

Rapid evaluation of the FLS110

Choose the most appropriate sensor module and fluidic fixture for your intended application by referring to the *FLS110 Evaluation Kit Fluidic Fixture Catalogue*. When you have received your kit you can be up-and-running in a matter of minutes:

- 1. Connect up the hardware (Figure 1) and plug the USB-I²C adapter into a USB port on your computer
- 2. Install and launch the GUI
- 3. Optionally, change some default settings
- 4. Start measuring flow (or differential pressure)!



Figure 1: FLS110 Evaluation Kit hardware

It's all explained in this user guide. More information about FLS110 digital flow sensing solutions is available in the datasheet and technical notes, available via the Flusso <u>customer portal</u>:

- FLS110 Miniature Gas Flow Sensor Datasheet (FL-000038-DS)
- Developing Your Flow Sensing Solution with FLS110 (FL-000986-TN)
- FLS110 System Characterisation and Calibration (FL-000561-TN)

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1 Connect up the hardware

FLS110 Evaluation Kit V6 with GUI V6.0.x provides full support for volumetric flow and differential pressure measurements with dynamic compensation for flow pressure. It does this using an independent pressure sensor (with I²C interface) on the sensor module. The GUI is backward compatible with Evaluation Kit V5 sensor modules and fluidic fixtures that don't incorporate a pressure sensor.

Referring to Figure 1:

- 1. Mount your sensor module in the fluidic fixture that you wish to test with (if it isn't already).
- 2. Connect the fluidic fixture to your flow or differential pressure (DP) source. Make sure the direction of flow is in the direction of the arrows on the sensor module PCB and fluidic fixture.
- 3. Connect the sensor module to the USB-I²C adapter using the ribbon cable provided (note the position of the connector keys and red "pin 1" wire in the ribbon cable in Figure 1).
- 4. Plug the USB adapter into your computer, using a USB Type A extender cable, if necessary. Windows won't notify you that a USB device has been plugged in that's expected behaviour.

Avoid disconnecting and reconnecting the fixture too many times because the 3D printed material of the fixtures is not very hard, and the grippers can scratch the surface. For fixtures with larger tubes, use a hose with a clamp. Refer to the *FLS110 Evaluation Kit Fluidic Fixture Catalogue* for more information about this.

2 Install the latest GUI and firmware

The FLS110 Evaluation Kit GUI only runs under Windows 10. Download the latest version to your PC from the Flusso <u>customer portal</u>. Look for

• FL-000093-SW FLS110 Evaluation Kit GUI

Unzip the install files, and run *setup.exe*. Note: if you ever need to install a newer version of the GUI you will have to uninstall your current version.

If a message box like this appears the Microsoft ClickOnce installer had a problem – usually after you have uninstalled a previous version of the GUI. Re-booting your PC to clear the ClickOnce cache usually solves the problem. If it persists, search for the error message online and you will find other possible solutions (such as <u>this one</u>).



After installation, the GUI will start up and scan COM ports for a Flusso USB-I²C adapter. If it doesn't find one, the message box shown on the right will appear. If that happens, check your USB connection and re-launch the GUI manually.

If you have more than one USB-I²C adapter plugged in, you can run multiple instances of the GUI – one for each USB-I²C adapter

When the GUI starts, version and build numbers are shown in the **Firmware** panel at the top left . If you just see *Version 0.0.0* for the sensor module firmware it means the ribbon cable is not properly connected. Re-make the connection and try again.

When you have a working connection to the sensor module, we recommend that you check that you have have the latest firmware running on both the sensor module and USB-I²C adapter. Refer to section 6 on page 11 for details about how to do this.



f Flusso FLS110 Evaluation Kit GUI 6.0.0 (build 19.0.0)					
FLS110 A	bout				
Firmware					
USB-I2C	adapter	Sensor m	odule		
Version:	6.0.1	Version:	6.0.1		
Build:	63.0.1	Build:	63.0.1		
Up	odate	Up	date		



3 Change settings in the GUI

The GUI starts with some default settings, which can be changed before you start testing, if you wish:



- 1. Readings: select an operating mode for the sensor module:
 - a. In **Continuous** mode readings are plotted and logged at a selectable **Update rate** from 1 Hz to 50 Hz (note: the update rate could be limited by the power of your PC).
 - b. In **Single Shot** mode you can select a **Period** of up to 60 seconds between readings, during which the module will go into low power Idle mode. In the **Sensor module** panel (top right) you can see the effect on average power consumption.

Select up to 128 **Averaging points** to reduce noise in your readings. The moving average increases the time to first reading in **Continuous** mode and to a **Single shot** reading by 4 ms per point.

- 2. Flow pressure: you can enter p_{flow} manually or have it read from a sensor, if present.
- 3. **Graph settings**: you can select **Temperature units** and the number of **Readings on X axis** to be plotted from 50 to 1000 (approximately). The number might be limited by the power of your PC.
- 4. Measurement:
 - a. Tick the Log data box at any time to start/stop writing of flow readings to a .csv file
 - b. Set the log file folder and name by typing in the text box or browsing
 - c. Enter comments to be included in the log file header (e.g., a description of test conditions)
 - d. Click the Start button to begin plotting and logging flow readings (more on this in section 4).
- 5. **Offsets and calibration:** functions of these buttons are described in section 5. The **Current calibration** panel shows how your sensor module/fixture assembly are currently calibrated. "Factory calibration" by Flusso will reflect the type and nominal range of the fluidic fixture.
- 6. **Firmware**: shows the firmware version and build number for your USB-I²C adapter and sensor module. Refer to section 6 on page 11 for information about updating to the latest firmware.



4 Start measuring flow (or differential pressure)

When you click *Start*, the FLS110 firmware will start taking readings and logging them (if *Log data* is ticked), until you click the button again.

If you find that the GUI becomes unresponsive after you click *Start* it could be because your PC doesn't have enough processing power available to support the **Update rate** and/or number of **Readings on X axis** that you have selected. You will have to use windows Task Manager to close the GUI. Most PC's capable of running Windows 10 should be able to cope with at least 10 Hz **Update rate** and 200 **Readings on X axis**, but you might need close other programs while running the GUI.

4.1 Flow and temperature graphs on the screen

System flow (or differential pressure) and flow temperature readings are plotted on the screen. The charts will scroll to the left once the chart has reached the number of *Readings on X-axis* that you selected.



The axes of the graphs change scale to automatically fit the data plotted. You can use your mouse to adjust them (which has been done in the screenshot above):

- 1. Move the curves by dragging them with the right mouse button
- 2. Zoom in or out using the scroll wheel (hold Ctrl for fine adjustment)
- 3. Zoom in to a region by drawing a box with the middle mouse button (or right mouse button with Ctrl)

Right click on a graph to get a menu with options to resume auto scaling or to clear the graph.

Left clicking on a graph will display the exact time and value at that point.



4.2 Log files

Readings can be logged to a .csv file for later analysis by ticking the **Log data** box. You can do this at any time before starting or during measurements. Each time you (re)start logging a new file is created.

The log files have a header section with some information about the GUI, USB-I2C adapter, sensor module and calibration, followed by the readings in a table with four columns:

- 1. **Timestamp**: a timestamp for each reading. If you open the .csv file in Excel, apply "hh:mm:ss.000" to this column to see the timestamp properly, with millisecond precision. Note, however, that Windows is not a real time operating system so timestamps won't be accurate to the millisecond.
- 2. **Reading (***units***)**: the flow or differential pressure readings, on the basis in the units that were defined during calibration (see section 5).
- 3. **T_flow (units)**: flow temperature, in units selected in the **Graph settings** panel.
- 4. **P_flow (Pa)**: flow pressure in pascals. This might have been entered manually in the **Flow pressure** panel (and therefore be the same for all readings) or taken from a pressure sensor on the fluidic fixture, in which case the value recorded will vary.

File Home Insert Page Layout Formulas Data Rev F23 Image: A state of the stat	view View Develo
F23 Image: Second sec	D E
A B C	DE
1 ELS110 Evoluation Kit CIII Log	
1 PLSTIC Evaluation Kit Gol Log	
2 GUI version 6.0.0 build 19.0.0	0
3 FLS110 firmware version 6.0.1 build 63.0.7	1
4 USB-I2C adapter firmware version 6.0.1 build 63.0.1	1
5 Processor ID 31 38 47 08 37 32 31 38 30 00 2f 00	
6 Processor ID (short) 302f	
7 USB-I2C adapter ID 7b2ac9135335374e36202020ff0126	510
8 Measurement basis Mass flow	
9 Units sccm	
10 S1 20	
11 S2 100	
12 S3 180	
13 C1 2195.106689	
14 C2 142820.75	
15 C3 -1116708	
16 R25 F0 F1 F2	F3 P0
17 126.848999 0 20	100 180 15
18	
19 Comments Comment	
20	
21 Timestamp Reading (sccm) T_flow (C) p_flo	ow (Pa) h
22 18:09:05.127 99.2813 23.703	102600 0.021081
23 18:09:05.196 99.3984 23.727	102600 0.0210986
24 18:09:05.265 99.5625 23.809	102600 0.0211226
25 18:09:05.327 99.5078 23.773	102600 0.0211147
26 18:09:05.392 99.5078 23.766	102600 0.0211148
27 18:09:05.465 99.6133 23.789	102600 0.0211305
28 18:09:05.527 99.7578 23.891	102600 0.0211516
data_2021-08-24_18-09-05 ↔	1
Ready E	G Displ

5. **h**: heat power transfer to the flow, from which the reading.



calibration

5 Offsets and system calibration

The FLS110 Evaluation Kit GUI allows you to try all the offset and calibration procedures that are described in *FLS110 System Characterisation & Calibration* via buttons in the **Offsets and calibration** panel

FLS110 Evaluation Kit sensor modules are tested and calibrated in the Flusso-supplied fixture before shipping. You can use these features to recalibrate your sensor module in the supplied fluidic fixture or in your own flow path.

5.1 Temperature sensor offset

To try out flow temperature offset determination, click the Temperature sensor offset correction button:

f Flow temperature offset	×			
The flow temperature offset only needs to be determined once. It must be done before the zero-point offset is determined. Make sure there is no flow through the system (zero differential pressure) and the FLS110 is in equilibrium with the ambient temperature.				
Enter ambient/device temperature: 25.00 🔹 °C Go]			
Cancel]			
For more information see FLS110 System Characterisation and Calibration.				

5.2 Zero-point offset

The zero-point offset must be determined *after* the temperature offset. To try the procedure, click the *Zero-flow/DP offset correction* button:

The zero-point pressure accros	offset ensures s the FLS110 p	that readings a orts).	are zero	when there is no	o system f	low (zero diff	ferential
Flow Pressure:	 Manual 	O From Sensor					
Make sure: 1. There is no f 2. Flow pressur 3. The FLS110 is	low through the s re (p ₀) is stable (N s at a stable temp	ystem (zero DP). ote: p₀ does not ma ierature.	atter in ma	ass flow basis)			
Zero-point Ensure there is	offset a no system flow i.e	. zero DP	p ₀	102600.00 ▲ Pa		Go	

onsets and calibration	
Flow temperature (Tflow) offset	Zero-point offset
Three-point system calibration	Manual entry of calibration
Single-point	Restore factory

Offsets and calibration

system calibration



5.3 Three-point system calibration

Click the *Three-point system calibration* button in the **Calibration** panel and follow these steps.

- 1. Select the measurement basis for the calibration and subsequent readings
 - mass flow or
 - volumetric flow / differential pressure
- 2. Enter a string as a reminder of the flow or differential pressure units that you will apply.
- 3. For volumetric / differential pressure basis you can choose to enter flow pressure manually or have the GUI read it from the pressure sensor on a type FL-001168-PT sensor module.
- 4. Carry out a zero-point offset step
 - For volumetric / DP basis and if you chose the manual option, enter the flow pressure.
- 5. For each of the three setpoints:
 - Set your system flow or differential pressure to the chosen setpoint and let it stabilise
 - Enter the setpoint value
 - For volumetric / DP basis and if you chose the manual option, enter the flow pressure.
 - Click the Go button to trigger a flow measurement

Refer to the technical note *FLS110 System Characterisation and Calibration* for guidance on setpoints. In the example below, they were chosen for a through-flow configuration at 10%, 50% and 90% of the FLS110 nominal operating range of 200 sccm.

f Three-point system calibration	×						
Three-point system calibration The flow temperature (Tflow) offset must have been determined beforehand. The FLS110 device and flow temperatures should be stable and the same.							
The zero-point offset is determined before measurements at the non-zero setpoints. Make sure the system flow (or differential pressure) is stable at each setpoint before clicking "Go". Note: setpoint values are multiplied by 256 then stored as integers, so precision is limited to unit/256. When calibration is completed, readings will be on the basis and in the units you selected.							
Calibration will be stored in profile 1 (selected on the main window)							
Measurement basis: Ass flow Volumetric flow or differential pressure (DP)							
Measurement units: sccm (max 4 chars)							
Flow Pressure Manual From Sensor							
Zero-point offset Ensure there is no system flow i.e. zero DP p_0 102556.00 Pa GoFirst Setpoint 20.00 $sccm$ p_{flow} 102556.00 Pa GoSecond setpoint 100.00 $sccm$ p_{flow} 102556.00 Pa GoThird setpoint 100.00 $sccm$ p_{flow} 102556.00 Pa Go							
For more information see <u>FLS110 System Characterisation and Calibration</u> .							



After clicking *Go* for the third setpoint the coefficients: C₁, C₂ and C₃ are calculated by the firmware, the calibration data is stored in microcontroller non-volatile memory and a message box is displayed:

New calibration	ee-point calibration	i completed
Basis: Mass flow	Setpoints	Coefficients
Units: sccm	S1 = 20	C1 = 2195.11
	S2 = 100	C2 = 142820.75
	S3 = 180	C3 = -1116708.00

After calibration, readings will be calculated on the same basis and in the same units as were used for calibration. In fact, the firmware does not really "know" about units and setpoints, they just become inherent in the values of C_1 , C_2 and C_3 that are generated by the calibration procedure. The units string and the setpoint values are only stored and displayed by the GUI as a convenient reminder for you.

5.4 Manual entry of calibration coefficients

If you have determined default coefficients (values of C_1 , C_2 and C_3), for your system design, you can program them into other sensor modules using the GUI: click the *Manual entry of calibration* button and a dialogue box opens that is pre-populated with current calibration settings. The measurement basis and coefficients must be entered for calibration settings to be valid. Entry of the units string and the setpoints that were originally used to create the coefficients you are entering is optional.

f Manual calibration		- 🗆 X						
Manual entry of calibration								
Manual entry of calibration data is mainly intended for programming the sensor module with default coefficients that were determined by characterisation of your flow subsystem. The basis and units entered here must be same as you used during characterisation.								
Measurement basis: \odot Mass flow \bigcirc Volumetric flow or differential pressure (DP)								
Enter flow units (max 4 chars): sccm (optional)								
New calibration	New calibration							
Basis: Mass flow	Setpoints (optional)	Coefficients						
Units: sccm	S1 = 20.00	C1 = 2195.11						
	S2 = 100.00	C2 = 142820.75						
S3 = 180.00 C3 = -1116708.00								
Go								
For more information see <u>FL</u>	S110 System Character	risation and Calibration.						



5.5 Single-point calibration

Single-point calibration takes default coefficients programmed into a product unit and combines them with a single non-zero flow/DP measurement to generate new coefficients that achieve better accuracy, especially over a limited part of the FLS110 operating range. Click the *Single-point system calibration* button and a dialogue box opens displaying the measurement basis and units string associated with the existing (default) calibration. The single-point calibration will be on the same basis and in the same units.

- 1. Carry out a zero-point offset step
 - For volumetric / DP basis and if you chose the manual option, enter the flow pressure.
- 2. Set your system flow or differential pressure to the chosen setpoint and let it stabilise
- 3. Enter the setpoint value
- 4. For volumetric / DP basis and if you chose the manual option, enter the flow pressure.
- 5. Click the Go button to trigger a flow measurement

point system calil	oration			
temperature (Tflow) of 10 device and flow ten -point offset is determ re the system flow (or point values are multi libration is completed	ffset must have been mperatures should b nined before measure differential pressure plied by 256 then sto readings will be on	n determined beforehand. e stable and the same. ements at the non-zero set i is stable at each setpoint b ored as integers, so precisio the basis and in the units y	points. before clicking "Go". n is limited to unit/256. ou selected.	
on will be stored in pro	ofile 1 (selected on t	he main window)		
Aeasurement basis:	Mass flow	\bigcirc Volumetric flow or diffe	rential pressure (DP)	
Veasurement units:	sccm (max 4	4 chars)		
low Pressure	Manual	From Sensor		
Zero-point offset Insure there is no system flor	v i.e. zero DP	p₀ 102556.00 ▲ Pa	Go	
irst Setpoint	20.00 sccm	Pflow 102556.00 ♥ Pa	Go	
second setpoint	100.00 sccm	p _{flow} 102556.00 ▲ Pa	Go	
hird setpoint	180 💂 sccm	Pflow 102556.00 Pa	Go	
	Third setpoint	10 device and flow temperatures should b 10 device and flow temperatures should b -point offset is determined before measure e the system flow (or differential pressure) point values are multiplied by 256 then stolibration is completed, readings will be on on will be stored in profile 1 (selected on t Aleasurement basis: Mass flow Measurement units: sccm (max 4 How Pressure Manual Zero-point offset Insure there is no system flow i.e. zero DP irst Setpoint 20.00 sccm sccm sccm Find setpoint 100.00 sccm sccm 	10 device and flow temperatures should be stable and the same. -point offset is determined before measurements at the non-zero setper termined before measurement (in the units of the uni	The period of the full of the second set of the second set of the set of the second set of the second set of the set of th



After clicking Go, new values of C_1 , C_2 and C_3 are calculated by the firmware and stored in microcontroller non-volatile memory. A message box is displayed to confirm the new calibration:

Single-point system calibrati	on	- 🗆 X
New calibration	le-point calibration	n completed
Basis: Mass flow	Setpoints	Coefficients
Units: sccm	S1 = 120	C1 = 2315.38
	S2 = -	C2 = 134653.47
	S3 = -	C3 = -724113.88
Processor ID: 31 38 47 08	37 32 31 38 24 00 2f 00 ;	; Short ID: 242f
Computer:	Operator:	
Copy to clipb	oard	Close

Note that only the setpoint used for the single-point calibration is now stored.

5.6 Restoring factory calibration

If you have tried out calibration procedures and wish to restore the calibration that was done by Flusso, simply click the *Restore factory calibration* button:

f Restore factory calibration			×
			flasso
Current calibration	Cotocinto	Coefficients]
Basis: Mass flow	Setpoints		
Offics. Sector	S2 = 0	$C_1 = 2315.30$ $C_2 = 134653.47$	
	S3 = 0	C3 = -724113.88	
	Will be replaced	with	
Factory calibration			
Basis: Mass flow	Setpoints	Coefficients	
Units: sccm	S1 = 0	C1 = 2499.26	Go
	S2 = 0	C2 = 117682.20	
	S3 = 0	C3 = -314364.00	
			Cancel
For more information see FLS110 System	Characterisation ar	d Calibration.	



6 Updating firmware

Latest firmware for the USB-I²C adapter and sensor module can be downloaded from the Flusso <u>customer</u> <u>portal</u>. It's best to check and, if necessary, update the USB-I2C adapter first.

6.1 USB-I²C adapter

Download

• FL-001470-FW FLS110-STM32 Sensor Module Standard I2C Firmware

In the .zip file you will find a binary image with a filename like this:

• FLS110-STM32_USB-I2C_Adapter_Vx.y.z_build_a.b.c.bin

If the version number or build number is newer than what you have installed, click the *Update* button for the USB-I²C adapter, select the .bin file from the .zip file and click *OK*. Windows File Explorer will appear briefly, as if a USB drive had been plugged in. When the update is finished you should see the new version and build numbers in the Firmware panel of the main GUI window.

6.2 Sensor module

Download

• FL-001470-FW FLS110-STM32 Sensor Module Standard I2C Firmware

In the .zip you will find a hex image with a filename like this:

• FLS110-STM32_Sensor_Module_Vx.y.z_build_a.b.c.hex

If the version number or build number is newer than what you have installed, click the *Update* button for the Sensor module, select the .hex file from the .zip file and click *OK*. When the update is finished you should see the new version and build numbers in the Firmware panel of the main GUI window.

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