ordered sensor matrices.

NOTE: The frame processing can also be performed software sided. See section 7.5.3 for more information.

7.5.3 Scan Options

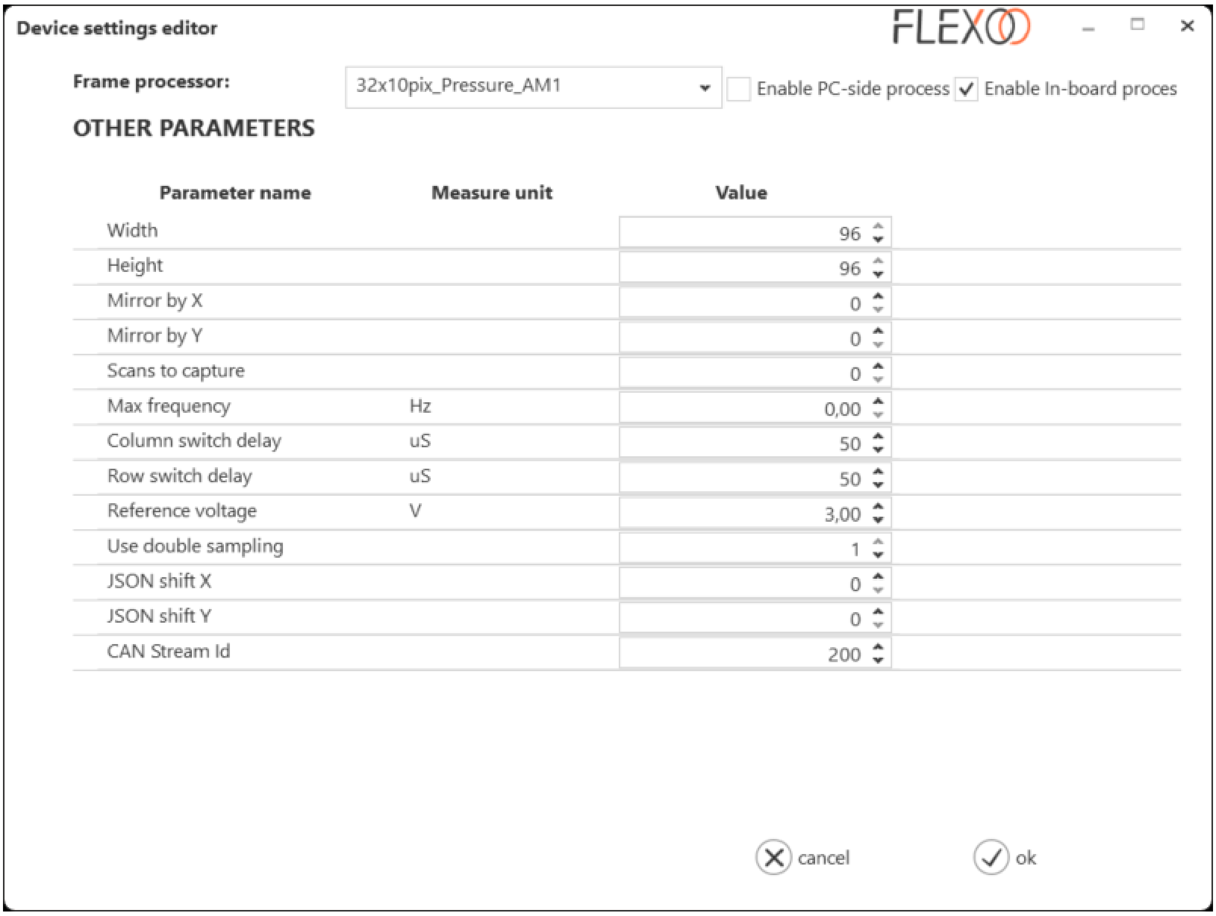


Figure 24: *Scan Options editor*

Click the *Scan options* button (**Figure 22**) for a specific stream to open the scan options editor (**Figure 24**).

The *Frame processor* option allows the selection of a specific processor for software-sided frame processing. It must be activated with the *Enable PC-side processing* checkbox.

The board Frame processing is automatically enabled by default, to disable the frame processing the *In-board* checkbox can be disabled.

NOTE: Make sure that *In-board* frame processing is disabled to prevent unwanted behavior by doubled frame processing.
NOTE: Compared to In-board frame processing, PC-sided frame processing reduces the maximum readout frequency because the complete readout area (96x96) must be measured before transmission to the PC. In-board frame processing is recommended.

The other stream parameter’s descriptions and details are listed as follows.

Name	Description	Unit	Type	Min. Value	Max. Value
Width	Define the max width of the sensor	None	bool	1	96
Height	Define the max Height of the sensor	None	bool	1	96
Mirror by X	mirrors the view by the x-axis	None	bool	0	1
Mirror by Y	mirrors the view by the y-axis	None	bool	0	1
Scans to capture	allows you to limit the number of captured images per session. When this number is reached, the session will be stopped. If this value is set to 0, the session is not limited and can only be stopped using the *disconnect* button.	None	uint	0	65535
Max Frequency	describes the upper limit for the measurement frequency of a session in Hz (samples per second). If this value is set to 0, the measurement will be performed at the maximum frequency possible.	Hz	float	0.0	1000.0
Column switch delay	allows you to set a delay between multiplexing the readout area’s columns. This value can affect image quality and provides control over timing.	µs	uint	0	65535
Row switch delay	allows you to set a delay between multiplexing the readout area’s rows. This value can affect image quality and provides control over timing.	µs	uint	0	65535
Reference voltage	allows you to set a reference voltage value on the board. In general, the higher the reference, the higher the sensitivity of the sensor system to external stimulus. It is recommended to start measurements with a low reference voltage and to increase it if necessary.	V	float	0.0	3.2885
Use Double sampling	This feature improves the measurement’s quality. Some electrical component imperfections are neglected. Disadvantage: The sampling rate drops by approx. 50 %.	None	bool	0	1
JSON shift X	Allows to shift the frame processing area (provided as a JSON file) in x-direction.	None	bool	0	1
JSON shift Y	Allows to shift the frame processing area (provided as a JSON file) in y-direction.	None	bool	0	1
CAN Stream Id	Specifies a CAN frame ID for the selected stream. If data is transmitted via the CAN	None	uint	0	2047

	interface, data for the selected stream is transmitted with the ID given.				

NOTE: If frame processing is configured for any matrix on analog module 1, then it can also be read from the analog module 2 connector if JSON shift X and JSON shift Y are set to 32.

NOTE: For additional information regarding the CAN interface, please see the hardware manual.

7.5.4 Time Filter Settings

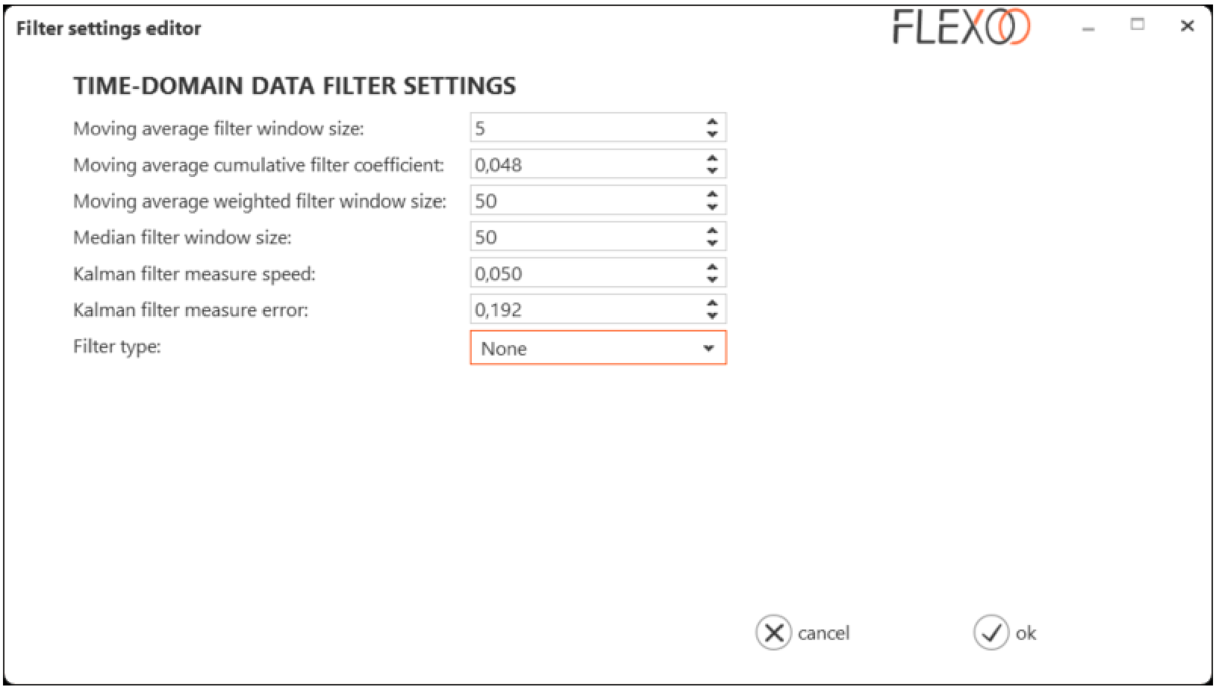


Figure 25: *Filter settings editor*

Click the *Filters* button (**Figure 22**) for a specific stream to open the filter settings editor (**Figure 25**).

In this window, the on-board time domain filtering of the sensor data can be enabled and configured. This reduces measurement noises and delivers a steady output. Filter computation is performed for each pixel individually.

A detailed description about the filters and their configuration is given in section 9.1.

7.5.5 Calibration Settings

Figure 26: *Calibration settings editor*

Click the *Calibration* button (**Figure 22**) for a specific stream to open the calibration settings editor (**Figure 26**).

This window allows to import, export, and generate calibration data. Typically, a mapping from original measurements to physical values based on calibration data is performed in two steps. First, the original 12-bit measurement values are adjusted on-board. Second, those modified 12-bit values are transferred to a physical value on software side. Both steps can be enabled and disabled using the *Enable on-board calibration* and *Enable value mapping mode* checkboxes.

NOTE: A detailed explanation about the calibration concept is given in section 0.

The calibration data can be stored in an MS-Excel File (XLSX). To import or export calibration data, the *import from the file* and *export to the file* buttons are used. To confirm the calibration settings hit the *ok* button and load the new settings to the device to apply them.

7.5.5.1 Reference Points

Reference points are used to assign matrix measurement data to a single physical value. To generate a new snapshot, first make sure that the correct width and height is selected. Change the *Width* and *Height* fields according to your stream configuration and apply. Next, click the *add reference point* button and a new reference point entry is added to the list (**Figure 27**).

NOTE: Make sure that on-board calibration is disabled on your board. If on-board calibration is enabled, disable the checkbox, click ok and press the *save to device* button before continuing.

Figure 27: *Adding a snapshot.*

To capture the matrix data for the current reference point, click the *Snapshot* button. The calibration snapshot capture window will open (**Figure 28**).

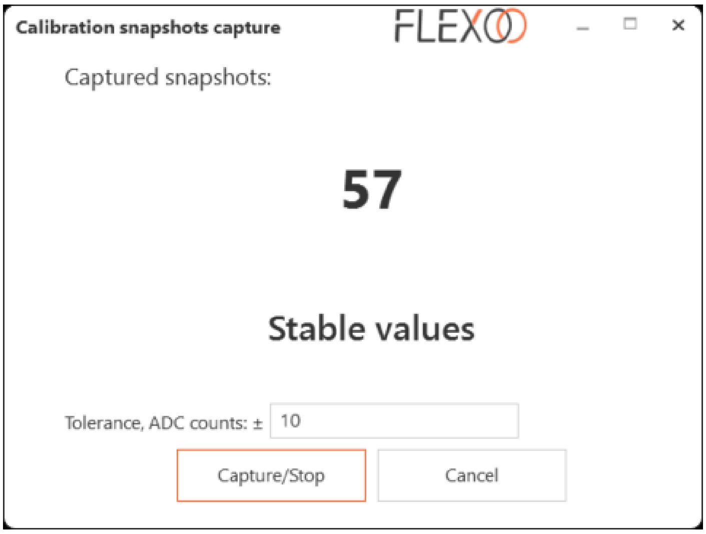
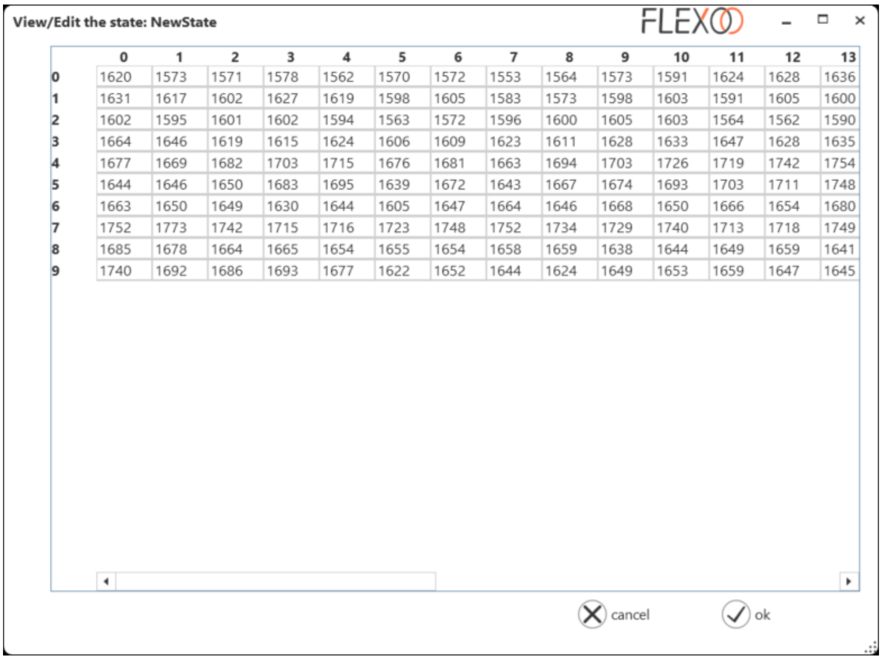


Figure 28: *Calibration snapshot capture window*

With the Capture/Stop button, matrix measurements are started and stopped. The number in the window's center indicates the number of recorded matrix samples. To guarantee stable measurement conditions, a tolerance window can be set. If the measurements for some sensor cells will leave this window, their position is indicated, and no snapshot is obtained. After leaving the window, the average matrix over all recorded samples is stored. This matrix can be reviewed and edited using the *Edit* button (**Figure 29**).



	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	1620	1573	1571	1578	1562	1570	1572	1553	1564	1573	1591	1624	1628	1636
1	1631	1617	1602	1627	1619	1598	1605	1583	1573	1598	1603	1591	1605	1600
2	1602	1595	1601	1602	1594	1563	1572	1596	1600	1605	1603	1564	1562	1590
3	1664	1646	1619	1615	1624	1606	1609	1623	1611	1628	1633	1647	1628	1635
4	1677	1669	1682	1703	1715	1676	1681	1663	1694	1703	1726	1719	1742	1754
5	1644	1646	1650	1683	1695	1639	1672	1643	1667	1674	1693	1703	1711	1748
6	1663	1650	1649	1630	1644	1605	1647	1664	1646	1668	1650	1666	1654	1680
7	1752	1773	1742	1715	1716	1723	1748	1752	1734	1729	1740	1713	1718	1749
8	1685	1678	1664	1665	1654	1655	1654	1658	1659	1638	1644	1649	1659	1641
9	1740	1692	1686	1693	1677	1622	1652	1644	1624	1649	1653	1659	1647	1645

Figure 29: *View/Edit state window.*

Optionally, a physical value, a reference value (at least one of both) and a state name can be assigned to the reference point.

NOTE: At least two reference points are required to use the calibration data saved to a device.

7.5.5.2 Calibration Example

In the following, an example for calibration of a temperature sensor matrix is given. Consider the sensor matrix is placed in a temperature-controlled setup, that applies the same temperature to all sensor cells of the matrix.

NOTE: No matter which physical values are referenced to a sensor matrix (e.g., pressure, temperature, etc.), the setup for calibration requires to apply the same value to each single sensor cell. In addition, it is required to know the physical reference value as precise as possible.

1. Select the corresponding stream for the temperature matrix and open the calibration settings editor.
2. Change the width and height to the corresponding sensor size then click apply. Example: W = 32 and H = 10.
3. Add as many reference points as desired.
4. Apply several temperatures to the sensor matrix, record snapshots and notate the corresponding temperature values in the *physical value* fields
   Write the desired physical value and if needed write the state name for more information as shown in (**Figure 30**).
   a. Physical value: represents the real temperature/pressure value.
   b. Reference value: represents the ADC values which range from 0 to 4095. The software will generate the values automatically when pressing arrange from physical units.

Figure 30: *Calibration example*

5. After finish taking the snapshots for each point click the *arrange from physical units'* button to automatically compute the reference values for on-board calibration as well as the parameter for value mapping (*Coefficient* and *Offset*). Assign the correct unit (in this case °C) to the Units field (**Figure 30:** Calibration example).
6. Enable calibration and value mapping mode checkboxes. Click *ok* and save the settings to the device. The next time a measurement session is started, the board will restart. Afterwards, the physical values will be displayed in the matrix visualization during a measurement.

8 Visualization

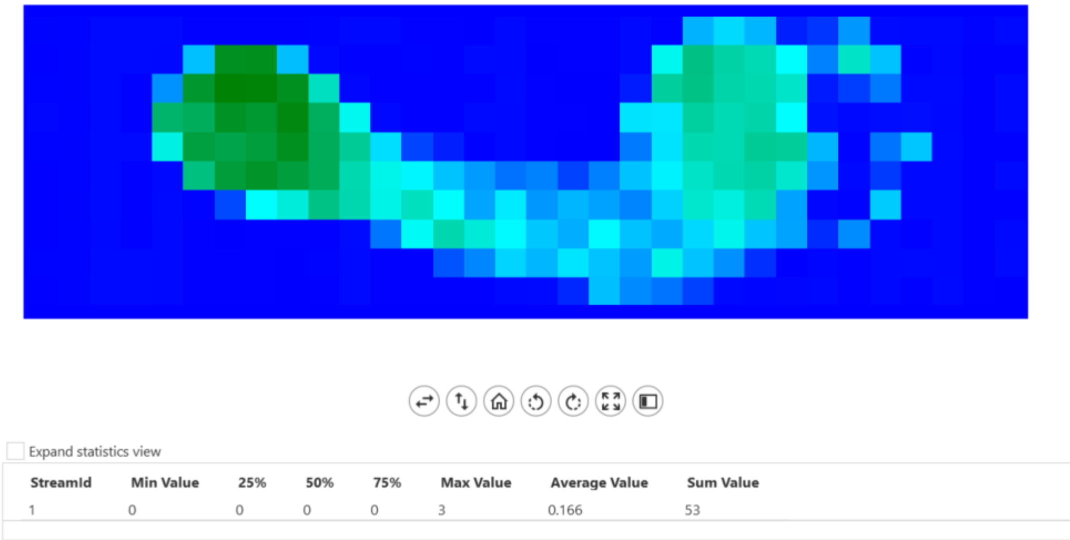
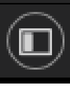


Figure 31: *Visualization area showing the pressure distribution of a foot.*

Figure 31 shows the visualization area, accessible in the *MATRIX* main tab (section 7.1) and session view (section 7.2). It provides several features which are described in the following subsections in detail.

8.1 Control Panel

The control panel is placed directly below the view port. Its functions are listed below.

Button	Description
	Mirror the view vertically
	Mirror the view horizontally
	Return to default view
	Rotate the view by a 90° left turn
	Rotate the view by a 90° right turn
	Switch to fullscreen mode
	Open/close the advanced visualization settings panel (section 8.3)

8.2 Matrix Statistics

Below the control panel, the statistics panel is placed (**Figure 32**). The current view's matrix statistics are displayed here. These are (from left to right):

- Minimum value
- 25% percentile
- 50% percentile (median)
- 75% percentile
- Maximum value
- Average value
- Sum of all values

Expand statistics view

StreamId	Min Value	25%	50%	75%	Max Value	Average Value	Sum Value
1	0	0	0	0	6	0.266	85
2	0	0	0	0	1	0.134	43
3	0	0	0	0	2	0.213	105
4	0	0	0	0	5	0.184	235

Figure 32: *Matrix statistics panel*

The expand statistics view checkbox will expand the table when selecting multiple streams if needed.

8.3 Advanced Visualization Settings

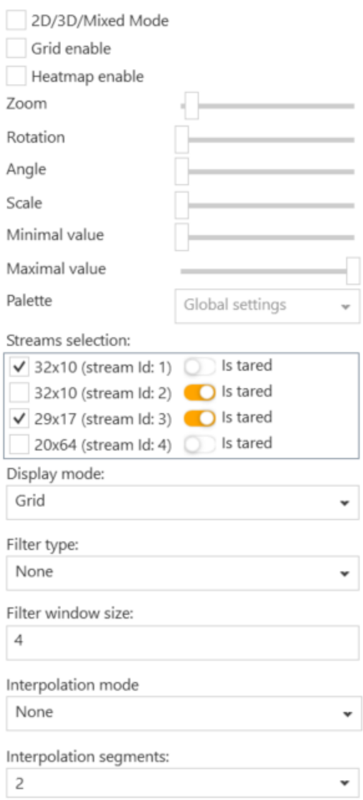


Figure 33: *Advanced visualization settings panel*

Figure 33 shows the advanced visualization settings panel which can be accessed using the rightest button in the control panel (section 8.1). Its features are described in the following subsections.

8.3.1 General Settings

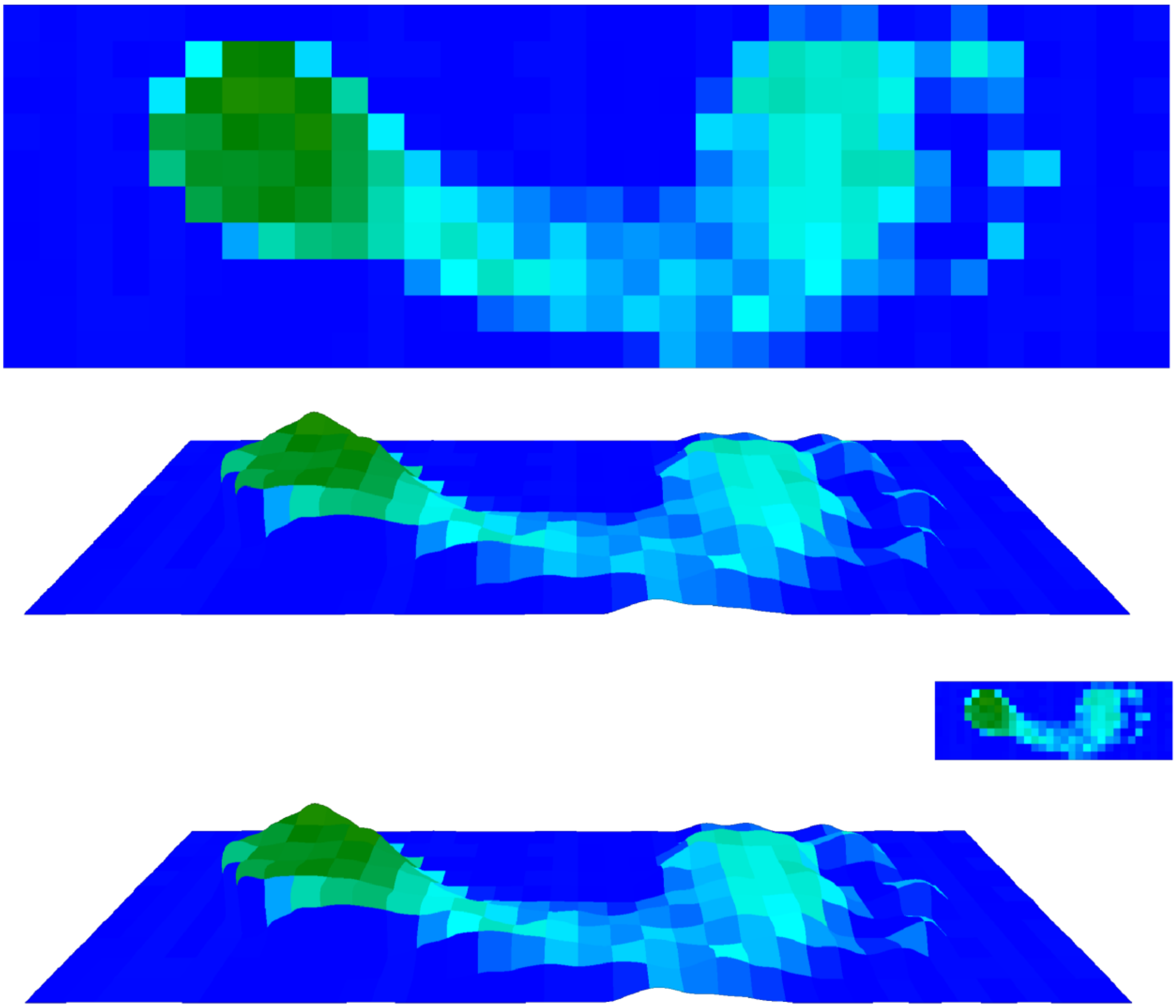


Figure 34: *Presentation of the three visualizations modes on the example of a foot's pressure distribution. Top to bottom: 2D mode, 3D mode, mixed mode*

- The *2D/3D/Mixed Mode* checkbox allows to switch between the three visualizations modes (**Figure 34**).
- The *Grid enables* checkbox controls if a grid is projected onto the matrix visualization or not.
- To switch between pixelated and interpolated visualization, the *Heatmap enable* checkbox can be used.
- The sliders *Minimal value* and *Maximum value* adjust the boundaries for the colormap.
- With 3D mode or mixed mode enabled, four slider controls are provided to adjust the view in the 3D scene. Those are *Zoom*, *Rotation*, *Angle* and *Scale*.
- The *Stream Selection* feature allows you to switch between different streams or select multiple streams simultaneously (***Multi-Matrix View***) for comprehensive analysis. It supports both horizontal and vertical alignments.

- The *Is tared* feature modifies the RAW or Calibrated data to correct for residual pressure, it is useful to remove residual loads from manufacturing and set all the sensors resistance to the same value. The RAW or Calibrated data is not affected by the tare function.

8.3.2 Image Filtering

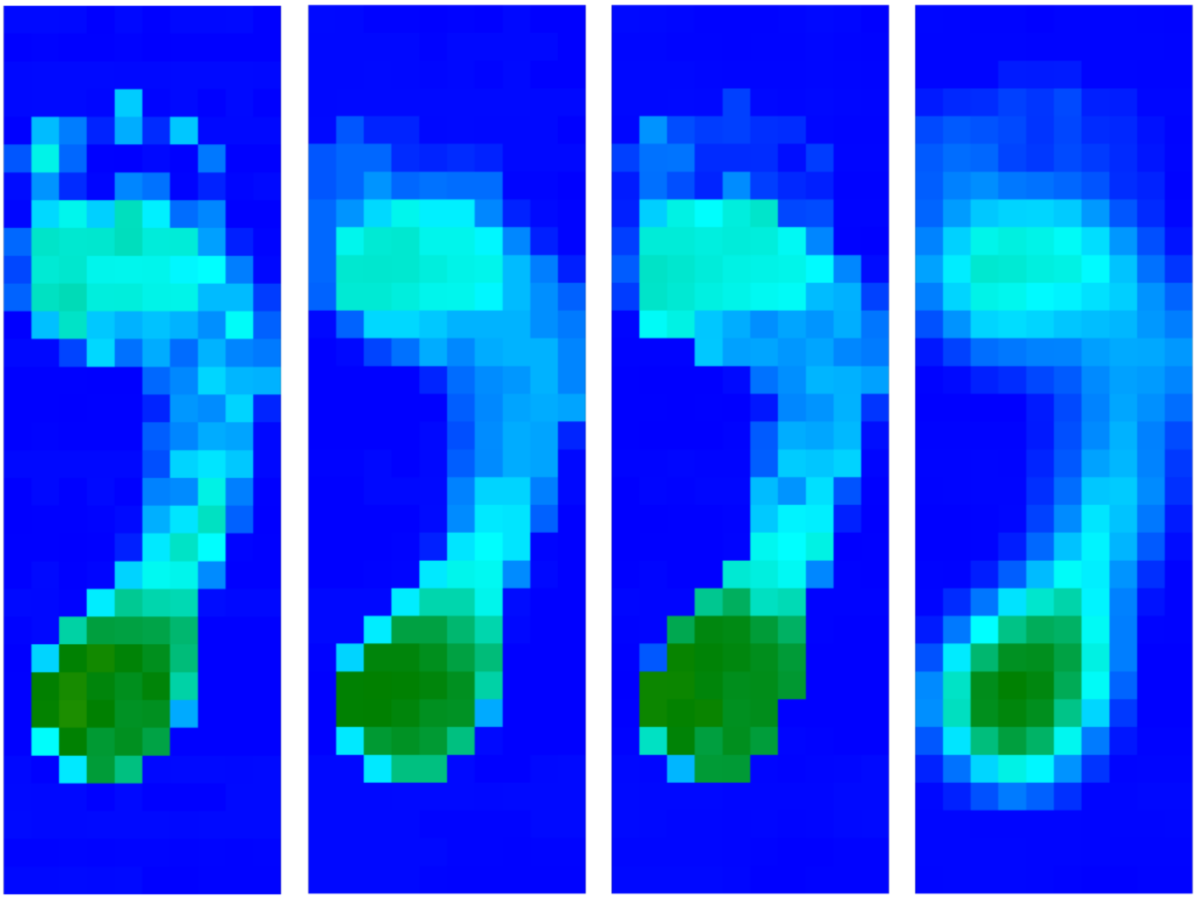


Figure 35: *Presentation of the filter methods on the example of a foot's pressure distribution. Left to right: original, median filter, SNN filter, mean filter.*

The *Filter type* dropdown menu provides three image filters:

- Median filter
- Statistical Nearest Neighbor (SNN) filter
- Mean (Average) filter.

The filter's window size can be set below. **Figure 35** shows a comparison of the different filter types for window size 3.

8.3.3 Image Interpolation

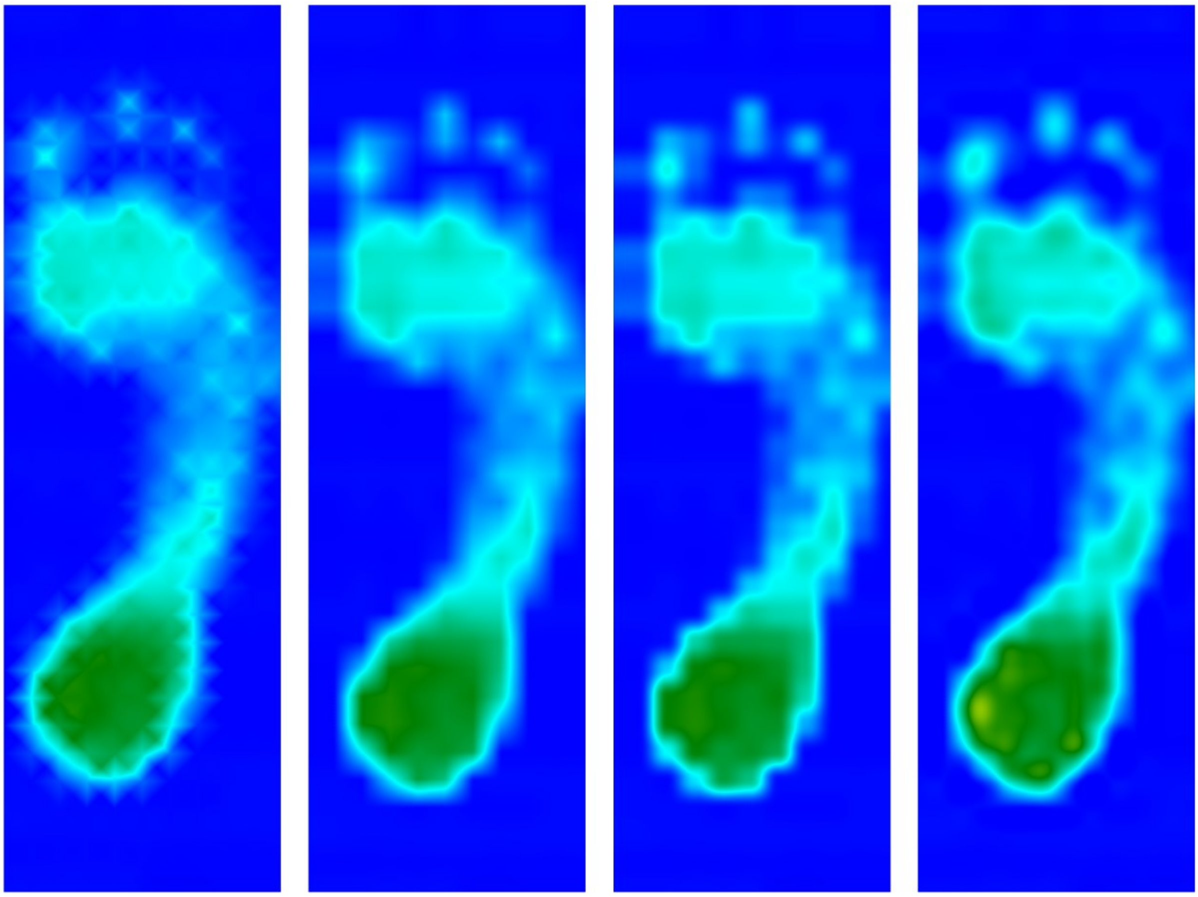


Figure 36: *Presentation of the three filter methods on the example of a foot's pressure distribution. Top to bottom: None, Bilinear, Cosine, Bicubic*

The *Interpolation mode* dropdown menu provides three interpolation types:

- Bilinear
- Cosine
- Bicubic

The number of interpolation segments can be set below. **Figure 36** shows a comparison of the different filter types for 8 segments.

8.4 Real-time Charts

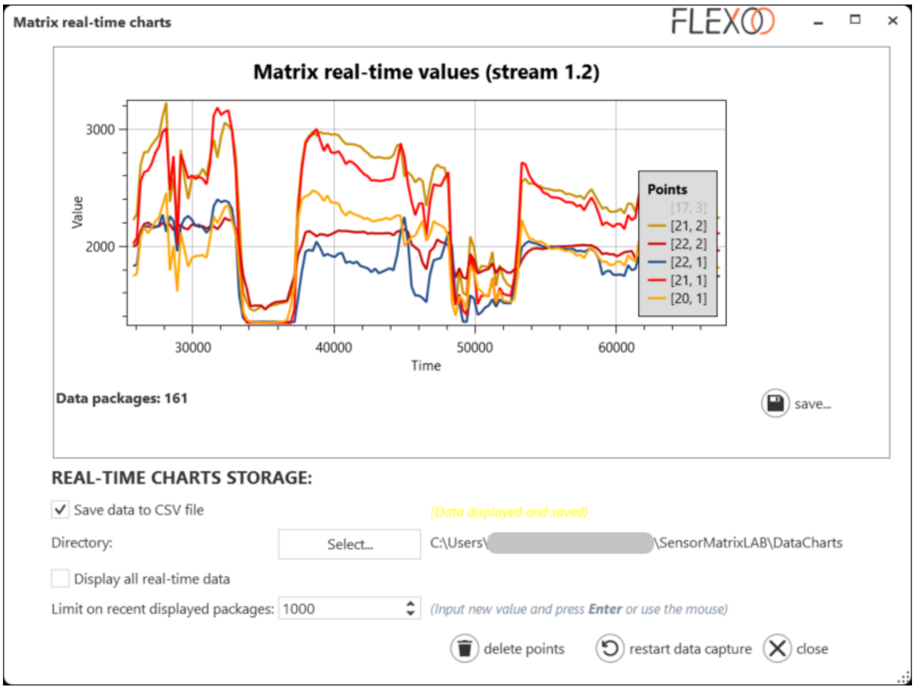


***Figure 37:** Matrix real-time charts*

It is possible to visualize the measurement data for a specific selection of sensor cells in a line plot. Therefore, double click onto the pixel (sensor cell) in the view port. The real-time charts window opens (**Figure 37**).

NOTE: This function is only available in 2D mode.

Several pixels can be selected and displayed at the same time. Use the buttons to restart the plot or to save it to an image file.

8.4.1 Real-Time chart storage:

- Save data to CSV file: When this option is checked, the software will automatically save a CSV file containing the value and time for the selected pixel. If multiple pixels are selected, the software will generate separate CSV files for each pixel.
- Display Real-Time Data: When this option is enabled, all data from the moment of selection will be displayed in real time. If this option is not enabled, only the most recent data points, up to the limit specified below (1000 in your case), will be displayed. This feature is designed to optimize memory usage.

  To prevent memory overload, real-time data is capped at 100,000 packages. For example, with a frame rate of 100, this limit would correspond to approximately 1,000 seconds of data.

  Note: Upon restarting pixel data capture, new data will be appended to the existing data and saved. This ensures that no data will be lost during a restart
- Delete Points: will delete all selected pixels.

9 Advanced Features

9.1 Time-Series Filtering

This section provides information about the device's time filtering functionalities and how to configure them. Five filter algorithms are provided, which are described in the following subsections. The timestamp index of a measured sample x is notated with i. The filtered sample is notated with y.

NOTE: Time filtering is performed on-board. If enabled, the original data cannot be accessed after a measurement session. If it is required to keep the original measurement data, disable time filtering, and perform it manually.

The parameter details for the filter configuration are listed below.

Name	Notation	Unit	Type	Min. Value	Max. Value
Moving average filter window size	k_a	None	uint	1	100
Moving average cumulative filter coefficient	α	None	float	0.0096	1.0
Moving average weighted filter window size	k_{aw}	None	uint	1	100
Median filter window size	k_m	None	uint	1	100
Kalman filter measure speed	v	None	float	0.0096	1.0
Kalman filter measure error	r	None	float	0.0096	1.0

9.1.1 Moving Average Filter

For each sample x this filter outputs an unweighted average y_a of the current and previous $k - 1$ data points (if available). The k_a parameter represents the window size.

$$y_{a,i} = \begin{cases} \frac{1}{i} \sum_{j=0}^{i-1} x_{i-j} & i < k_a \\ \frac{1}{k_a} \sum_{j=0}^{k_a-1} x_{i-j} & i \geq k_a \end{cases}$$

9.1.2 Moving Average Cumulative Filter

An Exponentially Weighted Moving Average (EWMA) applies weighting factors to input data points that decrease exponentially. The coefficient α controls the effect of the filtering. For $\alpha = 1$ no filtering takes place.

$$y_{ac,i} = \alpha \sum_{j=0}^{i} (1-\alpha)^j \, x_{i-j}$$

9.1.3 Moving Average Weighted Filter

A weighted average is an average that has multiplication factors to give different weights to data at different positions in the sample window. The most recent sample is weighted the most. The parameter k_{aw} represents the window size.

$$y_{aw,i} = \begin{cases} \frac{1}{i(i+1)} \sum_{j=0}^{i-1} (i-j)\, x_{i-j} & i < k_{aw} \\ \frac{1}{k_{aw}(k_{aw}+1)} \sum_{j=0}^{k_{aw}-1} (k_{aw}-j)\, x_{i-j} & i \geq k_{aw} \end{cases}$$

9.1.4 Median Filter

The median filter returns the median of the last k_m samples, where k_m notates the window size. The median of a given set of values is the center value of the sorted set of those values. In the following, an example for $k_m = 5$ is given.

$$\begin{matrix} \dots \\ \left(\begin{matrix} x_{i-5} = 2765 \\ x_{i-4} = 3135 \\ x_{i-3} = 2912 \\ x_{i-2} = 3829 \\ x_{i-1} = 3430 \\ x_i = 3731 \end{matrix} \right) \end{matrix} \rightarrow \left(\begin{matrix} x_{i-3} = 2912 \\ x_{i-4} = 3153 \\ x_{i-1} = 3430 \\ x_i = 3731 \\ x_{i-2} = 3829 \end{matrix} \right) \rightarrow y_{m,i} = x_{i-1} = 3430$$

9.1.5 Kalman Filter

Implementation of a one-dimensional Kalman filter based on iterative computation of an estimate for measured values in a time series. K notates the Kalman gain, p the estimate error. The Kalman filtering can be configured using the measurement error r and the measurement speed v. The start conditions are $p_0 = 40$ and $y_0 = x_0$.

For each time stamp index i, three computation steps are required.

1. In the first step, the Kalman Gain K_i is computed.

$$K_i = \frac{p_{i-1}}{p_{i-1} + r}$$

2. Second, the filtered value (estimate) y_i is computed.

$$y_i = y_{i-1} + K_i(x_i - y_{i-1})$$

3. Finally, the error estimate for the next iteration p_i is computed.

$$p_i = (1 - K_n)\, p_{i-1} + v|y_i - y_{i-1}|$$

This process is repeated iteratively for each new data sample.

9.2 Calibration (Universal Matrix only)

The conversion from 12-bit integer measurement values to physical values is performed using calibration data. This conversion is split in two parts, an on-board integer to integer conversion and a software sided value mapping. The basic idea is to choose the reference values such that the software-sided value mapping can be performed using a linear function.

9.2.1 Introduction

In the following, for simplicity the process is explained for a single sensor cell. In general, this process is performed for each cell in the sensor matrix individually. Consider having a sorted set of n physical values P which correspond to a set of n original measurements M (12-bit integers). This kind of corresponding data usually arises from a calibration scenario. In addition, a set of n reference values R (12-bit integer) is defined, with their parameters still unknown.

$$M = [m_1, m_2, \dots, m_n]$$

$$P = [p_1, p_2, \dots, p_n]$$

$$p_1 < p_2 < \cdots < p_{n-1} < p_n$$

$$R = [r_1, r_2, \dots, r_n]$$

To compute a physical output y for any given measurement x, first an on-board conversion based on the reference values must be performed (f_1). Second, given the slope a and offset b of a linear function, value mapping is performed (f_2).

$$y = f_2(a, b, \hat{x}) = a \cdot \hat{x} + b$$

$$\hat{x} = f_1(R, M, x)$$

The on-board conversion is computed by linear interpolation of the measurement set M to the reference set R. For $m_i \leq x < m_{i+1}$ the computation of $\hat{x}$ derives as follows.

$$\hat{x} = r_i + (x - m_i)\frac{r_{i+1} - r_i}{m_{i+1} - m_i}$$

For a functioning value mapping, R, a and b must be chosen such that $p_i = f_2(r_i) = f_2\big(f_1(m_i)\big)$ for every i. In other words, the reference values must provide a linear correlation to p. The task is to define R such that this constraint is satisfied.

NOTE: Saved data (CSV or DB) does not contain physical values but converted 12-bit values. Use the parameters a and b to convert them to physical values manually.

9.2.2 Parameter Computation

1. First, the reference boundaries must be determined. Typically, the boundaries are set to $r_1 = 0$ and $r_n = 2^{12} - 1 = 4095$ to provide maximum resolution. However, as the on-board conversion provides also linear extrapolation, this range can be reduced. In this case measurements that lie outside of the calibration range will be linearly extrapolated instead of clipped to the boundaries.
   NOTE: The *arrange from physical units* button in the calibration settings editor performs the computation for $r_1 = 0$ and $r_n = 4095$ by default.
   NOTE: The reference values R are a 12-bit integer. Therefore, only integer values between 0 and 4095 are valid entries.

2. Second, the linear function parameters a and b are computed. Each pair (r_i, p_i) must satisfy the following condition.

$$p_i = a \cdot r_i + b$$

   With r_1 and r_n already defined, the parameters a and b can be derived.

$$\binom{p_1}{p_n} = a \binom{r_1}{r_n} + b$$

$$a = \frac{p_1 - p_n}{r_1 - r_n}$$

$$b = p_1 - a \cdot r_1 = p_1 - \frac{p_1 - p_n}{r_1 - r_n} \cdot r_1$$

   NOTE: In the calibration settings editor a refers to the *Coefficient* and b to the *Offset*.

3. Finally, the remaining reference values are computed directly from the physical values.

$$r_i = \frac{p_i - b}{a}$$

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