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Force Matrix Kit

A next-generation measurement system

User Manual

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Content

Version history

Version	Date	Description of the changes
V1.0	21.11.2025	Initial release

1. Introduction

NanoSen specializes in large-scale manufacturing of polymer nanocomposite (PNC) force sensing materials. Our force sensing material is made from a medical grade polymer base and is available in various sizes up to 40 cm x 45 cm. Individual sensor material pieces can easily be cut from these sheets and combined with a suitable electrode to create customized force sensors.

The NanoSen Force Matrix Kit provides a plug-and-play solution for developers to quickly integrate and test our sensor technology in applications where a thin, flexible and robust force sensor distribution is necessary. With the included readout electronics, users can explore the capabilities of our force sensing solution while actively suppressing the electrical crosstalk between the sensors. Highly customized sensor matrix can be developed using our PNC force sensing material, for which customers can continue to use the electronics included in the Force Matrix Kit. For serial sensor production, our PNC material is available in bulk quantities, allowing us to cater to both small-scale prototypes and scalable sensor solutions.

Safety Hints

Read and understand the user manual and safety instructions before using the kit.

The symbol in the manual indicates general hazard.

The symbol denotes helpful notes for the user.

2. Content of the kit

Readout electronics	Necessary for measuring the force sensor matrix while actively suppressing electrical crosstalk between sensors.
Sensor matrix	The 6x6 sensor matrix is formed by 36 sensor points with a 20 mm diameter PNC sensor material combined with suitable contact electrodes.
USB cable	For connecting the readout electronics to a PC for power and serial data transmission.

***Optional upgrade: The readout electronics can be upgraded to 100 sensor channels under request**

3. Intended use

The PNC Force Matrix Kit is intended for research and development (R&D) purposes only. It must be installed and operated by qualified personnel in an industrial or engineering environment in strict compliance with local safety regulations and the guidelines contained therein.

Manufacturer disclaimer

The manufacturer assumes no responsibility for damage, injury, or malfunctions caused by improper use or failure to follow the guidelines provided in this manual. Users are solely responsible for ensuring proper handling, installation, and operation of the kit. Usage of the Force Matrix Kit or its components outside these guidelines and the following limitations will void the warranty and may result in equipment damage or injury.

Key guidelines

Professional use only:

- This kit is not intended for consumer, personnel, or household applications (See also chapter 4 Improper Use).
- It must not be used in life-critical or hazardous environments unless additional safety systems are implemented.

Indoor use:

- Operate the kit in dry, indoor environments only. Avoid exposure to wet or humid conditions

Incorrect connections:

- Ensure all connections, including I2C interface, are correctly made according to the instructions in this manual. Unsecure connections may cause severe damage to the components.
- Improper integration of the kit into systems or devices, especially without adhering to the guidelines, may lead to malfunction or equipment damage.

Warranty compliance:

- Do not modify the readout electronics. This will immediately void the warranty. Connecting incompatible hardware, incorrect wiring, or improper power supply causing damage to the device will result in warranty void.

4. Improper use

Prohibited applications

Consumer use:

- This kit is not a toy and may not be used by untrained individuals, including children.
- It is not suitable for life-support systems, medical devices or safety-critical applications without additional safety and redundancy measures independent of this kit.

Hazardous environments:

- Do not use the kit in hazardous, explosive, or outdoor environments, and environments with excessive humidity.

Operational limits

- The sensor matrix and readout electronics must be operated within the limits specified in this manual:
  - Maximum input voltage: 5V DC
  - Maximum current: 500 mA
  - Force sensor overload capacity: 20 MPa (6200 N)

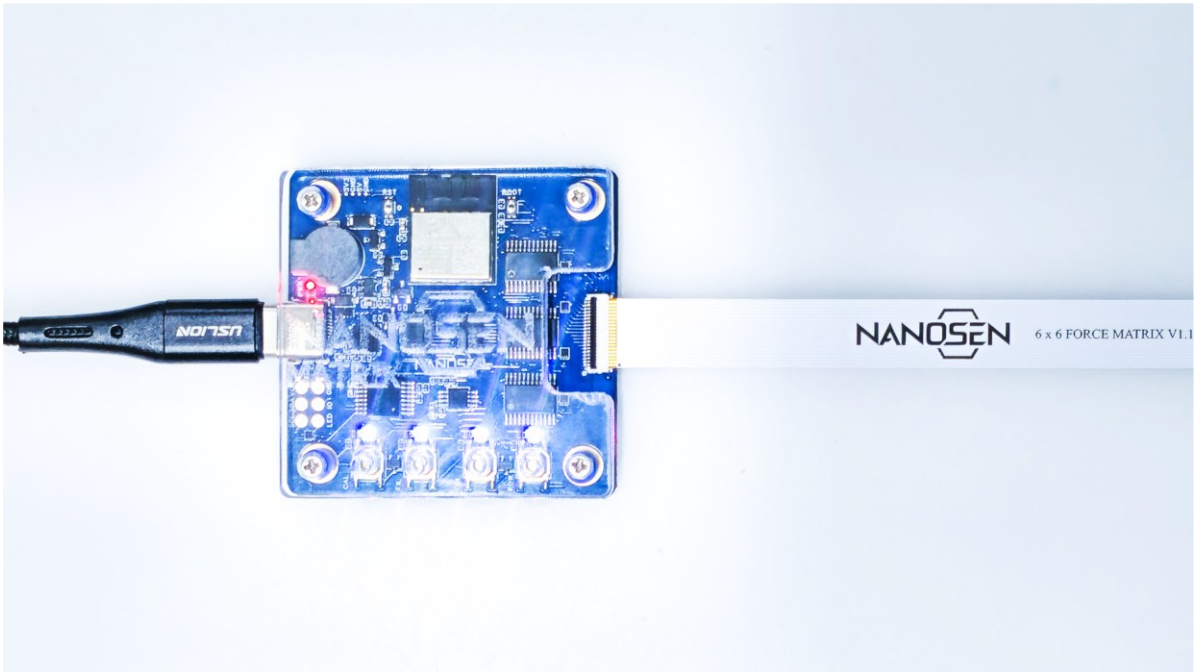
Environmental conditions:

- The device may only be operated at temperatures between -20°C and 70°C.
- Direct contact of the sensor matrix with electrically conductive materials can influence sensor response. In case of installation on conductive surfaces, such as metal housings, please isolate the sensor matrix with a non-conductive layer such as tape or plastic foil.

5. Quick start guide

Step 1: Connect the sensor matrix to the readout electronics.

Step 2: Use the provided USB-C cable to connect the readout electronics to a PC or laptop; this will power the unit on.



Step 3: Launch the provided GUI (Windows compatible) to visualize the sensor matrix response (see Section 8).

6. Hardware description

6.1 Readout electronics

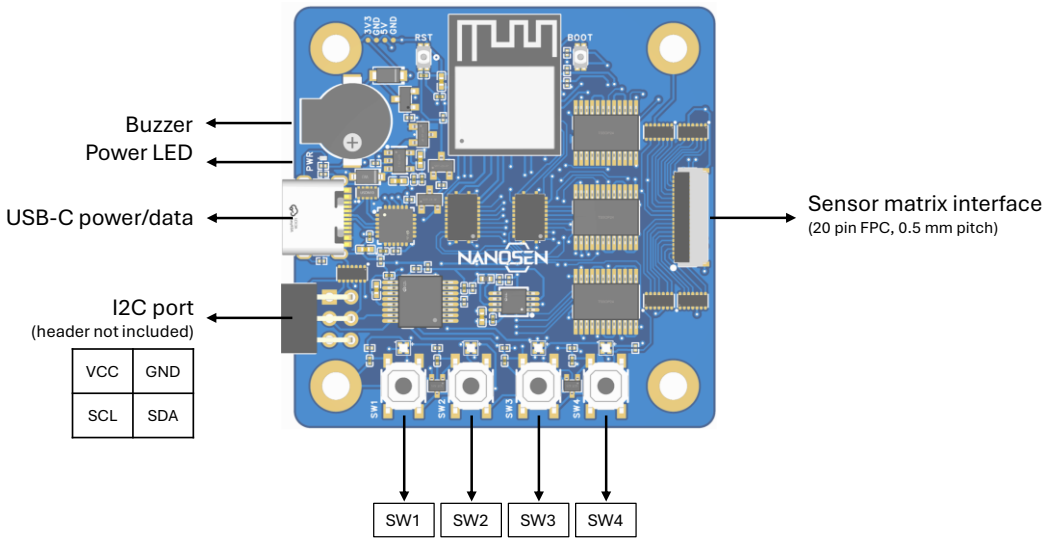
The PNC Force Matrix Kit includes advanced readout electronics with active crosstalk suppression, designed to fully utilize the performance of PNC force sensors. The electronics support connectivity for up to 100 sensors arranged in a 10×10 matrix. The kit comes with a 6×6 sensor matrix containing 36 PNC force sensors, each with 20 mm diameter.

The device is powered through a USB-C port (or an external 5 V supply), which also serves as the serial data transmission interface. Additional data transmission options include I2C protocol support and wireless communication via Bluetooth.

General specifications of the readout electronics

Input power supply rating	5 V DC, 500 mA
Power	USB-C port (or) I2C port
Data transmission	UART, I2C, Bluetooth
Integrated modules	• Buzzer • 4 buttons (offset correction, matrix size detection, averaging filter settings, Bluetooth activation)
I2C address	0x42
Data rate	4 samples per second with 36 sensors
Baud rate	115200
Operating temperature	-20°C to +70°C
Humidity	Sensor matrix encapsulation required / dependent on encapsulation material used
Outer dimensions:	L 50 mm x W 50 mm x H 14 mm

Port details

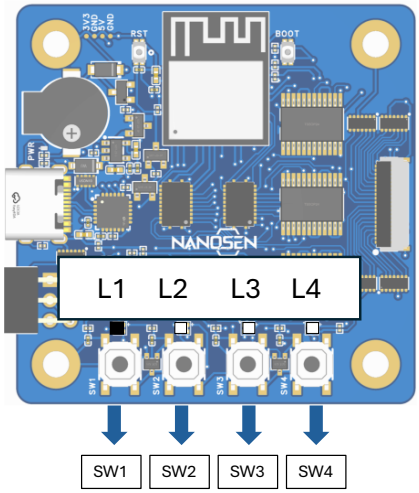


SW1 – Enable/Disable Bluetooth
SW2 – Select Sensor Gain
SW3 – Select Matrix Size
SW4 – Enable/Disable Offset Correction

- Each successful button press is confirmed with a short buzzer tone.
- Settings associated with SW1 & SW2 are permanently stored.

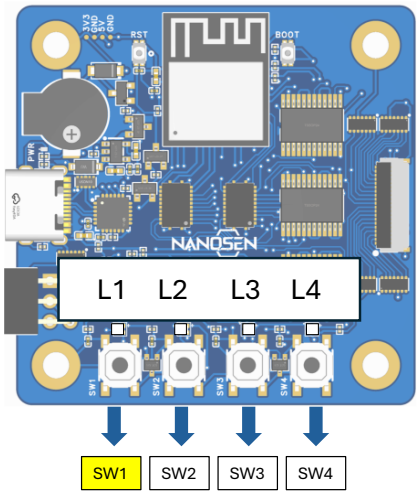
Configuration of the buttons S1 – S4

Default configuration:



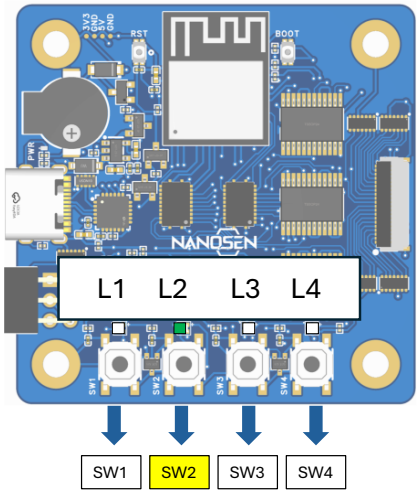
Switch state	LED state	Description of the function
SW1 – x	L1 – OFF	Bluetooth OFF
SW2 – x	L2 – white	No sensor gain
SW3 – x	L3 – white	6x6 matrix active
SW4 – x	L4 – white	Offset correction ON

SW1: Enable/disable Bluetooth



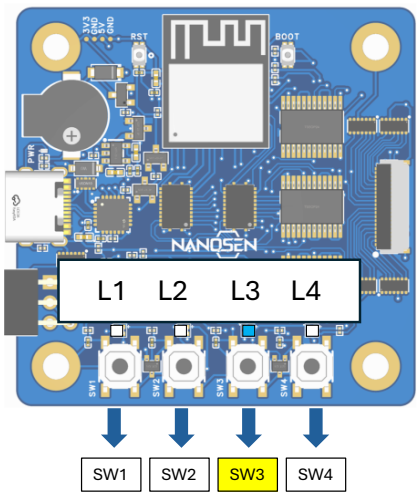
Switch state	LED state	Description of the function
SW1 – Long press	L1 – white	Bluetooth ON
SW1 – Long press again	L1 – OFF	Bluetooth OFF
SW2 – SW4	L2 – L4	Unaffected

SW2: Select sensor gain



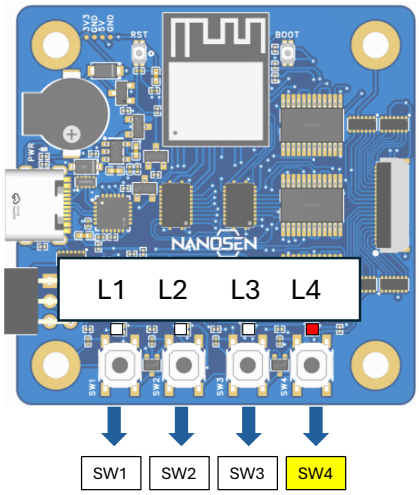
Switch state	LED state	Description of the function
SW2 – short press	L2 – blue	2x gain enabled
SW2 – short press again	L2 – green	5x gain enabled
SW2 – short press again	L2 – white	Back to default; No gain
SW1, SW3, SW4	L1, L3, L4	Unaffected

SW3: Select matrix size



Switch state	LED state	Description of the function
SW3 – short press	L3 – blue	10x10 matrix size selected
SW3 – short press again	L3 – white	6x6 matrix size selected (default)
SW1, SW2, SW4	L1, L2, L4	Unaffected

SW4: Enable/disable offset correction



Switch state	LED state	Description of the function
SW4 – short press	L4 – red	Offset correction OFF: Raw sensor data is transmitted.
SW4 – short press again	L4 – white	Offset correction ON (default): Sensor output is zero-referenced.
SW1 – SW3	L1 – L3	Unaffected

*Device power ON also applies the offset correction

6.2 PNC force sensor matrix

The PNC Force Sensor matrix comprises of two layers: individually cut PNC force-sensing material and the underlying contact electrode.

1. PNC force-sensing material:
   - This material is made from an electrically conductive nanocomposite, which combines a medical-grade polymer with conductive nanoparticles.
   - It is produced in sheets up to 45 cm x 40 cm, offering flexibility in design and allowing users to cut individual sensor pieces from these sheets for customized shapes and sizes as needed.
2. Underlying Contact Electrode:
   - This layer is a flex PCB with ENIG coated electrodes that serve as the electrical contact layer for the PNC force-sensing layer.

The included force sensor matrix features 36 active sensor units each with 20 mm diameter, making it well-suited for a variety of applications. The individual sensor units are securely glued in place

Handle with care: Do not pull on the PNC material at any sensor point, as this can tear the material or detach it from the electrode, permanently damaging the sensor point.

Do not cut: The sensor matrix must not be cut with any tools. Cutting methods such as laser or water-jet processing are strictly prohibited, as they can damage the PNC material and may generate hazardous dust.

General specifications of the force sensor matrix

Parameter	Value
Product line	Force Matrix Kit
Model number	6x6 Force Matrix
Version number	V1.1
Active sensor area	36 points with 20 mm diameter
Matrix dimension active zone	L 136 mm x W 136 mm x T 0.6 mm
Contact electrode	Flex PCB electrode matrix

* L: Length, W: Width, T: Thickness

7. Data transmission options

The readout electronics transmits sensor data using either UART or I2Ccommunication protocols: UART and I2C. Users can select the desired protocol depending on their application and compatibility with their receiving device.

UART configuration

When using the UART protocol (via USB cable), ensure the receiving device or tool is set up with the following parameters:

- Baud Rate: 115200
- Parity: None (No parity enabled)
- Data Bits: 8 bits
- Stop Bits: 1
- Flow Control: None (No flow control enabled)

Please configure these settings on your receiving device or software to ensure seamless data communication with the readout electronics.

Bluetooth configuration

When Bluetooth is turned ON, pair and connect the readout electronics ("NanoSen_BT") to a device with serial communication capability—such as a PC, smartphone, or any other Bluetooth-enabled data receiver—to transmit the data.

I2C configuration

With the I2C protocol, data is transmitted via the I^2C address 0x42. When using I2C, the readout electronics should not be powered via USB-C. Instead, power the device through the I2C port (e.g., from an Arduino UNO) to ensure proper operation. The pin connections are as follows:

SDA pin of the electronics → A4 pin of Arduino UNO
SCL pin of the electronics → A5 pin of Arduino UNO
GND pin of the electronics → GND pin of Arduino UNO
VCC pin of the electronics → 5V pin of Arduino UNO

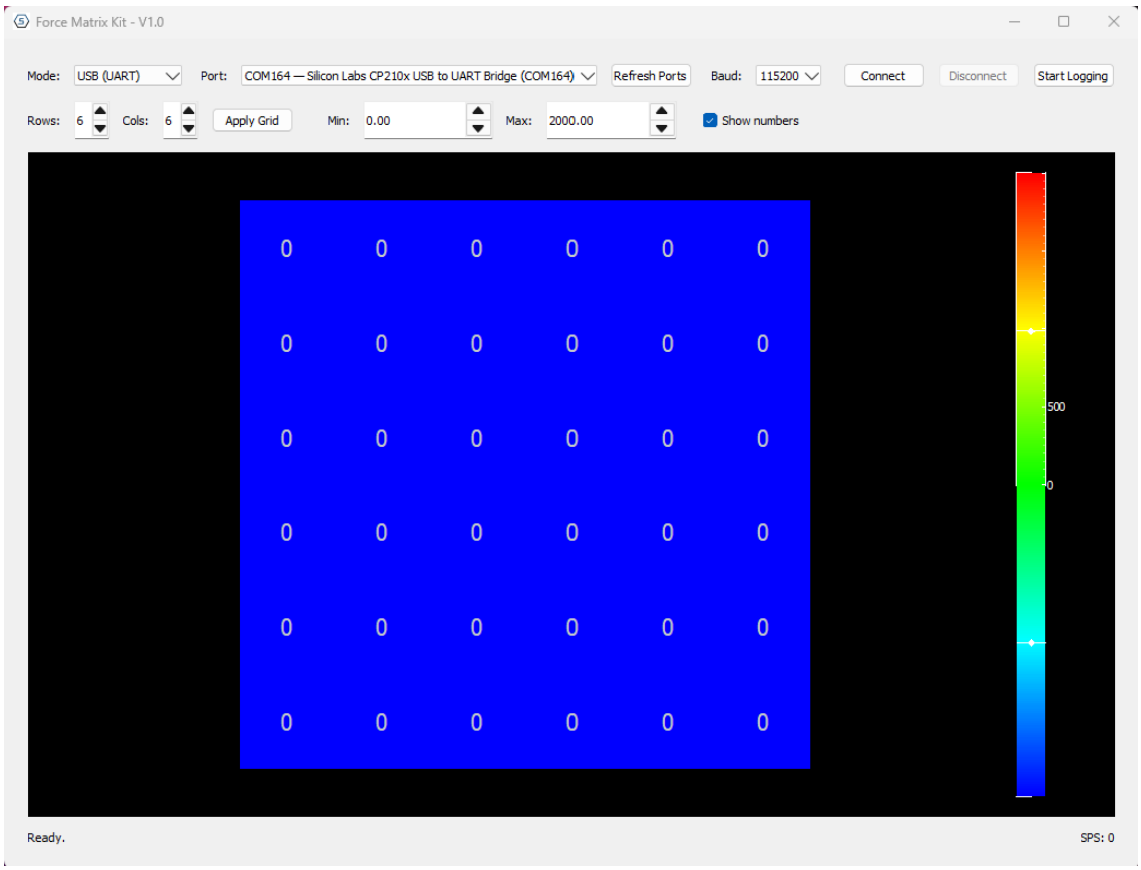
I2C receiving code (for Arduino Uno):

```
#include <Wire.h>

#define MAX_DATA_POINTS 100
#define NUM_BATCHES 9 // → Change to 25 for 10x10 matrix

const int i2cSlaveAddress = 0x42;
char incomingBuffer[128];
int bufferIndex = 0;
String batchData[NUM_BATCHES];
int currentBatch = 0;
int receivedData[MAX_DATA_POINTS];
int totalReceived = 0;

void setup() {
  Serial.begin(115200);
  Wire.begin(i2cSlaveAddress);
  Wire.onReceive(receiveI2CData);
  Serial.println("Ready to receive I2C data...");
}

void loop() {
  // Optional: You can print the stored array periodically for debugging
  // delay(2000);
  // printStoredData();
}

void receiveI2CData(int howMany) {
  while (Wire.available()) {
    char receivedChar = Wire.read();

    if (receivedChar == '|') {
      // End of one batch
      incomingBuffer[bufferIndex] = '\0';
      bufferIndex = 0;
      if (currentBatch < NUM_BATCHES) {
        batchData[currentBatch] = String(incomingBuffer);
        currentBatch++;
      }
    }
    else if (receivedChar == '+') {
      // End of all batches – combine and parse
      totalReceived = 0;
      for (int i = 0; i < currentBatch; i++) {
        parseCsvToArray(batchData[i]);
      }
      // Serial.print("Total Data Points Stored: ");
      // Serial.println(totalReceived);
```

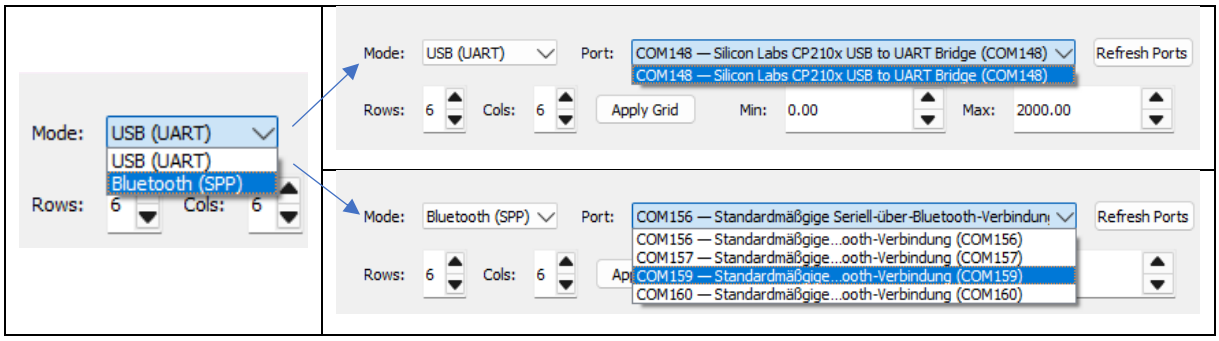
```
      printStoredData(); // Print all data as CSV
      // Reset for next frame
      currentBatch = 0;
      for (int i = 0; i < NUM_BATCHES; i++) batchData[i] = "";
      bufferIndex = 0;
    }
    else if (bufferIndex < sizeof(incomingBuffer) - 1) {
      // Normal character accumulation
      incomingBuffer[bufferIndex++] = receivedChar;
    }
  }
}

// --- Helper to parse CSV string into integer array ---
void parseCsvToArray(const String &csv) {
  int lastIndex = 0;
  while (true) {
    int commaIndex = csv.indexOf(',', lastIndex);
    String value;
    if (commaIndex == -1) {
      value = csv.substring(lastIndex);
    } else {
      value = csv.substring(lastIndex, commaIndex);
    }
    value.trim();
    if (value.length() > 0 && totalReceived < MAX_DATA_POINTS) {
      receivedData[totalReceived++] = value.toInt();
    }
    if (commaIndex == -1) break;
    lastIndex = commaIndex + 1;
  }
}

// --- Helper to print stored data as CSV ---
void printStoredData() {
  if (totalReceived == 0) return;
  // Serial.print("CSV Data: ");
  for (int i = 0; i < totalReceived; i++) {
    Serial.print(receivedData[i]);
    if (i < totalReceived - 1) Serial.print(",");
  }
  Serial.println();
}
```

8. Guide for using GUI (Windows OS only)

➢ **Step 1:** Open the application “Force_Matrix_Kit_GUI” to access the GUI



➢ **Step 2:** Under “Mode:” select either USB (UART) or Bluetooth and select the COM port of the readout electronics



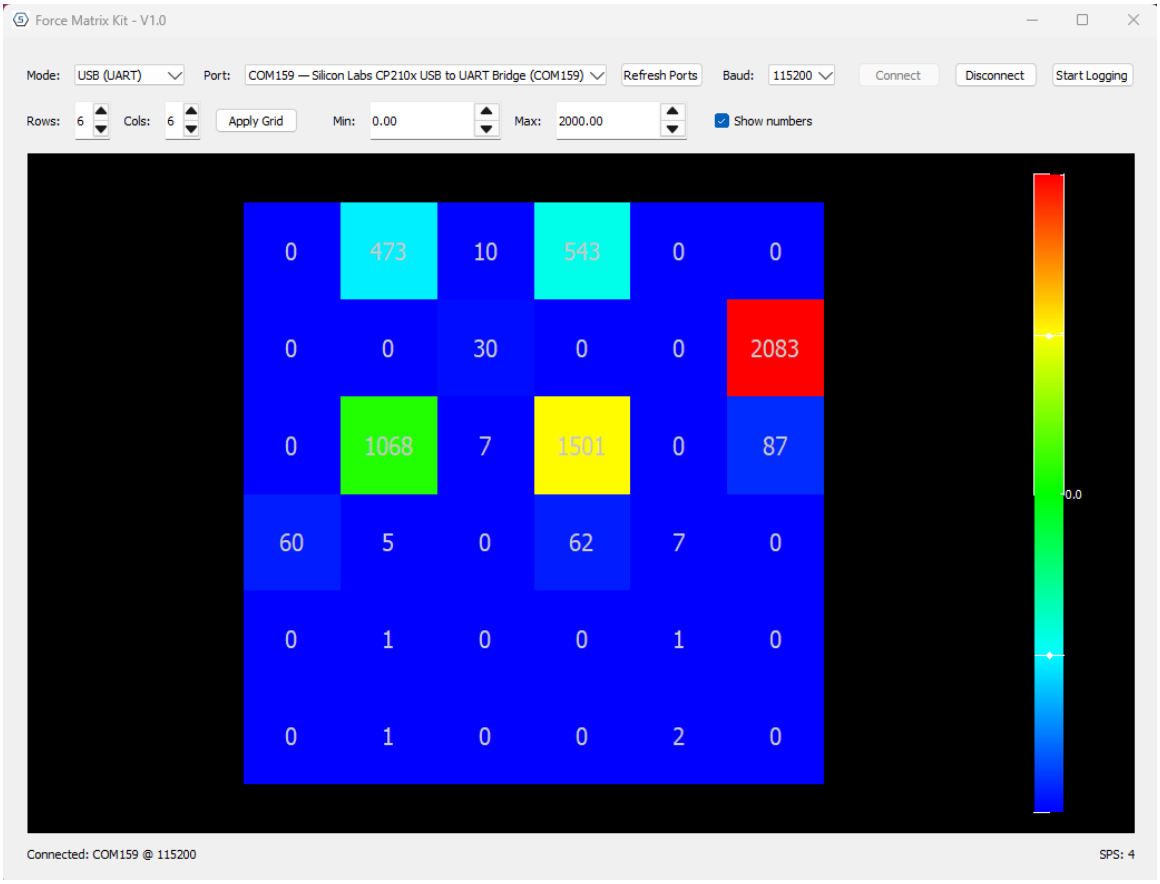
The USB COM port is typically shown as **“COMxx - Silicon Labs CP210x USB to UART Bridge.”** If the COM port does not appear correctly, install the required driver from the Silicon Labs website: https://www.silabs.com/developer-tools/usb-to-uart-bridge-vcp-drivers?tab=downloads

For Bluetooth mode, first pair the matrix kit with your PC using the device name **“NanoSen_BT.”** After pairing, the corresponding COM port will appear in the GUI, usually labelled as **“COMxx - Standard Serial over Bluetooth link.”**

***Note**: The **“Refresh Ports”** button refreshes the Bluetooth and USB ports.*

- **Step 3:** Select **115200** under **“Baud:”**. This is the default setting and should only be changed if required.
- **Step 4:** Select **6** for both **“Rows:”** and **“Cols:”** to match the 6×6 matrix, then click **“Apply Grid”**. This is the default configuration and should only be changed if necessary.
- **Step 5:** Click **“Connect”** to start the visualization and **“Disconnect”** to stop it. The **“Min:”** and **“Max:”** fields can be adjusted to map the sensor values to the color scale. The **“Show numbers”** option enables or disables the numerical display of the sensor data.

  ***Note**: The **“Disconnect”** button also resets the readout electronics.*



The **“Start Logging”** button saves the incoming sensor data—whether received via USB or Bluetooth—in CSV format. A folder named **“logs”** is automatically created in the same directory as the GUI. The same button changes to **“Stop Logging”** and is used to stop data logging.

The bottom-right corner of the window displays the SPS (samples per second) of the received sensor data. The left side of the window shows important status messages, such as device connected, device disconnected, logging started, and other notifications.

9. Hints & tips

The Force Matrix Kit provides a play-and-play solution for immediate application testing and validation.

While the kit offers a standard configuration, the sensor matrix is highly customizable to meet specific applications requirements. Key customization features include:

- **Scalable Sensor Density:** The number of sensor points can be configured up to 100 points (the data rate will be 2sps). For higher-density matrices, NanoSen offers compatible upgrades for the readout electronics upon request.
- **Adjustable Point Size:** The dimensions of individual sensor points can be tailored to your application. The minimum size for a single sensor point is 4 mm^2.

All customizations are available upon request and will be quoted based on your specific technical needs.

10. Waste disposal

The force matrix kit components should be disposed in accordance with local regulations regarding electronic waste. Do not dispose it within regular household waste.

11. Customer support

For troubleshooting or technical supports when operating with the Force Matrix Kit, please visit the website www.nanosen.de or contact us at info@nanosen.de.