# Instructions for running 4-point probe programs on Keithley 2400 SourceMeters

Connecting SourceMeters to the PC:

1. Use the Serial-to-USB adapters to connect the SourceMeters' RS232 ports to the PC. The SourceMeter labelled 24 should be connected to the USB-A port labelled COM4; the SourceMeter labelled 25 should be connected to the USB-A port labelled COM5.
2. Open 'Device Manager' on the PC to check the connection. There should be two devices under 'Ports (COM & LPT)' called 'Prolific USB-to-Serial Comm Port (COM4)' and 'Prolific USB-to-Serial Comm Port (COM5)'
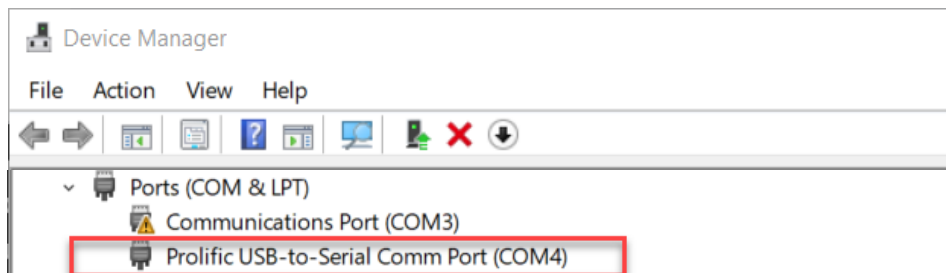
If 'Device Manager' says 'PL2303HXA PHASED OUT SINCE 2012. PLEASE CONTACT YOUR SUPPLIER.', follow these instructions in red.

Right click on the device and select 'Uninstall device'. Ensure the option to remove the drivers is ticked and press uninstall. Do this for both USB-to-Serial adapters. Use the 'Search for hardware changes' tool to scan for the adapters
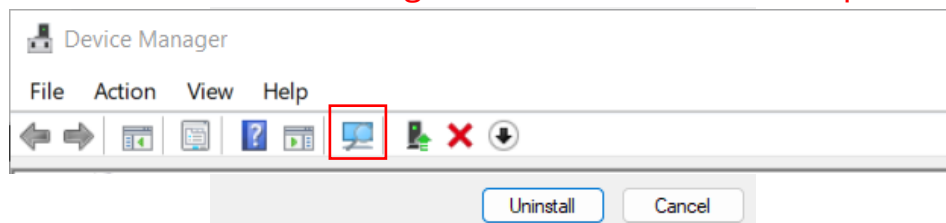
3. Ensure the SourceMeters are set up for RS232 communication. On the SourceMeters' keyboard: Menu > Communication > RS232.

Using the 'four_point_probe_data_collector.py' program:

1. Open the program with Visual Studio Code (VSC).
2. Configure the current source.

a. Use the commands on lines 172-178 to adjust the current range of the current source.
A line of code starting with '#' will not run; use '#' to activate and deactivate lines of code as needed.
The ':SOUR:CURR:RANG MAX' command sets the current range to its maximum value of 1A.
The ':SOUR:CURR:RANG MIN command sets the current range to its minimum value of 1µA.
The ':SOUR:CURR:RANG UP' command increases the current range by one increment.
The ':SOUR:CURR:RANG DOWN' command decrease the current range by one increment.

Current range indicator	Current range
1A	1A – 100µA
100mA	100mA - 10µA
...	...
10µA	10µA – 1nA
1µA	1µA – 100pA

':SOUR:CURR:RANG MAX'

':SOUR:CURR:RANG DOWN'

':SOUR:CURR:RANG UP'

':SOUR:CURR:RANG MIN'

3. Configure the current values to be used for the experiment.
   a. METHOD 1: Use the variables in lines 296-300 to enter the maximum (I_max) and minimum (I_min) current values to use, and the current step (I_res).
   put '#' in front of 'I_list = []' on line 306 `#I_list = []`

   b. METHOD 2: Set the current values to use for the experiment explicitly using line 306
   eg: `I_list = [1E-7, 2E-7, 3E-7, 4E-7, 5E-7, 6E-7, 7E-7, 8E-7, 9E-7]`

4. Select 'Run python file' in the top right corner of VSC
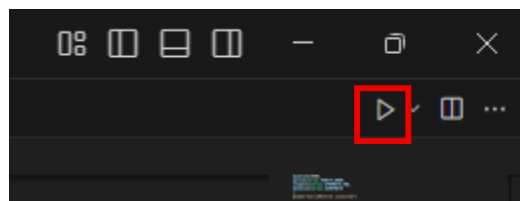
   a. The program will test the connection between the PC and SourceMeters; it will report *** SYSTEM INITIALIZATION COMPLETE *** if everything is correctly set up.

b. The program will display the current values it will use for the experiment in the console.

5. Enter the path where you want to store the file and press enter. The path must use use double \\ and end in \\. eg: the path 'C:\Users\my_name' becomes 'C:\\Users\\my_name\\'

6. The program will run. The displays on the SourceMeters will display the present current and potential difference readings. The resulting CSV file will be saved at the location you specified, with the name 'four_point_probe_data_dd-mm-yy-hhmmss' where 'dd-mm-yy' is the date, and 'hhmmss' is the time.

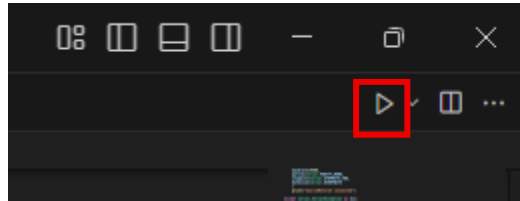## What the 'four_point_probe_data_processor.py' program does:

the 'four_point_probe_data_processor.py' program categorises data from the 'four_point_probe_data_collector.py' program into groups based on the current values used in the experiment.
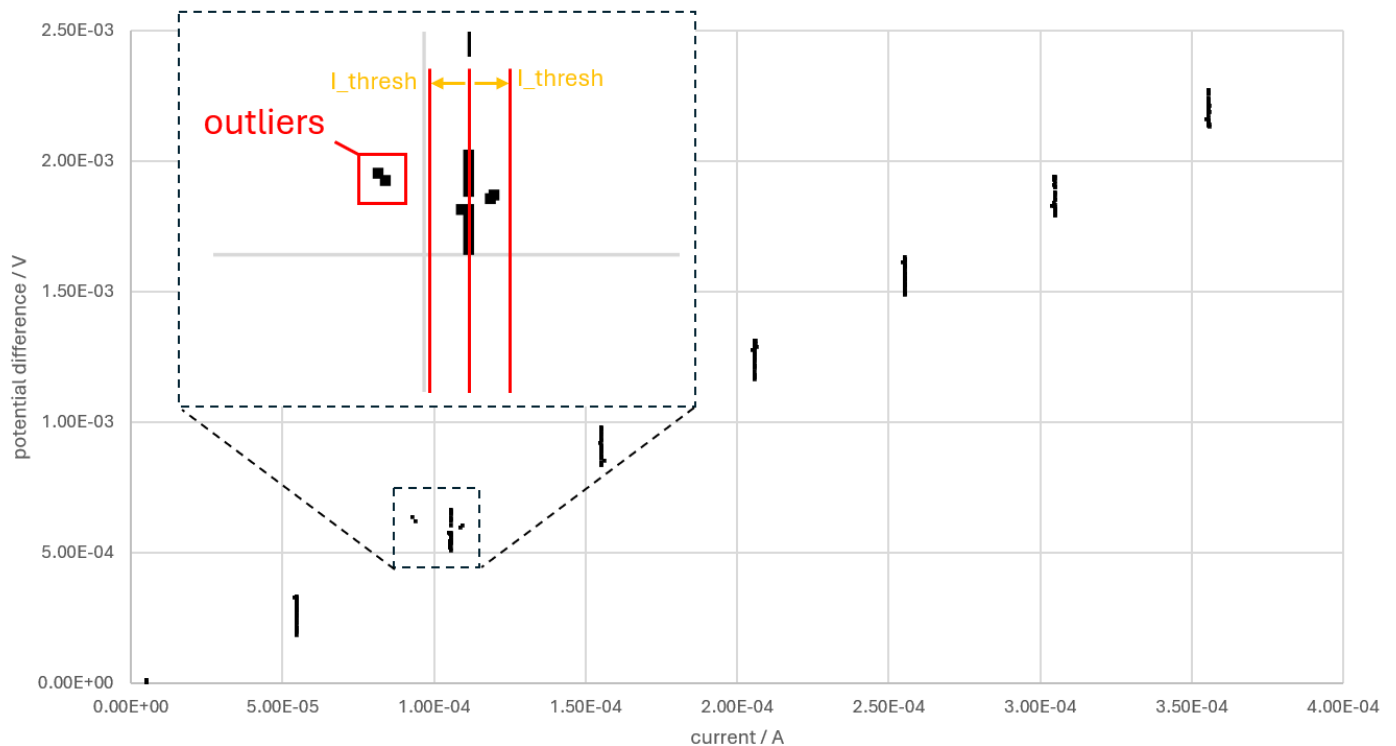
The plot above is example data produced by the 'four_point_probe_data_collector.py' program. For each current value used for the experiment (in this example: 0.0E-5 A, 0.5E-5 A, 1.0 E-5 A, 1.5 E-5 A, etc...) the 'four_point_probe_data_processor.py' program identifies which current value each data point belongs to. Any points that fall outside the window defined by a current value (I) and the current threshold (I_thresh) are identified by the program as outliers. An average current and potential difference are then calculated using these data, which are written to a CSV file.

Using the 'four_point_probe_data_processor.py' program:

1. Open the program with Visual Studio Code (VSC).
2. Set the current threshold on line 5 of the script. 1E-5 A is recommended.
3. Select 'Run python file' in the top right corner of VSC

4. Enter the path where the file containing the data produced by the 'four_point_probe_data_collector.py' program and the file name. Then press enter.
The path must use use double \\ and end in \\. Exclude the file extension.
eg: the file 'C:\Users\my_name\example_file.py' becomes
'C:\\Users\\my_name\\example_file'
5. The program will run. It will report the number of outliers it has identified in the console. The output file will be created in the same folder as that specified in Step 4.