Elveflow® Smart Interface

USER GUIDE

February 2019

ELVEFLOW
PLUG & PLAY MICROFLUIDICS

READ THIS MANUAL CAREFULLY BEFORE USING THE SOFTWARE

This manual must be read by every person who is or will be responsible for using the Elveflow Smart Interface (ESI).

Due to the continual development of the products, the content of this manual may not correspond to the new software. Therefore, we retain the right to make adjustments without prior notification.

Important ESI safety notices:

1. The ESI gives the user complete control over Elveflow products. Beware of pressure limits for containers, chips and other parts of your setup. They might be damaged if the pressure applied is too high.

2. Use a computer with enough power for ESI to avoid software freezing and setup damage.

IF THESE CONDITIONS ARE NOT RESPECTED, THE USER IS EXPOSED TO DANGEROUS SITUATIONS AND THE INSTRUMENT CAN UNDERGO PERMANENT DAMAGE. ELVESYS AND ITS PARTNERS CANNOT BE HELD RESPONSIBLE FOR ANY DAMAGE RELATED TO THE MISUSE OF THE INSTRUMENTS.

Contents

Description

Elveflow Smart Interface (ESI) enables interactive control of all Elveflow instruments. Up to 16 instruments can be controlled independently and simultaneously with a set of functions related to the instrument type, but whose can also work together within microfluidic projects.

Thanks to an intuitive interface, this application allows microfluidicists to use Elveflow products from the simplest commands for beginners to complex manipulations for experts.

Where to find the ESI

You can find the Elveflow Smart Interface in the **USB key** that was shipped with your Elveflow instrument.

We are always improving and adding new features to the ESI to make it more powerful and more intuitive. If you want to make sure you have the latest version, visit our dedicated **webpage**:

www.elveflow.com/elveflow-software

You can also find SDKs for LabVIEW, MATLAB, Python and C in the zip files available in the download section.

Minimum system requirements

- Window XP SP3* or later - both 32 and 64-bit versions are supported;
- USB 2.0 port or faster;
- 1 GB RAM;
- 3.0 GHz Pentium 4;
- 1 GB of free hard disk space.

* Elveflow instruments hold integrated components that require specific libraries which are incompatible with Windows XP SP2 and older, Mac OS and Linux.

Installation

1. Plug the Elveflow USB flash drive to the computer or unzip the downloaded file.
2. Open the Elveflow folder.
3. Run setup.exe.
4. Follow the instructions set by the installation assistant.
5. **Restart your computer** when prompted to finish the installation process.

Getting started

The following sections will guide you through the steps to add a new instrument or sensor, explore its basic and advanced features and use it with other instruments to automate your experiment.

Before starting

Hydrostatic pressure can cause flow without any pressure applied. Therefore, to prevent backflow in pressure regulator, always place liquid reservoirs below the instrument (OB1, AF1...)

Specific guides for Elveflow instruments

User guides are available for every Elveflow instrument. Check the dedicated guide to correctly set up your experiment before using the Elveflow Smart Interface.

Launch the Elveflow Smart Interface

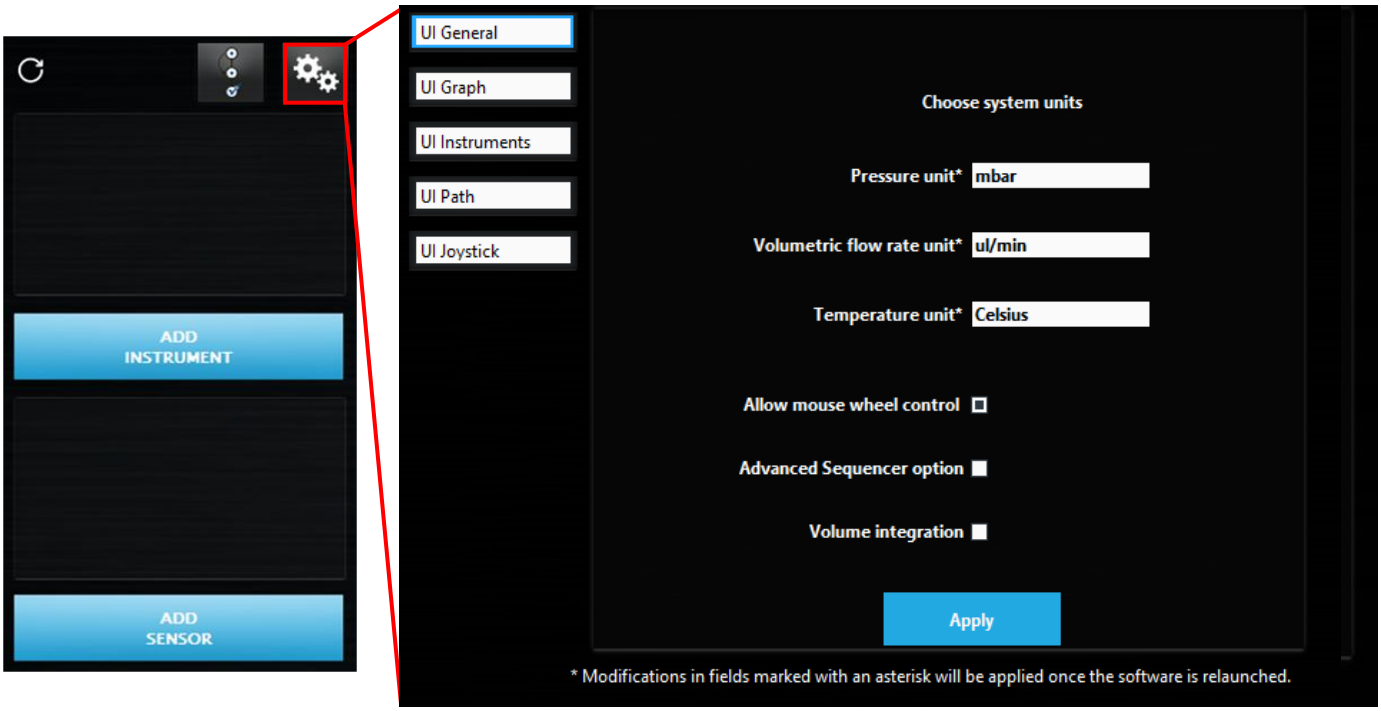
Nothing simpler than double-clicking on the ESI icon that was added to your desktop during software installation!

You can also find a shortcut to the software on “Start menu > Programs > Elveflow > Elveflow Smart Interface”.

Once the software is launched you will see the start menu window, similar to this one:

General settings

ESI v3 lets you choose the units to be used for displaying and controlling pressure, flow rate and temperature. In order to select the units you prefer, click on the General settings button:



In the general settings window, select your preferences and apply the modifications by clicking Apply.

Two more settings are available:

Allow mouse wheel control allow you to modify the regulation value with mouse wheel (used for OB1 and AF1).

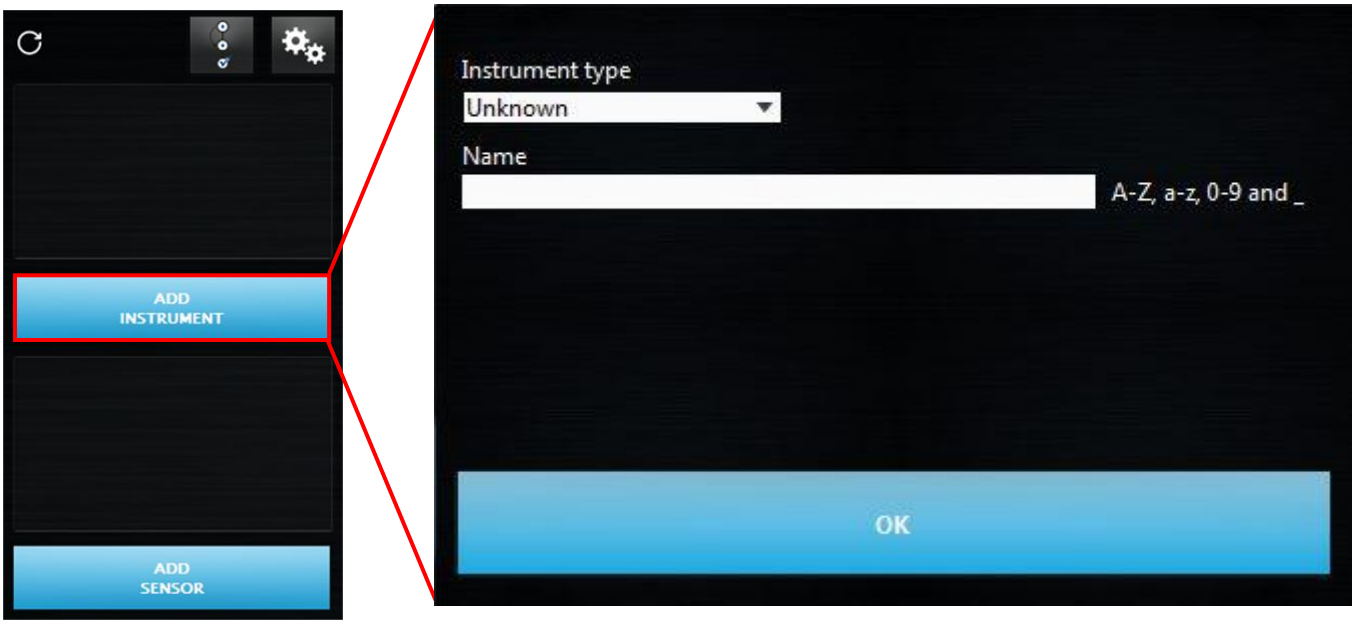
Advanced Sequencer option enables some advanced option in the sequencer (See Sequence p.34).

Volume integration enables to show up an indicator with your OB1/AF1, when using a flow sensor, under the flow rate. You can reinitialize volume value by typing any value to this indicator.

In the UI Graph tab, the default graph settings such as Time format and default acquisition frequency can be edited (see Graphs section p.18). The UI Instruments tab enable you to set general instruments properties as the acquisition rate. The UI Path tab enable you to select default path for data recorded from graph (see Graphs p. 18), the instrument configuration (see section Using configurations p.25) and the saved sequences (see Sequence p.34). UI Joystick tab enabled to use Joystick provided by Elveflow and to chose the behaviour of the Y axis to control the pressure of an OB1 or AF1. Two options are available: either used the increment (see AF1, OB1, MSR, BFS control p.14) or continuous modification proportional to the joystick value.

Add a new instrument

In order to add an instrument which is not already recognized by the software, click on the ADD INSTRUMENT button.



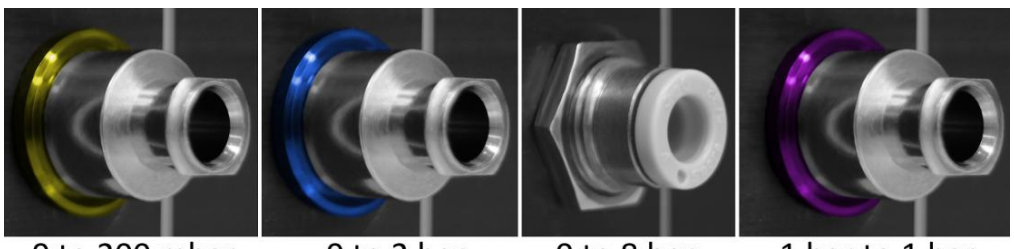
In the New Instrument window, select the Instrument type and give it a Name. Allowed characters are letters from A to Z (both upper and lower cases), numbers from 0 to 9 and underscores. The instrument name cannot contain any space.

Note that if more than one new instrument of the same type is connected to the computer, an instrument selector will appear at the top right corner. In order to be sure you are selecting the correct instrument you can temporarily disconnect one of them from the computer while adding the other.

On the image above, in the empty space between Name and OK, more required settings corresponding to specific instruments may appear, as follows:

AF1 and **OB1**
Select the Pressure range for each channel: 200 mbar, 2 bar, 8 bar or -1 to 1 bar.

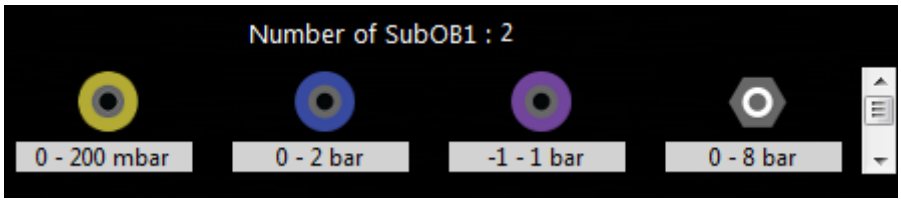
If you are not sure of the pressure ranges you have in an AF1 or OB1, check the ring on its outlet(s).



OB1

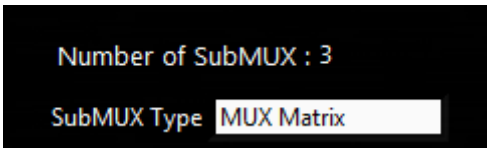
Select the type of OB1 (either MK3 or MK3+)

OB1 Custom
Select the Name of the OB1 Custom.
The number of subOB1 is indicated, and all the regulators types are automatically shown.



MUX Distributor and MUX Flow Switch Matrix
Select the Number of valves (6 or 10 for MUX Distributor and 4, 8, 12 or 16 for MUX Flow Switch Matrix).

MUX Custom
The number of subMUX is indicated. The type of the subMUX can be selected.



Other instruments
No additional configuration is required.

Click OK and your new instrument will appear in the main window.

From left to right you can see:

The Instrument settings button. 

The Launch control window button. 

And a text showing the Instrument type followed by the Name you have given to your instrument.

Important! Have you chosen a wrong pressure range on an AF1 or OB1, a wrong MUX type or number of valves? Go to the instrument's settings and in the General tab click on Delete. You can now re-add it as a new instrument.

Also Important! For MUX Distributor and BFS, driver installation may be required. Drivers are embedded into the installation folder (Default folder: C\...\Elvesys\driver\Driver_MUX_Distributor.exe) or in FTDI web page http://www.ftdichip.com/Drivers/D2XX.htm

Note! If an instrument is already recognized by the ESI (you added it according to the previous steps) and you cannot see it in the instrument list, click on the Refresh list button to make it appear.

This is useful when connecting an instrument to the computer after launching the ESI.

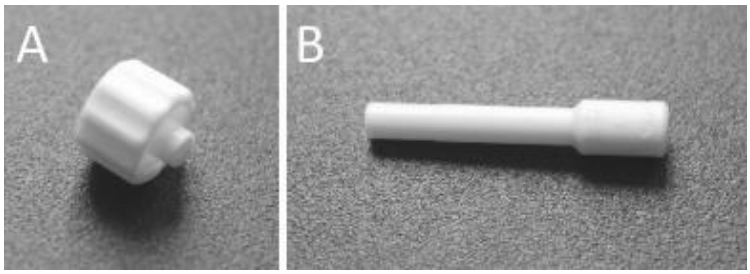
Calibrate your instrument

Pressure regulator (like AF1 and OB1) requires calibration:

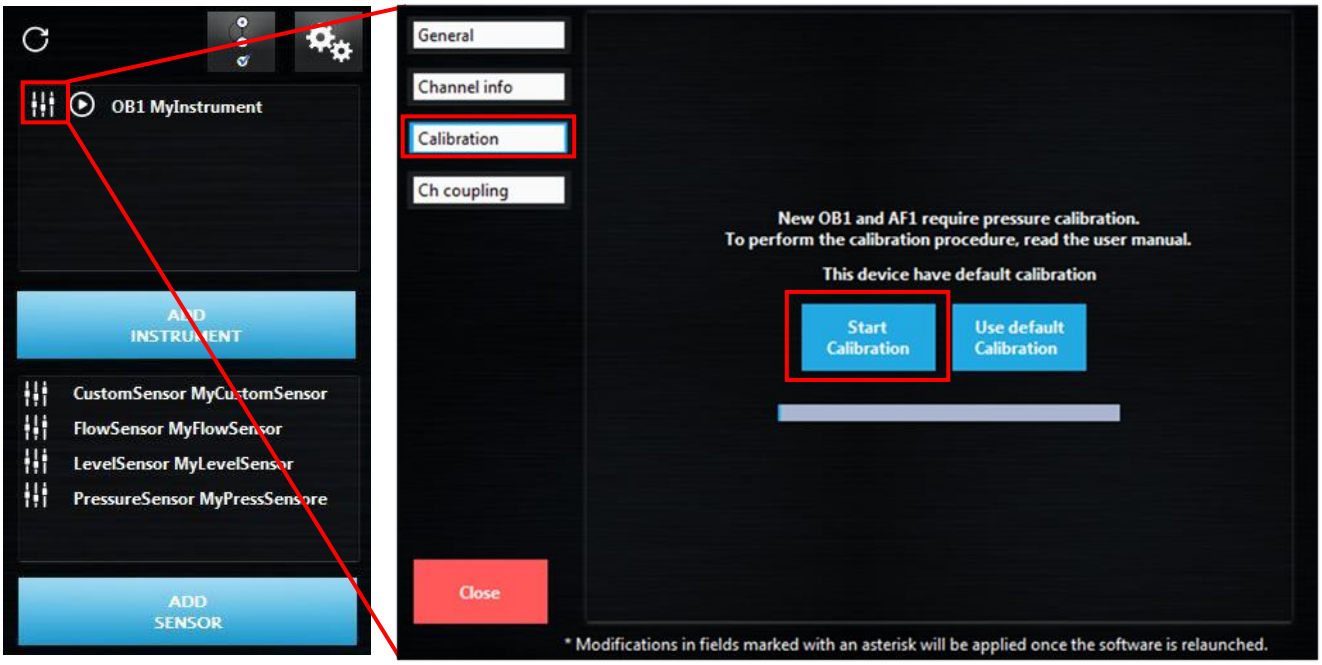
- When the instrument is connected to a computer for the first time;
- Any time a difference between the requested value and the measured value is observed.

Prior to calibration, close all pressure outlets with the appropriate Luer Lock or Push-in fittings:

A: for 200 mbar, 2 bar and -1 bar outlets;
B: for 8 bar outlets.



Then open the Instrument settings windows and go the calibration tab. The second line indicates which is the actual calibration in use (either default calibration or previously made calibration). Once all the pressure outlets have been closed, press Start Calibration. This process takes few minutes. A detail description of all available settings will be described in another section of this user guide (Instrument tabs p. 26).



Add a new sensor

Click on the ADD SENSOR button to open the following window:

Select the Sensor type (flow sensor, pressure sensor, level sensor or custom sensor)

Select the Communication type (for flow sensor only)

Select the Sensor model. As soon as you select the type, the model list is updated so you will have the corresponding ranges available. For digital sensor, the sensor model is automatically recognized.

Give your sensor a Name. Giving it a name will enable to ensure you can configure the correct sensor later on. Select also the instrument that host the sensor (Connected to) and the selected Channel?

NB: The Mini-Cori Flow (BFS) should be added as an instrument and not as a sensor.

Click OK and your new sensor will also appear in the main window.

From left to right you can see:

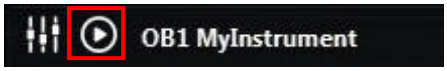
The Sensor settings button. 

And a text showing the Sensor type followed by the Name you gave to your sensor.

Control Instruments

In this section, the main control windows for every instrument will be described.

To open the instrument windows, click on the Launch control window button.



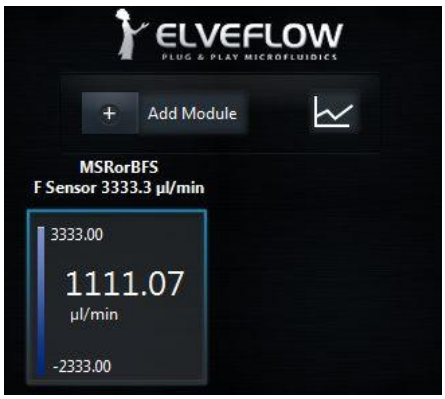
A new window will be open that enable instrument data visualisation and/or Instrument control

AF1, OB1, MSR, BFS

Two types of windows exist, one for instrument with regulator and sensor (AF1 and OB1), and one for instrument with Sensor only (MSR, BFS).

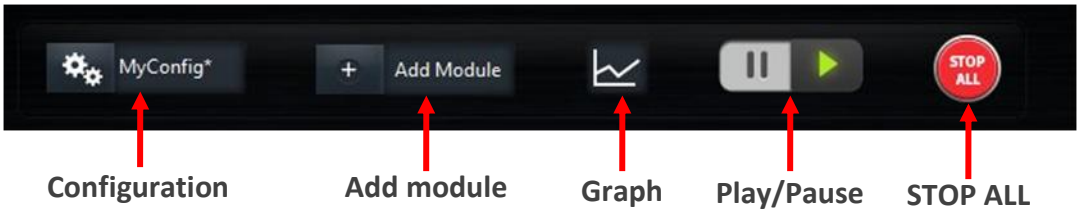
AF1 and OB1

BFS and MSR



NB: In the examples above only one channel is present. For multiple-channels OB1 or a Sensor Reader, the content delimited by the white box with shaded edges will appear up to four times, corresponding to the number of channels.

The left-hand and top side of this window present functions which apply to all channels at once:



The general STOP ALL button will toggle all the channels, i.e. will simultaneously bring all pressures down to zero (OFF).

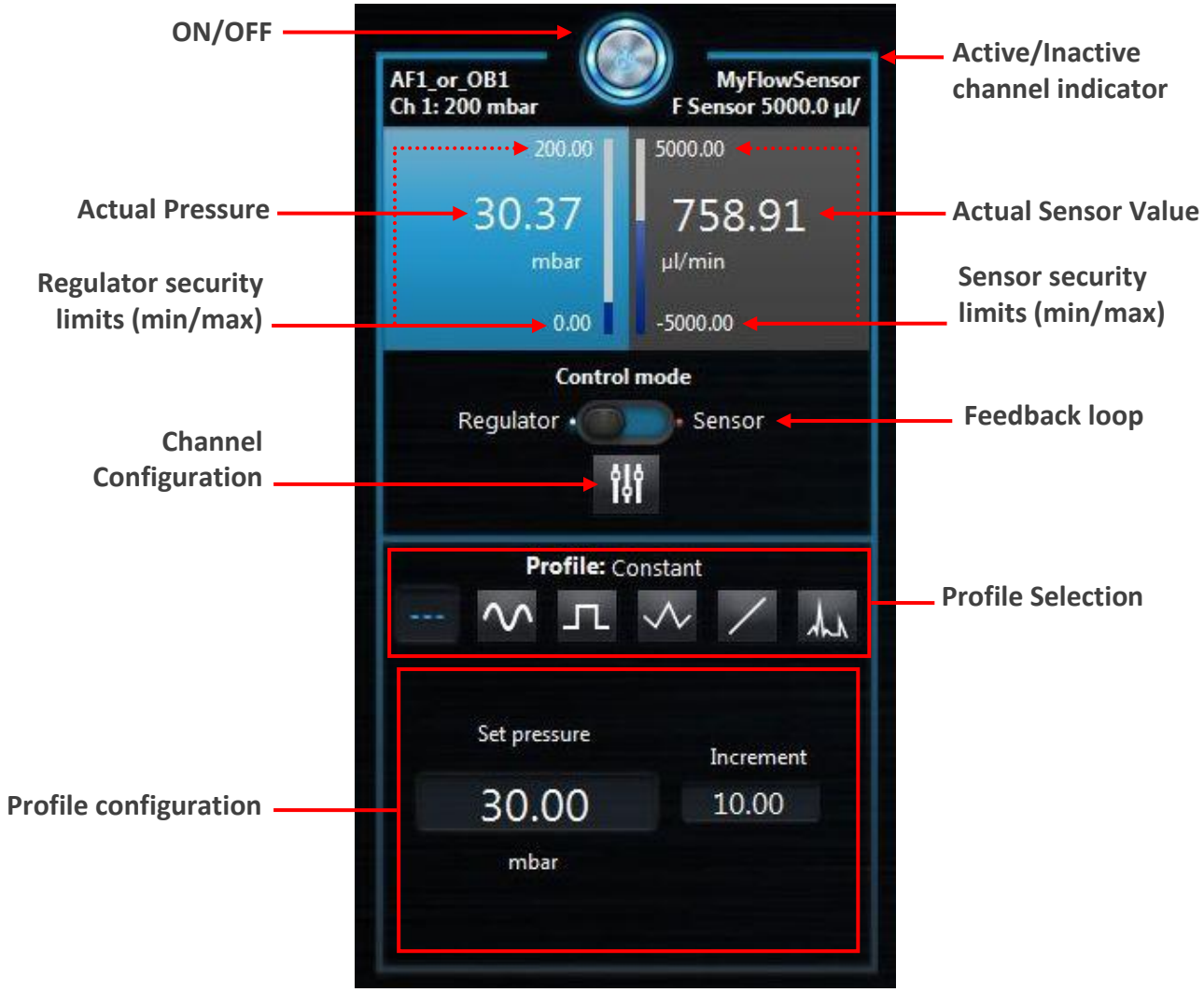
The Graph button will open a live graph showing measured data of all regulators and sensors present in the control window. More details are presented in the end of this section.

The Configuration selector is an automation feature further described in a dedicated section (Using configurations p.25).

The Play/Pause button allows you to edit settings without modifying actual state of the instrument. It can be used to create and edit configurations.

The add module button allows you to add extra module. Those modules are described in Modules section p. 45.

The white box with shaded borders contains the channel-specific controls and displays:



The frame in the around controls indicates that this is the active channel.

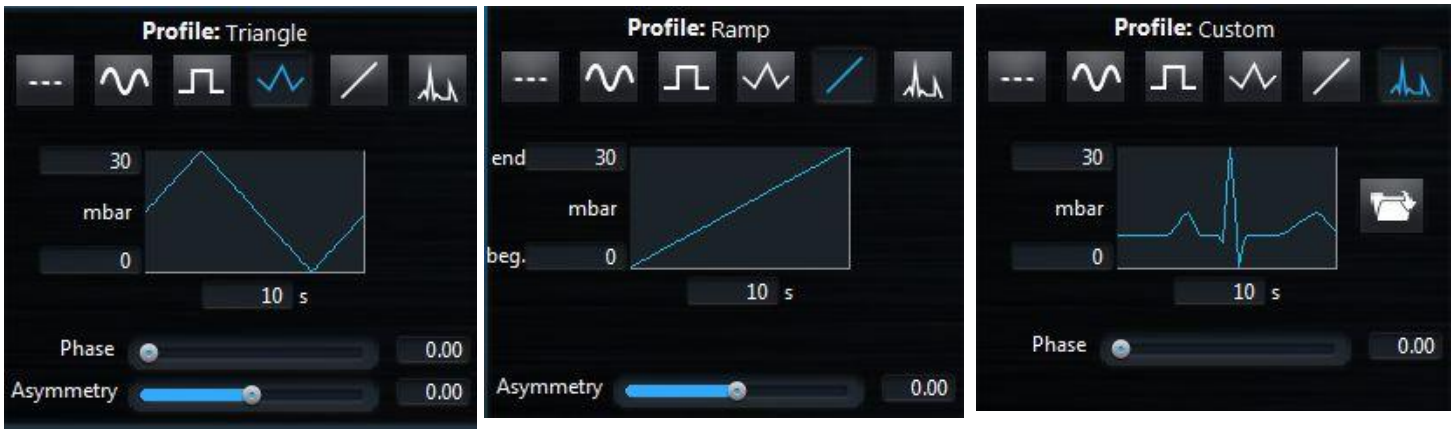
The ON/OFF button activate/stop the channel.

On the upper part, the left side is dedicated to display information about the regulator, while the right side display the sensor information. The texts on each side indicate useful information about each part to help you quickly see which channel you are controlling.

The actual value of pressure, flow rate or voltage is shown in larger numbers with its unit below. Above and below are the security limits, which can be edited in the configuration menu.

Set up profile

Different Profiles are built-in to make the setting-up of an experiment quick and easy:



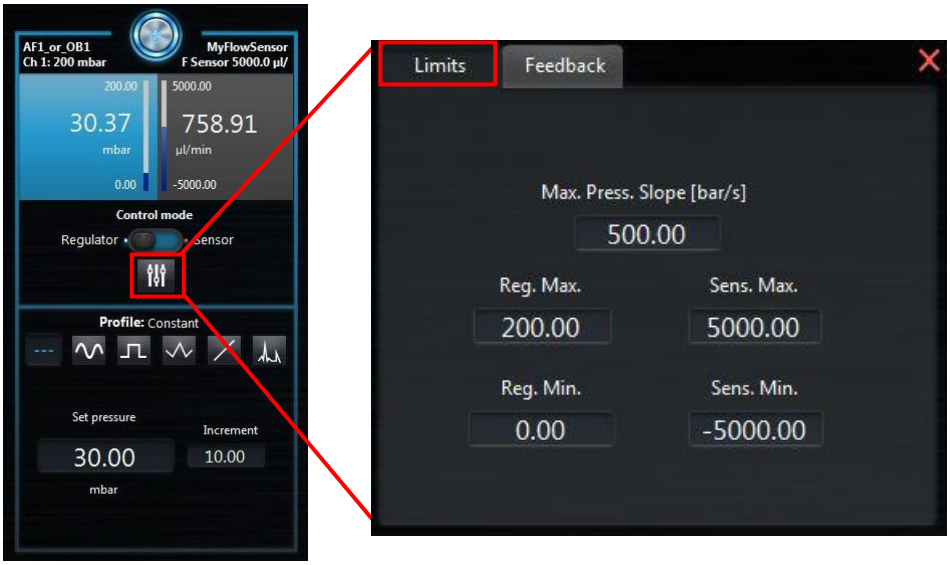
Constant means that the value shown in Set pressure is applied continuously. The Increment value will be added (removed) to the Set Pressure when the keyboard key “arrow-up” (“arrow-down) is pressed. If the mouse wheel control is activated the mouse wheel will have the same effect

Ramp, Sinus, Square and Triangle are functions that execute the shape depicted in the schematic. The range and the duration of the chosen pattern are shown respectively on the left and at the bottom of the graph. Those 3 indicators can be directly edited here. Phase and Asymmetry, when available, can respectively help positioning the curve in time and shaping it. For Ramp profile the starting and ending pressure should be set.

Custom profiles can also be imported from CSV or TXT. The imported files shall contain two columns separated by a comma (CSV, exported from an excel spreadsheet) or by a tab (TXT). The first column indicates the time; the second indicates the pressure, flow rate or voltage. Click on the Load data button to indicate a file to be loaded.

Channel configuration

The channel configuration windows can be open by the configuration button



A very useful feature for chip security or a means to quickly obtain on-demand ramp profiles is Max pressure slope, which is accessible through the Channel settings button below. It ensures that the pressure change rate will never go above this value.

By adjusting the maximum ramp, which corresponds to the maximum pressure variation a channel can perform over a certain time, any modification in pressure will occur at the chosen rate, unless the selected profile imposes a lower rate.

Feedback loop (Sensor mode)

You can set a flow rate, pressure or voltage on a sensor and have the ESI automatically adjusting the pressure applied in a regulator. In Control mode select Sensor to active this feature.

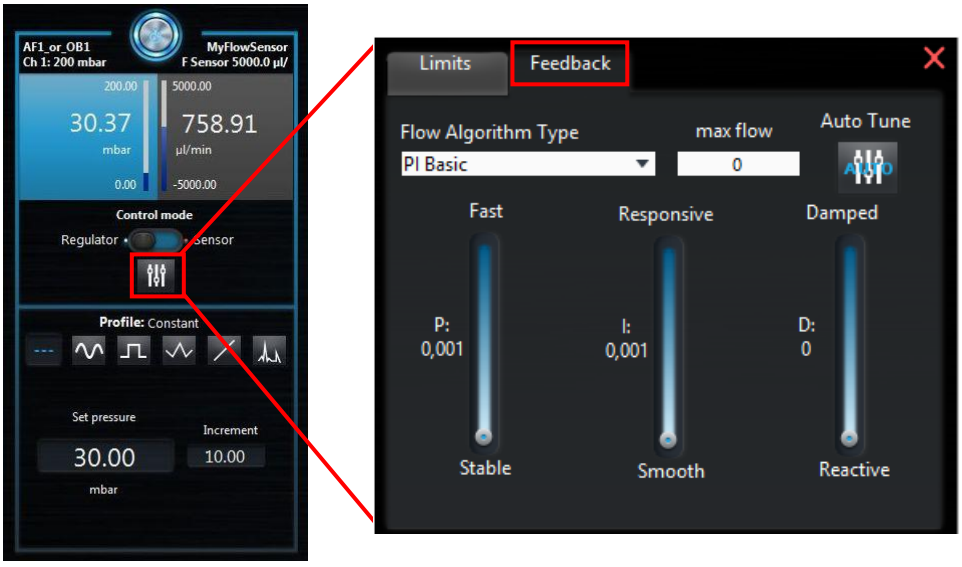
NB: In order to enslave a pressure regulator to a sensor connected to MSR or BFS, the virtual channel may be used (see Modify instrument/sensor settings : AF1, OB1 p.26)

The sensor mode can be used with constant set values, all built-in profiles or a custom profile loaded by the user. The ESI uses a PID-like algorithm to adapt the pressure as a function of the value set to the sensor. In optimum conditions in which the pressure range corresponds to the full sensor range, the performance of the algorithm is the best when Proportional (Fast/stable) and Integral (Responsive/smooth) terms are set to 1 (Default value: 0.001). If the user identifies the need to change these parameters, they both can be found in the Channel settings menu (see section Channel configuration p16). Several PID have been developed and can be selected from PID Type:

PI Basic: Generic PI regulator can be used for most application.

PID Basic: Generic PID regulator that includes the D parameter and that can be used for most application.

Large Reservoir: PI regulator more adapted for large volume (lot of air), since it takes times to fulfill the reservoir.



The PID optimum parameters can be obtained using the Auto tune functionality.

The max flow parameter can help to have optimum regulation around P and I value close to 1 when the working range is much smaller that the sensor range.

Graphs

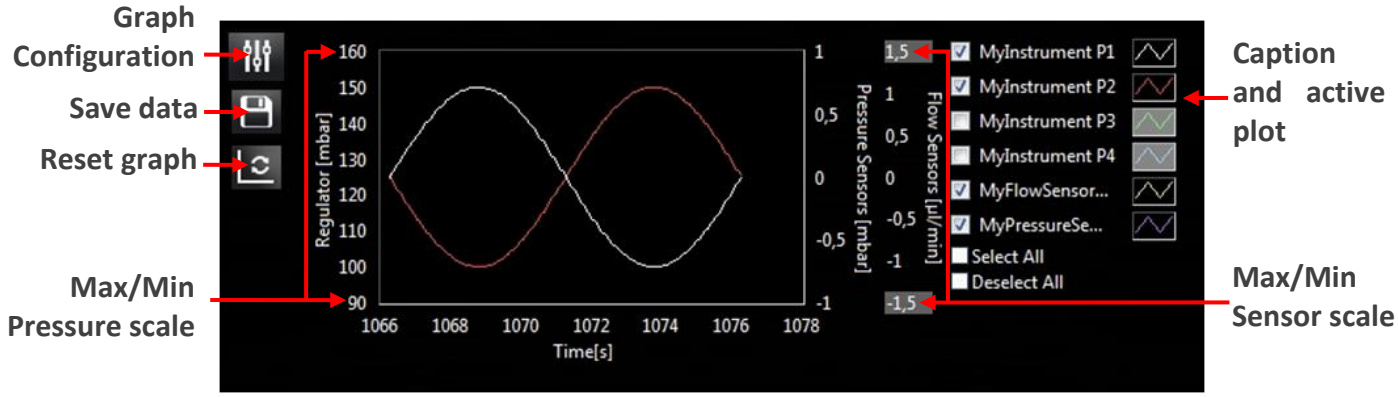
Up to 10 independent graphs can be opened for each AF1, OB1, Sensor Reader or BFS control window. The advantage of having so many graphs available is that, for each channel, the user can perform a fine adjustment of the display range without having several superimposed curves in the same window. If needed, all curves can be shown in a single graph.

Click on the Graph button on the control window to open a graph window.

AF1 and OB1

BFS and MSR

The graph window's size can be adjusted or can be easily maximized for better viewing. As soon as the window is launched the graph starts to auto-update with live data from all regulators and sensors connected to the corresponding instrument.

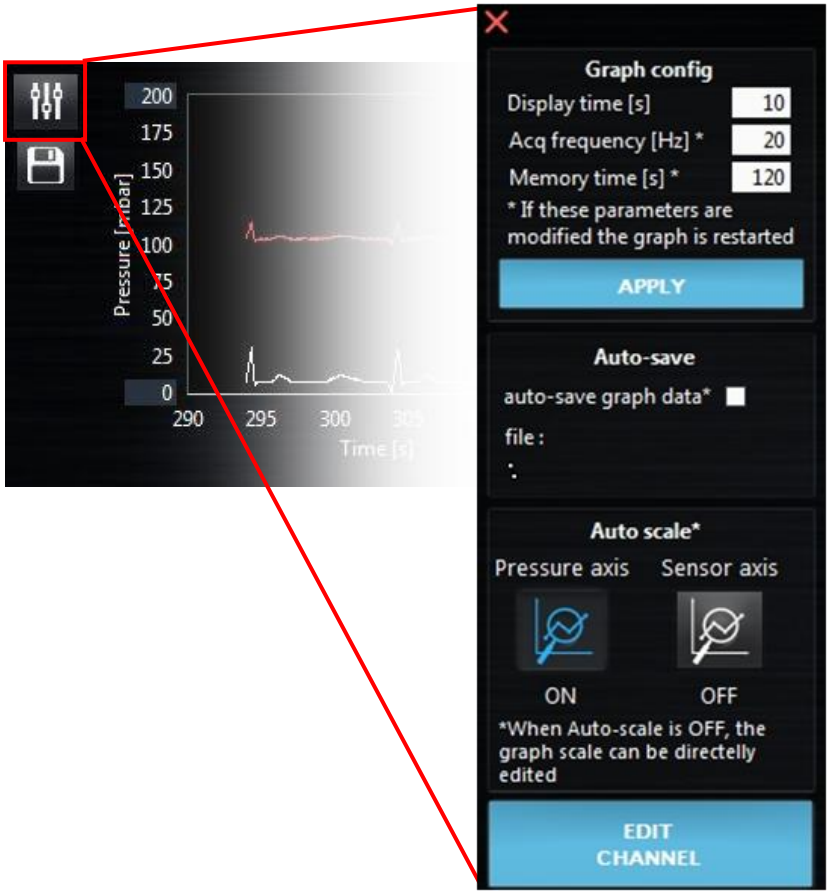


To adjust the ranges of the vertical axes of the graph, edit the maximum and minimum value of the range (gray editable zone). If the auto-scale is active (as for the regulator axis below), the range cannot be edited (see Graph settings below).

The graph to be visualized can be selected using Active channel.

To restart the graph, click on the Restart graph button. Click the Save data button to export data from the graph. Notice that the data exported will contain the latest measured values during the period indicated in Memory time, not only the data displayed in the graph. Moreover, all data from the elements displayed at the right-hand side of the window (even if not ticked) are exported at once. The target pressure of every regulator is also saved.

The click on the graph configuration button to open graph settings windows:



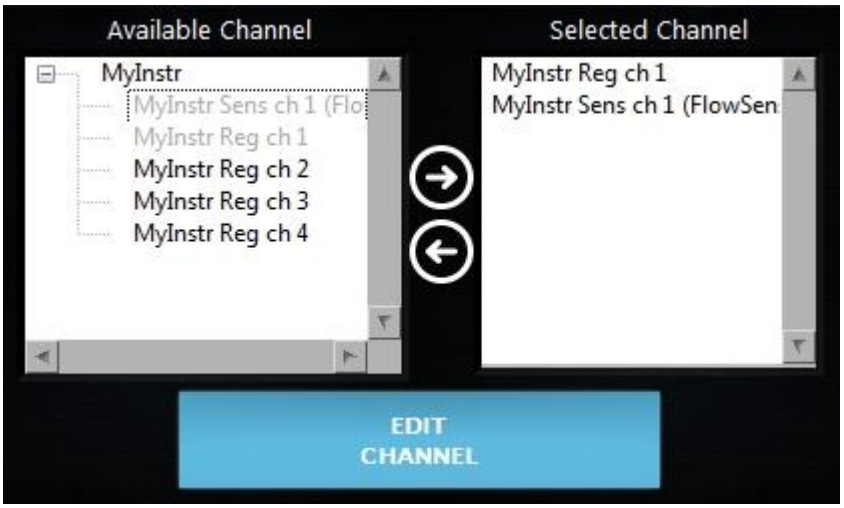
Inside the Graph settings the user can modify how much data is displayed by adjusting the Display time and setting the data Acquisition frequency. Note that this simply represents how often data is sent to the graph. Real data acquisition from the instrument occurs at a fixed, high frequency. To modify the default graph settings, see General settings p.7.

If needed, data can also be kept in memory for a longer time than the limit displayed in the graph. Using a Memory time higher than the Display time ensures that sufficient data can be later exported while keeping the view in the graph reduced and practical during an experiment.

For experiments that last many hours, or if the user needs to be sure that data is kept safe at all times, the Auto-save graph data option can be activated. In this case there will be no need for exporting data; they will be saved every 1 minute in the selected file.

The axis auto-scale of both axis (pressure axis and sensor axis) can also be enable/disable from this windows.

The Edit Channel button enables the user to change the channel to be visualized. It opens the following windows.

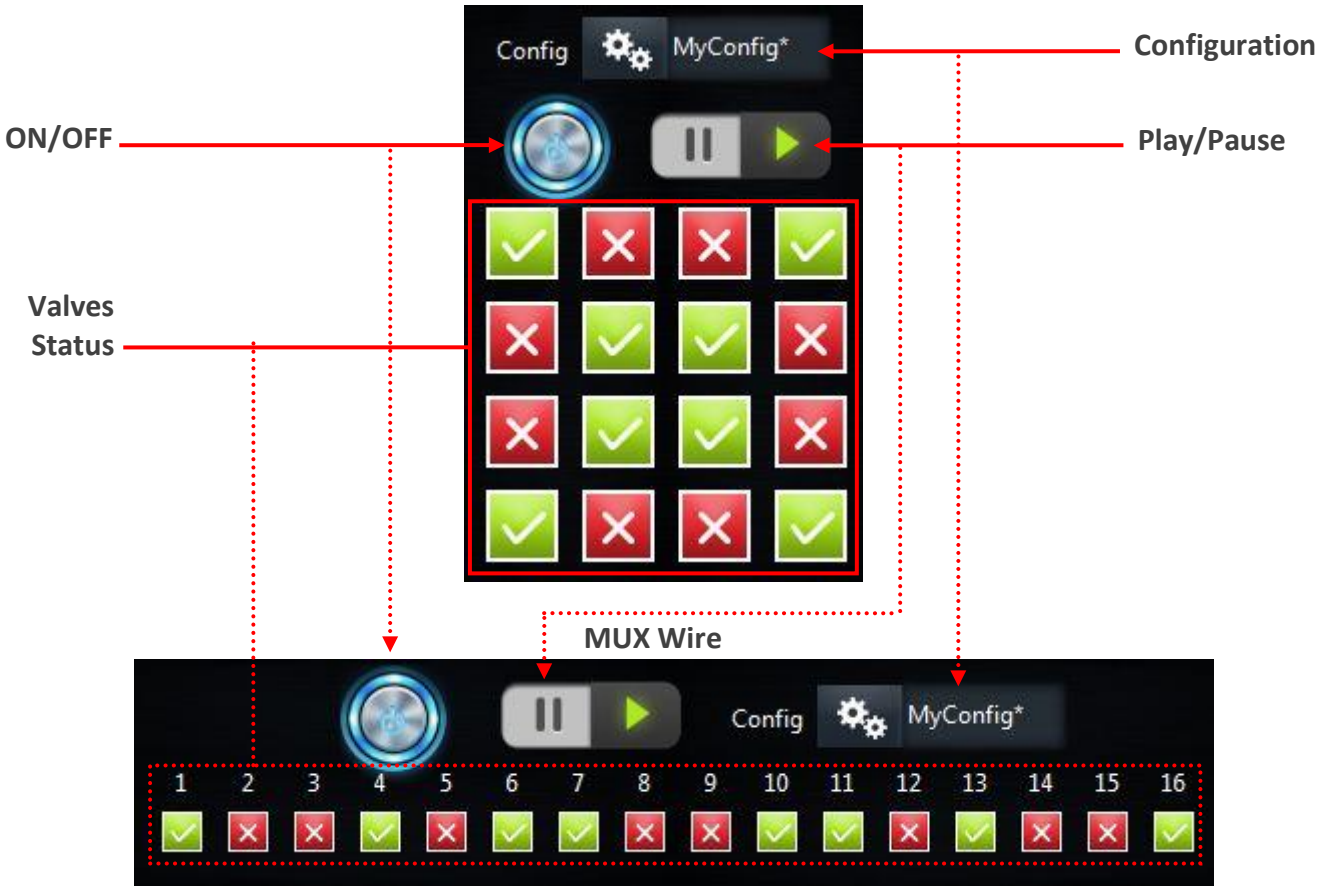


A list of all Available channels is listed on the left panels. The selected channels are gray. The Selected channels are listed on the right panel. Double click on a channel or use the right/left arrow to select/deselect. If an instrument is double clicked, all the channels from that specific instrument are selected.

MUX Flow Switch Matrix, MUX Wire, MUX Quake Valve and MUX Cross-Chip

The MUX is a valve matrix that can be used either to block/let flow a fluid (MUX Flow Switch Matrix, MUX Wire) or to distribute a fluid from an inlet to a selected outlet (MUX Quake Valve and Cross Chip). Below is represented a typical control window for a MUX.

MUX Flow Switch Matrix, MUX Quake Valve & MUX Cross-chip



MUX Flow Switch Matrices can have 4, 8, 12 or 16 valves, so up to three columns may be deactivated according to this setting.

Each Valve button in the 4x4 matrix corresponds to a valve in the MUX. Green shows that the valve is opened, while red shows that it is closed. In MUX Quake Valves, green means that the outlet is connected to the Common open inlet and red to Common close.

For MUX Wire, a 1D array of button represents the power state of each output. It can have 8 or 16 valves.

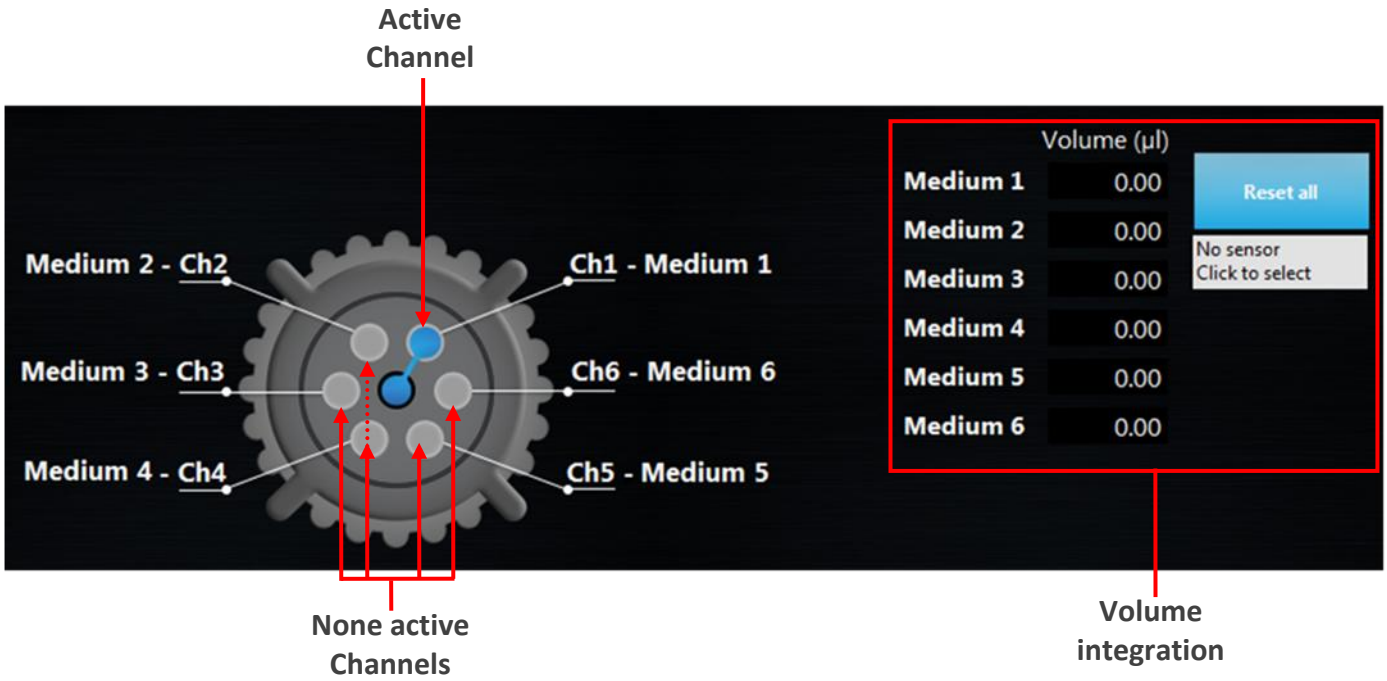
Note that those control windows also display an ON/OFF button. If the button is ON, the valve states are those represented in the 4x4 matrix or 1D array. If it is OFF, all valves are closed (MUX Wire, MUX Flow Switch Matrix and MUX Cross-chip) or all outlets are connected to Common close (MUX Quake Valve).

The Configuration selector appearing at the top of the window is discussed in a dedicated section (Using configurations p.25).

The Play/Pause button allows you to edit settings without modifying actual state of the instrument. It can be used to create and edit configurations.

MUX Distributor

The MUX Distributor is a rotatory injection valve allowing a single inlet/outlet to be connected to up to 10 different reservoirs/chips for selective injection. Two models are available: 6 or 10 valves. The controls and extra features are similar for both models. The image below represents a 6-valve MUX Distributor.



On the left side, the Wheel both displays the current state and serve as a control for valve position. Click on any valve to select a new position.

The Media names can be modified by double-clicking on the text (both connected to the Wheel or on the list on the right-hand side) and typing a new name.

If a flow sensor is connected to the central line of the valve - and to another instrument such as an OB1 or a Sensor Reader, which can read its data – it can be integrated to the MUX Distributor in order to calculate the volume flowing through each channel. The ESI will add the volume calculated by the sensor to the list, at the active valve position. Click on the gray box on the right to open a list of available sensors.

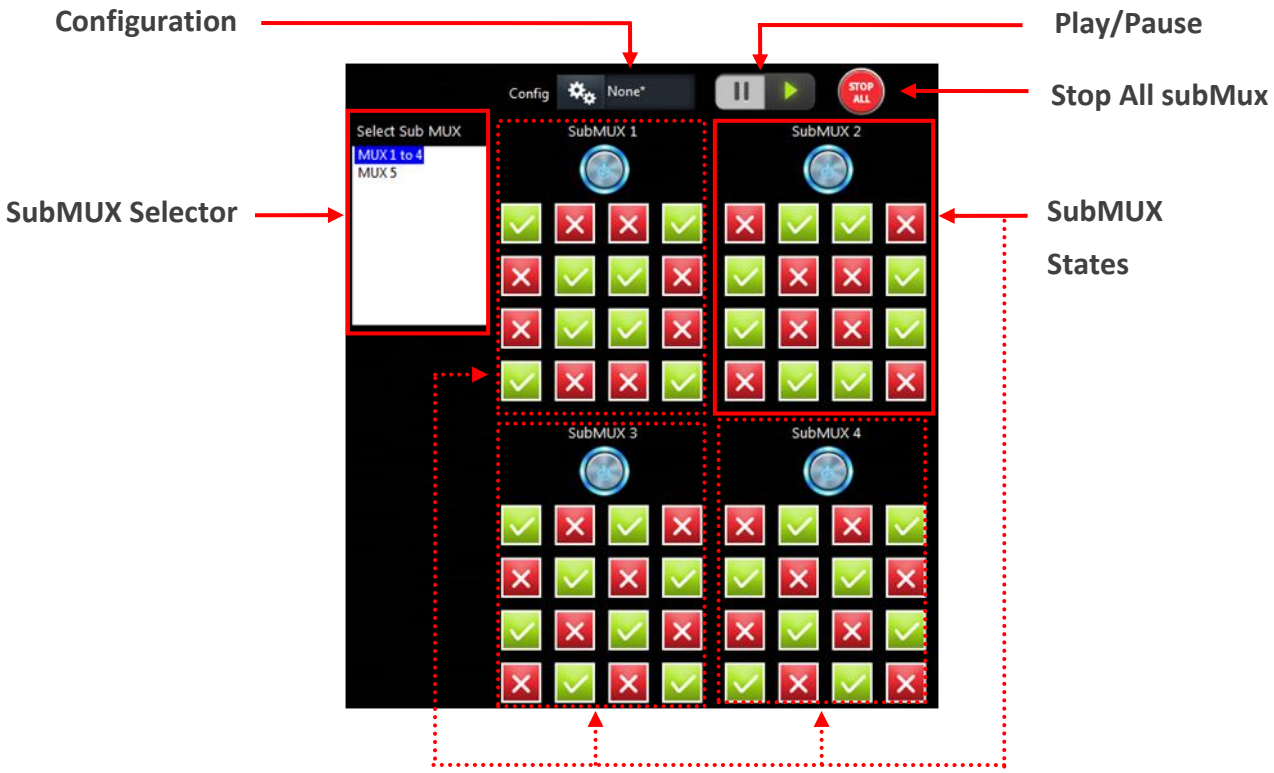
The Reset all button sets all volumes back to zero. If needed, each volume on the list can also be modified manually.

Meta Instruments (OB1 Custom, MUX Custom)

Meta-instruments are instruments that used sub instruments and allow an easy visualization and handling of them as a single entity, in a single window. Those instruments provides all the functionalities than normal instruments

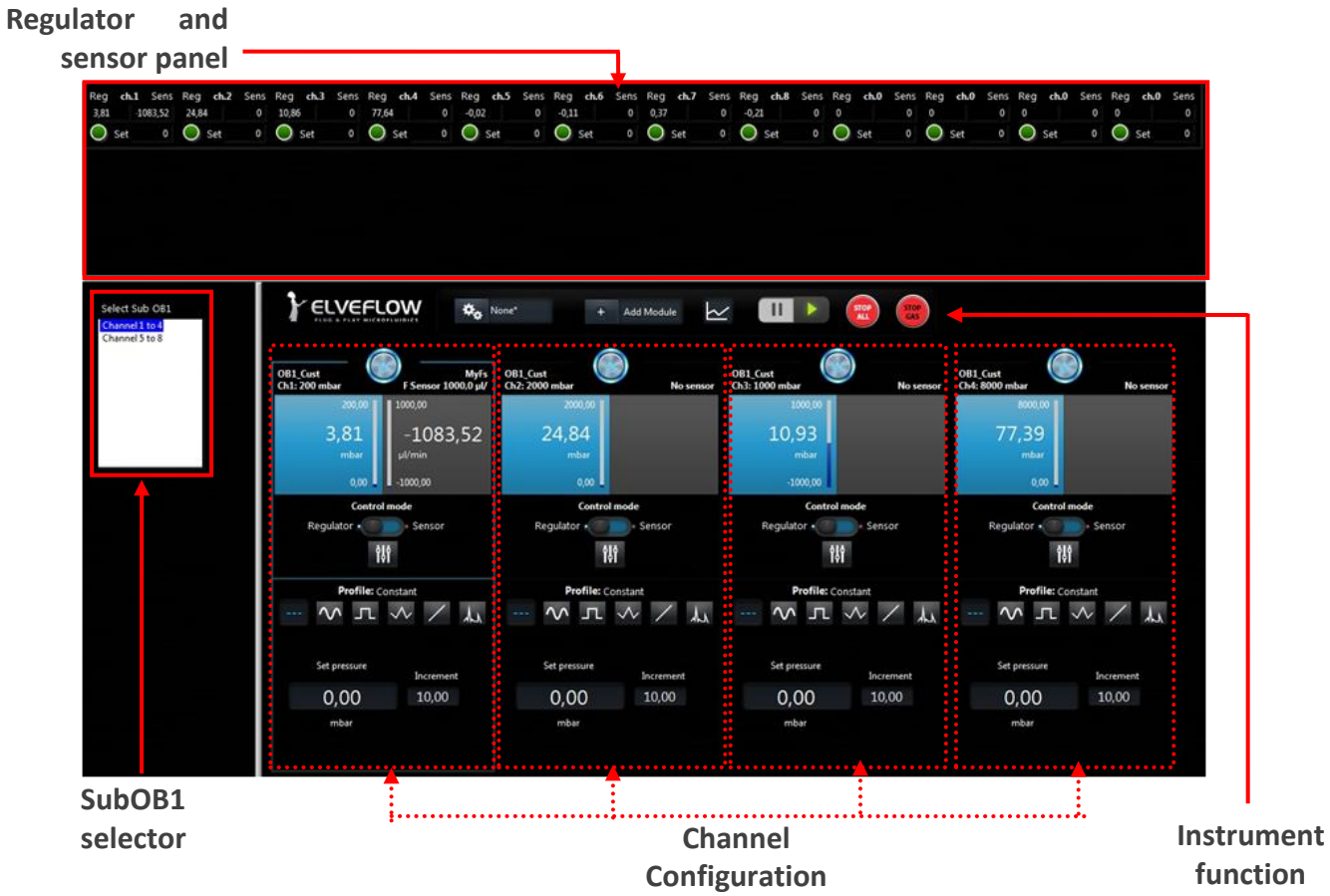
MUX Custom

The custom MUX enables the visualization of up to 4 MUX simultaneously. If more MUX are present, a SubMUX Selector appears on the left of the window to switch between MUXs. As for standard MUXs, this instrument can be edited with the Play/Pause button and can be controlled with configurations. Those configurations save the state of all subMUX of this instrument (including the one not shown in the windows).



OB1 Custom

The custom OB1 enables the visualization of several OB1s in a single window. All regulator pressure and sensor values can be read in the regulator and sensor panel (top). For fast modification of the instrument, the feedback values (green button) and the constant value of every channel can also quickly be modified by this panel. On the bottom left panel, the SubOB1 Selector enable to select the active OB1 controllable in the bottom right panel. As for standard OB1s, some instrument functions are applicable to all channels: the Play/Pause button enables to edit all the channels and change them all at the same time. All channels can be controlled with configurations. Those configurations save the state of all subOB1 of this instrument (including the one not shown in the windows) and can be recall by a single click. As for other OB1, modules can be launch from the Add module button. The Graph button will display a graph containing all the channels of this instrument. The stop all button switches all the channels to off. Finally the stop gas button will close the gas inlet.



Using configurations

Some instruments allow the use of Configurations, as previously mentioned: AF1s, OB1s, MUX Flow Switch Matrices, MUX Quake Valves, MUX Wire and MUX Cross-chips. This feature is very practical when the user needs to quickly alternate between two or more states of the system, e.g., from a sinusoidal profile between 0 and 100 mbar to a custom profile between 300 and 400 mbar.

At first the Configuration selector appearing in the control window will have only the None* case. This means that no configuration is available. In order to create and use configurations:

- Set the desired parameters to controls (e.g. a pressure profile or valve state).
- Open the Config menu on the top of the control window.
- Save the configuration. The ESI will propose a standard location, but configurations can be saved anywhere in the computer.
- Repeat the three steps above for as many configurations as required.

In the end of this process there will be several configurations available on the selector. Changing from one to another will automatically change the state of the instrument.

Instruments Configurations are required to control instruments in a sequence (see Sequence section p.34).

NB: To create new configuration without modifying the actual state of the instrument, use the Play/Pause button.

Three more functions are available:

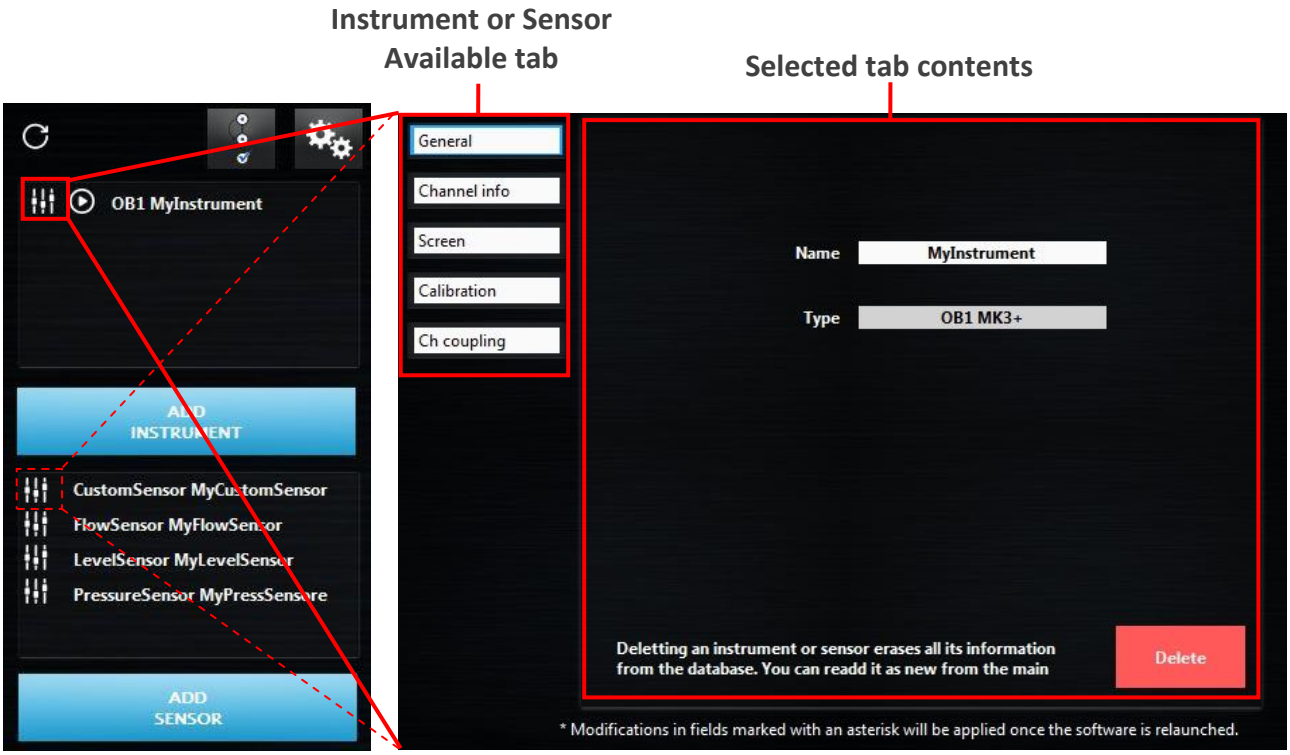
Load allows the user to use a configuration that has been previously saved.

Remove will delete the actual configuration from the list.

Open folder gives access to the standard configuration folder, where the user can easily manage all the configurations already saved.

Modify instrument/sensor settings

From the main window, as observed before, the user can have access to the instrument-specific settings window. Click on the Instrument settings or the Sensor settings button to access it.



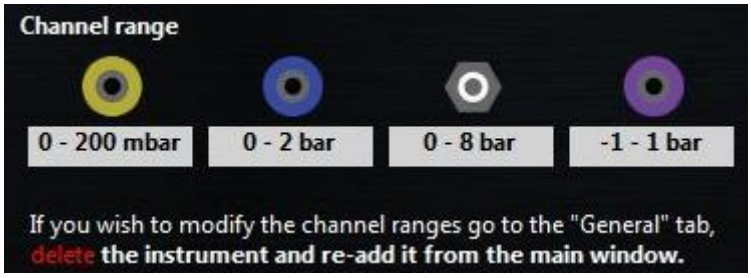
General tab

The General tab is available to all instruments and sensors. It shows the Name and Type of the part and a Delete button which can be used to remove it from the instrument/sensor list, in the case a mistake has been made while adding it or if it will not be used anymore.

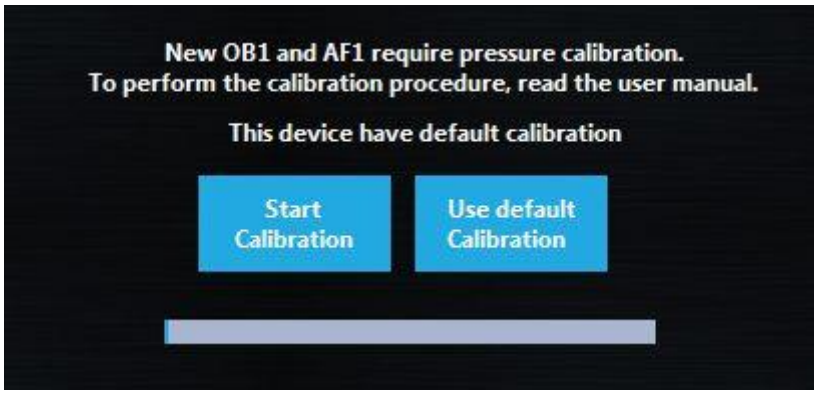
Instrument tabs

AF1, OB1, OB1 Custom

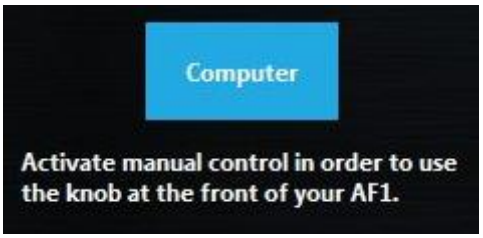
The Channel info tab displays all pressure channels present in the instrument and their ranges. Available to: AF1, OB1 and OB1 Custom.



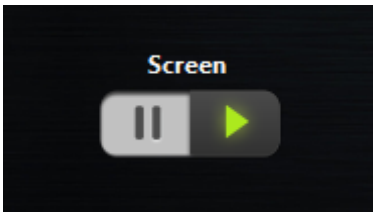
In the Calibration tab the user can Start a calibration and see its progress on the Status bar (remember to close all pressure outlets with the dedicated cap before calibrating). A Default calibration can also be used if needed. The used calibration is shown in the second line. Available to: AF1 and OB1.



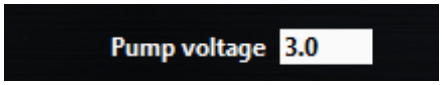
AF1s can be controlled both with the ESI and manually at the pressure knob. In the Manual control tab the user can select which mode is active. Note that the manual mode is also activated if the USB cable is disconnected from the computer. Available to: AF1.



OB1s have screens to show the actual pressure and sensors values. In the Screen tab, the user can activate or deactivate the screen update. The Screen update takes about 50ms and therefore can cause some fluctuation on the pressure when profiles pressure is required. For very sensitive experiment when the best performances are required, the screen should be switch off. Available to: OB1 and OB1 Custom.



The voltage of the pump inside an AF1 (version 2) can be adjusted at the Pump voltage tab. A higher voltage will increase air flow rate and allow large pressure changes to be performed faster. The noise of the pump, however, increases with the voltage. Available to: AF1 version 2.



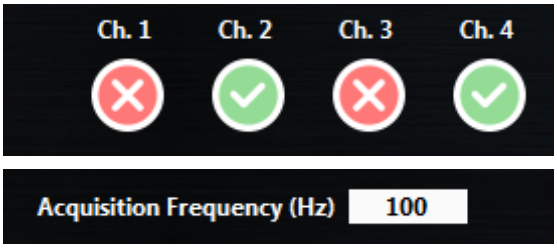
Channel coupling can be useful when the set values in multiple channels have to be modified proportionally and simultaneously. Select a channel on the left side and couple it with any available channels on the right by a multiplication factor. For instance, if channel A is coupled to channel B by a factor of 2, every pressure increase of 10 mbar in channel A yields a 20 mbar increase in channel B, and every pressure increase of 10 mbar in channel B yields a 5 mbar increase in channel A.

Available to: AF1 and OB1.

MSR (Sensor Reader)

The MSR Acquisition Frequency and hardware filters can be activated to pre-treat the single read by a Sensor Reader in the Filter and Acq Freq tab. The acquisition frequency can be set up to 1000 HZ.

Available to: Sensor Reader.



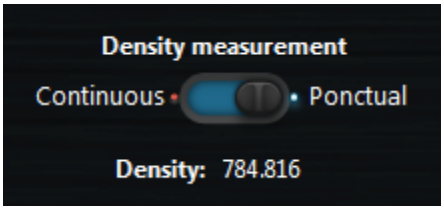
BFS (Mini Cori-Flow)

The BFS Config tab can be used to set BFS parameters.

The BFS Filter is an electronic filter within the instrument that can be tuned by the user.

The value of this parameter can be selected between 0.01 (smooth, but slow response) and 1 (fast but noisy response). This parameter can have a high impact on PID regulation.

BFS is an instrument that output mass flow (in g/h). This instrument can also measure the fluid density with high accuracy. This capability is used to determine the volume flow.



The fluid density can either be measured continuously or only one time. To update the density, switch back to continuous and then go back to punctual.

NB: Continuous density measurement increase by 20 ms the measurement cycle.

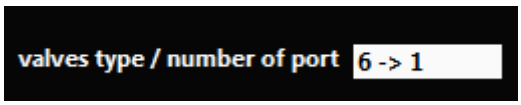
Flow unit can be set to mass flow instead of volume flow. Two options can be selected, either Volumetric flow (default settings that use density) or Mass flow (in g/h). This option is visible in the scaling tab of the BFS sensor parameters.

MUX Flow Switch Matrix

The number of valves in a MUX can be changed, in the case a mistake has been made while adding the instrument or if your MUX has been upgraded. Available to: MUX Flow Switch Matrix.

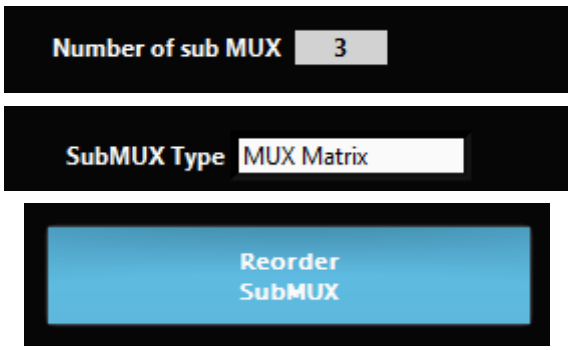
MUX Distributor

The valves types/number of port of a MUX Distributor can be modified in the Valves tab. The different options are Injection, 6->1 or 10->1. Available to: MUX Distributor.

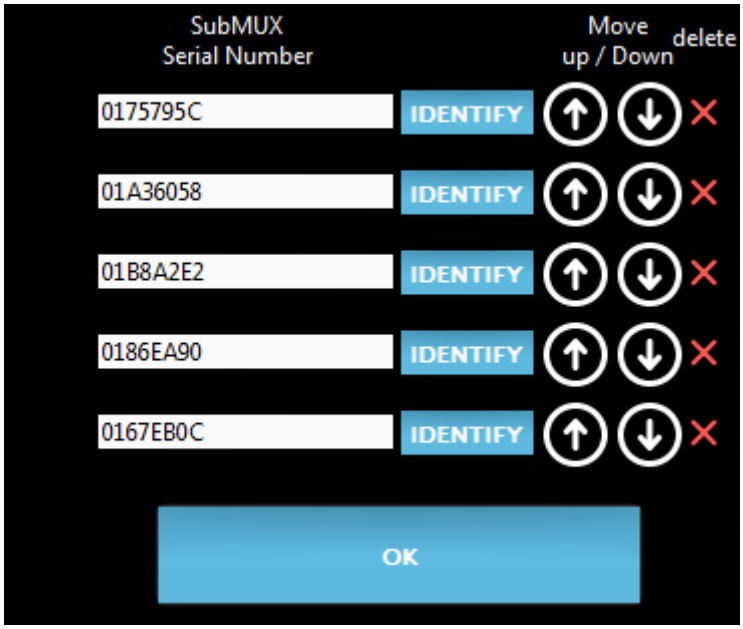


SubMUX

The number of subMUX indicates the number of sub units contains in the MUX Custom. The SubMUX Type can also be edited in this window. Finally the subMUX can be reordered by clicking on the Reorder subMUX button.



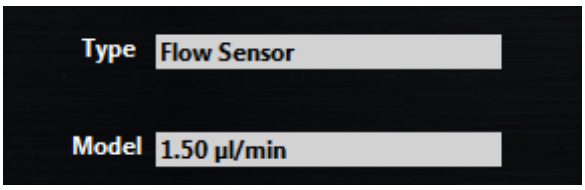
When this button is clicked, a new window opened



The first column indicates the MUX serial number. The identify button will open and close all the valve of the selected subMUX while all the other MUX valves are closed. This enables recognition of this MUX. Use the Up and Down button to reorder. The red cross is used to delete one specific subMUX for the MUX Custom instruments.

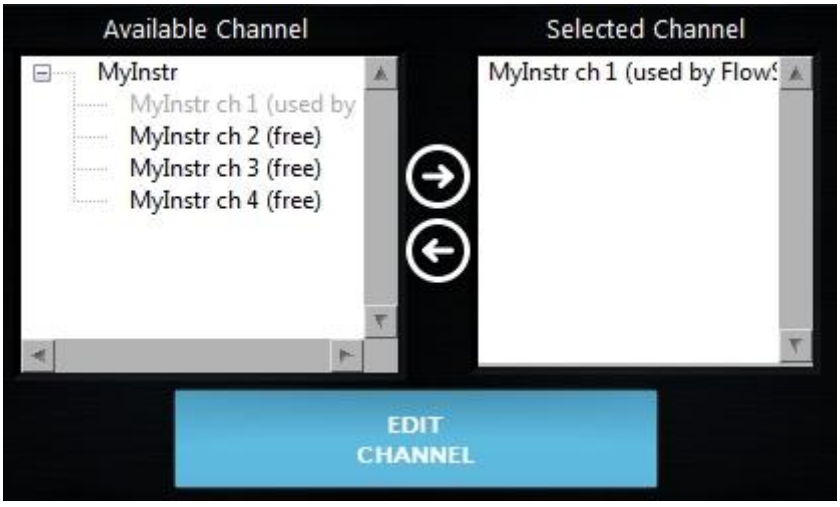
Sensors tabs

Information about the sensor Type and Model is available at the Sensor info tab. Available to: All sensors.



If the physical connection of a sensor to an instrument is changed, modify it in the Connected to tab. The sensor can also be visualized in one or more other channel than the connected channels. Available to: All sensors.

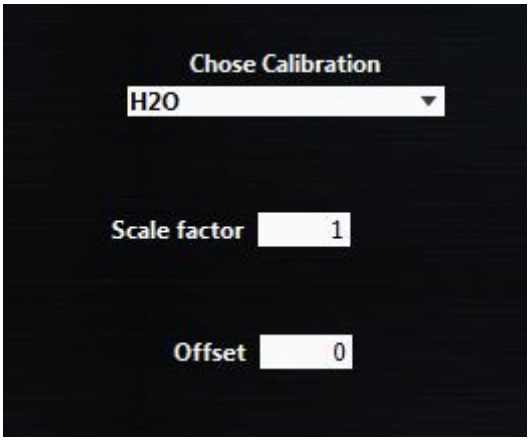
To edit visualization channel click on Edit Sensor Visualized in button. Available to: All sensors.



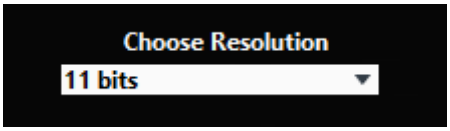
A list of all Available channels is listed on the left panels. Within brackets, the selected actual sensor is indicated. The selected channels are gray. The Selected channels are also listed on the right panel. Double click on a channel or use the right/left arrow to select/deselect it. If an instrument is double clicked, all the channels from that specific instrument are selected.

For specific applications the user may want to multiply the sensor readings by a Scale factor or displace it by an Offset. These values are available at the Scaling tab. Available to: All sensors.

For some digital flow sensor, the calibration can be switch between H_2O and Isopropyl alcohol using Chose Calibration field. Available to: Digital FS2, FS3 and FS4

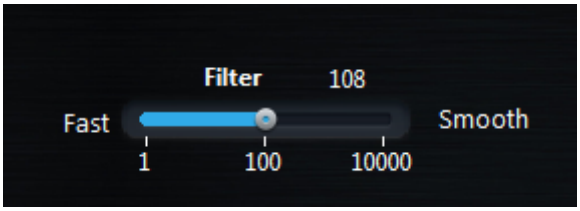


For all digital flow sensors, the sensor resolution can be chosen from 9 to 16 bits (default resolution 11 bits). Changing this resolution parameter will change the digital sampling time which is around 74 ms at 16 bits and 1 ms at 9 bits.

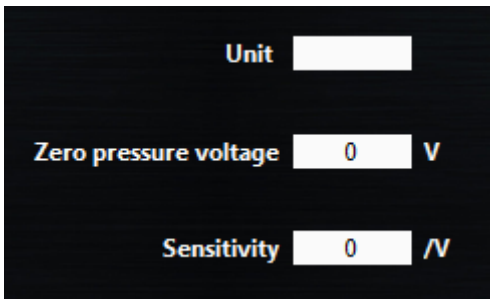


For BFS sensors, it is possible to change the displayed value to density, mass flow or temperature instead of volumetric flow rate. For digital flow sensors, volumetric flow rate and temperature are available.

At the Level Sensor Configuration tab, a filter can be applied. This filter provides a fast response if it's value is 1, but single bubble will cause a voltage drop. Smooth response can be obtained when the filter value is increased. Available to: Level Sensors.



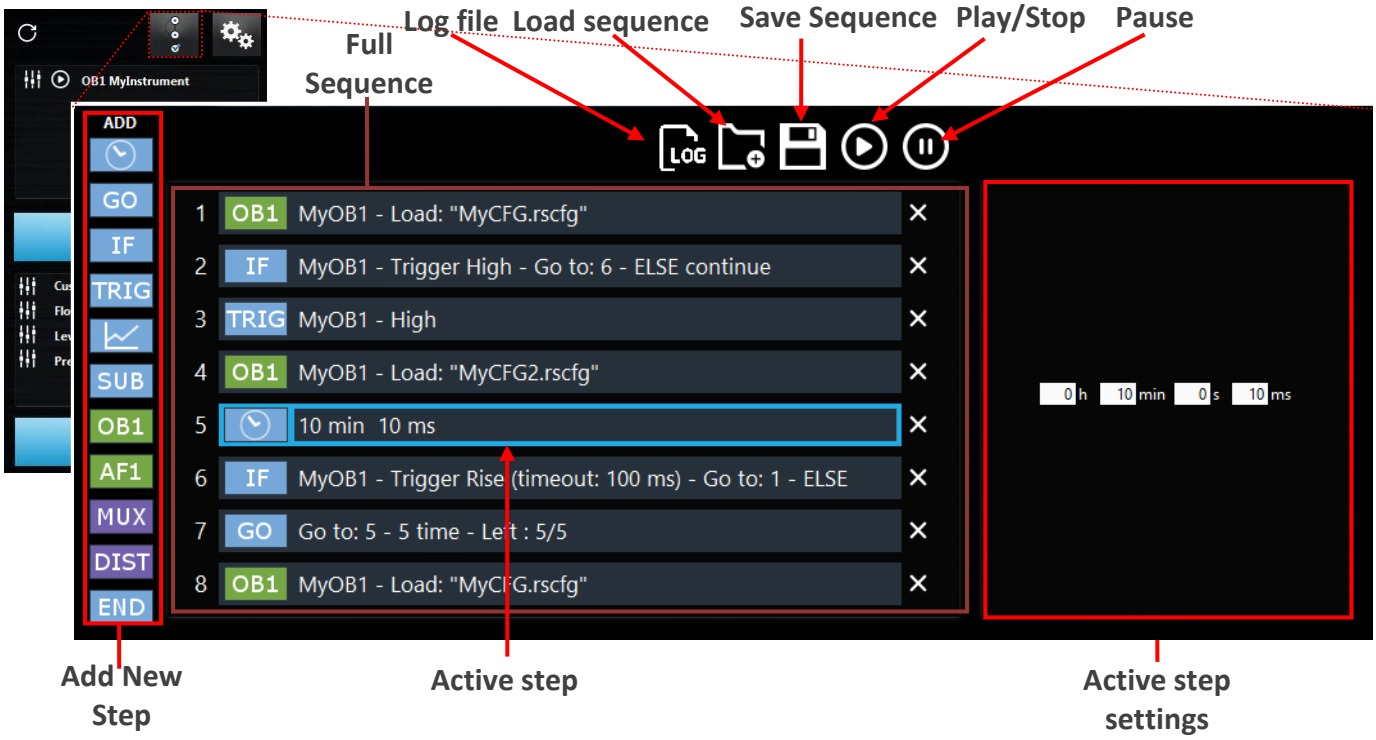
At the Custom sett. tab, a few extra parameters required for custom sensors can be configured: which Unit is used; at which voltage the sensor reads a Null value; and how many units it should increase per volt (Sensitivity). Available to: Custom sensors.



Sequence

For automation purposes or synchronisation of an experiment, a sequence of events can be programmed in the dedicated interface. Click the Sequence button on the main window to open it. This section details all the steps. For concrete example, refer to section

A standard view of this window with a short and simple sequence is represented below.



The window can be described as containing the following elements:

On the left side the Add step button. All steps will be described at the end of this section.

The darker panel in the middle shows the Sequence itself, with all steps.

The panel on the right present the Settings of the active step.

On the top, from left to right, are the buttons to choose a Log file to save sequence events, Load a sequence, Save sequence, Start/Stop and Pause the execution.

How to create and edit a sequence

Add new step and configure it

Click on the step you want to add in Add step. This new step will appear at the end of the Sequence.

Click in on this step in Sequence (panel 2); its actual settings will appear in the right panels.

Configure this step in the Active step settings panel (See Steps Settings p. 35).

Repeat this operation as many times as required.

Edit sequence order:

Steps can be dragged-dropped to another position in the sequence.

Hold Ctrl and drag-drop to copy a step to a specific position.

Delete Step

Delete a step by clicking the corresponding X button and by hitting the Delete key on the keyboard.

Steps Settings

Programming steps

Wait ( )

Wait introduces a "hold" in the sequence. During the wait period, all instruments will keep executing their current tasks.

Go To (GO)

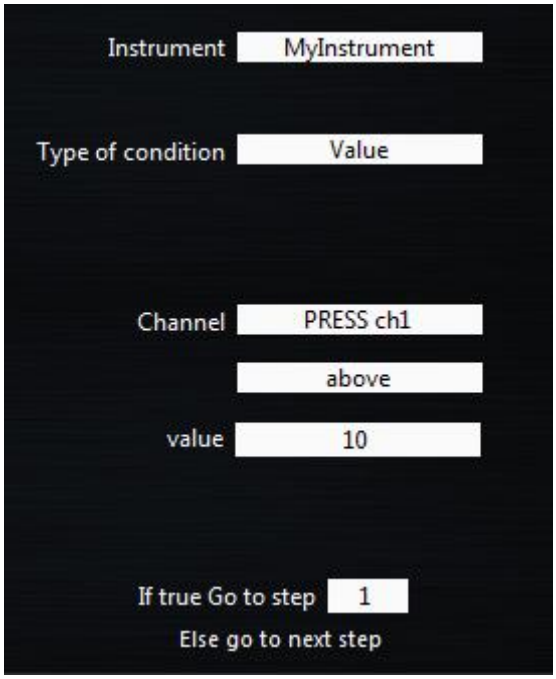
Go to step can be used to jump to a step before or after the current step. Use this to create a loop or to avoid executing steps without having to actually delete them from the sequence.

If (IF)

If will add a condition in the sequence. Two Type of condition can be used depending of the type of instrument: Value or Trigger. If the condition is true, the sequence goes to the step define in Go to step. Otherwise it goes to the next step.

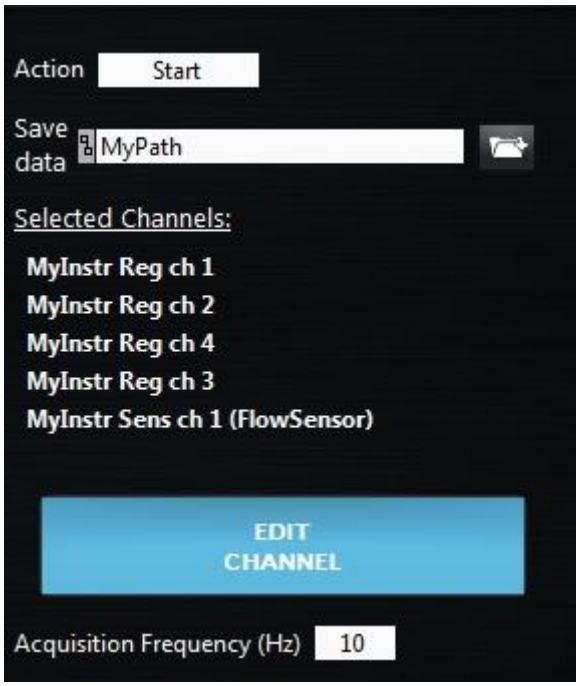
If Value is choose, the list of Channel allows you to choose the condition.

If Trigger is selected, select the type of trigger to be detected. For rising and falling edge the time out should be set (for High and Low the trigger status is only read once). The minimum value for time out is 20 ms.



Graph ( )

Graph will start/stop a graph from the sequencer (depending on the Action status). The data will be saved in the path defined by the Save Data field. The actual Selected channels are listed below. The graph Acquisition Frequency can be changed from this panel. To edit the channels, click on Edit Channel button. The Graph channel edition window (see Graphs section p.18) will be opened.



Sub Sequence (SUB)

Sub-Sequence can be loaded from the sequencer. Select the subsequence path using the Edit Path button. The button Edit Sub-Sequence enables the edition of the selected subsequence. When a sub sequence is edited a new button appears on the top of the Active Step Settings panel that enable to return to the main sequence.

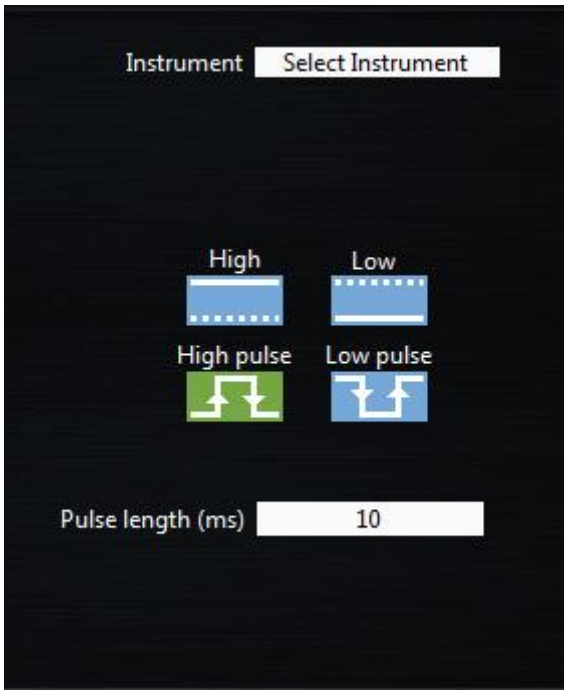
End (END)

End will stop the actual sequence. Any time a sequence reaches an End step, it stops executing. If this step is used in a subsequence, it only stops the sub sequence and the main sequence continues.

Instrument control steps

Trigger (TRIG)

Trigger control the trigger out of instruments. If high pulse or low pulse is selected, the pulse length can be set in this tab. For OB1 the high pulse is 3.3V. For other instruments, the high value is set to 5 V.

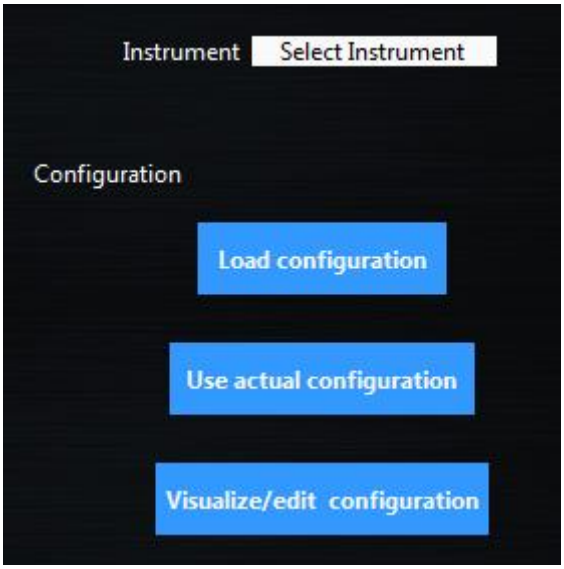


OB1, AF1 and MUX (OB1 , AF1 , MUX)

OB1, AF1 and MUX steps allows you to switch from one configuration to another. Read first the Configurations section (Using configurations - p.25). When adding one of these steps, first select the instrument (instrument field). Then click on Load configuration and select a previously saved configuration.

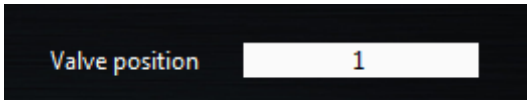
The actual configuration can also be used when clicked on the Use actual configuration.

N.b: To visualize or edit the chose configuration, press the Visualize/edit configuration button. Remember to save the configuration in the new windows otherwise the modification will not be taken into account.

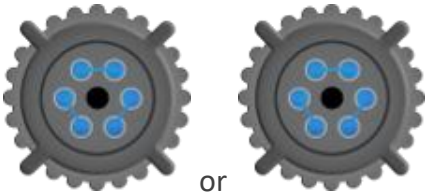


MUX Distrtibutor (DIST)

Mux Distributor steps, for standard MUX Distributors (6 or 10 positions), the target Valve position can be directly selected. This valve will be actived when the step is reached.



For injection version of the MUX Distributor a button let you select between the two position.



Advanced Settings

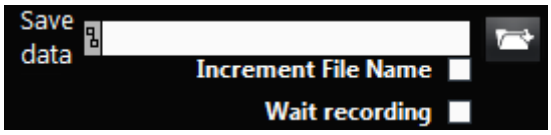
Some advanced options are unlocked only for advanced user. To activate those options, go to the general setting tab and activate Advanced Sequencer option. (See General settings p.7)

Graph ( )

The Graph step proposes two advance options.

If Increment File Name is activated, the files names are automatically incremented. This avoids overwriting the file if graph are call multiple time.

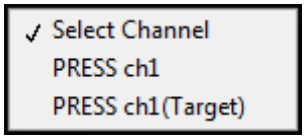
The Wait for recording option is activated; the graph will wait until the graph acquisition so start before going to the next step.



If (IF)

The If step proposes to use Target value or real value.

Important! The target value for sensor is only taken into account if the channel is configured in Feedback mode. If not the condition is set to false and the sequence goes to the next step.



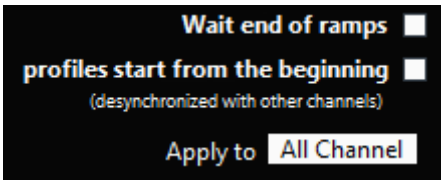
OB1 and AF1 (OB1 , AF1)

For OB1 and AF1 configured with Ramp(s) profile(s), the end of the Ramp can be automatically wait without adding a wait step if the option Wait end of ramps is checked.

N.B: If several ramps are in the actual configuration (on multiple channels instruments) this step will wait for the longest ramp.

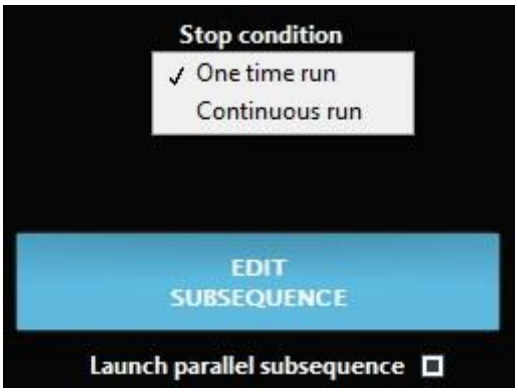
For configuration that uses profiles, the profile start from the beginning can be selected. If this option is not selected, all the profiles (from all instruments) are synchronized and start from the same reference time. Therefore the profile can start from anywhere when this step is executed. If this option is activated, the profile start from the beginning when this step is executed, but the synchronization with other channel will be lost.

The Apply to option enable you to apply the selected configuration to single channel and leave the previous configuration for all other channel.



Sub Sequence (SUB)

The Sub-Sequence step proposes to use Launch parallel subsequence with two stop conditions, either One time run or Continuous run.



The Launch parallel subsequence allows you to run a subsequence without waiting for its end to continue the main sequence. You can either run the subsequence one time to execute the subsequence while the main sequence is running or choose Continuous run to run the subsequence continuously during a determined time (chosen below) while the main sequence is running.

Running sub-sequences are listed when you execute the sequence. If a sub-sequence is not listed it means that the sub-sequence is not running. Only the sub-sequences launched using Launch parallel subsequence are listed.

Sub-sequences can be stopped at any time by clicking on the cross in the Running subsequences list.

Important! Graph cannot be used in sub-sequences launched this way.

Import sequence from text file

For advanced users, that are familiar with ESI interface, a text file can also be loaded in the sequence. Each lines should be a function in between brackets. Every argument should be separated by a coma (,).

The same function can have several prototypes (i.e. way to be written, with different parameters). When several parameters can be used, they are differentiated by a vertical lines. An curly bracket (}) indicate the merging of several function prototypes.

Optional parameters are displayed in *italic*. The keywords (text with expected value) are in **bold**.

Wait

Wait**(**Miliseconds, *Seconds, Minutes, Hours***)**

All the parameters should be integers.

Example:

Wait(3600000) → wait for 1 hour (3.6E6 ms)

Wait(350,1,0,1) → wait for 1h 1s and 350 ms

Go To

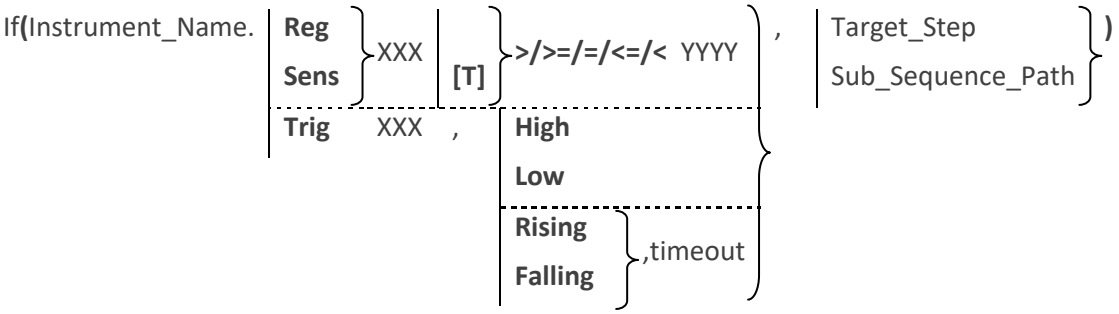
GoTo**(**Target_Step, Number_Of_Time**)**

All the parameters should be integers.

Example:

GoTo(1,10) → go to step 1, 10 times

If



The first parameter Instrument_Name is the name of the instrument. A dot (.) should be added to separate the instrument name and the type of condition (value of regulator, value of sensor, or trigger state). XXX is the channel or Trigger number. For most instruments (except OB1 or MUX Custom) the trigger number can only be one and can be therefore be ignored.

For target value (Regulator or Sensor):

- An optional [T] after the channel number indicates that the target value is used instead of the read value.
- A comparison sign (>, >=, =, <= or <) should be placed after the channel selection. It should be followed by the comparison value YYYY, that could be either another channel (Instrument_Name.RegX/SensX), or a constant value.

For trigger value, a second parameter is the trigger type (High, Low, Rising or Falling). For rising and falling conditions, the next parameter is the timeout.

The last parameter is either the the Target_setp (integer) or a subsequence path/name. If a name is used, the file should be in the default folder (see General settings p.7)

Example:

If(OB1.Reg1[T]>150,1) → If the target value of the first regulator of the instrument named OB1 is above 150, go to line 1

If(AF1.Trig, High, C:\Users\Public\Documents\Elvesys\ESI\Sequence\Sequence.txt) → If the trigger of the instrument named AF1 is in the High state, load the subsequence defined in the file Sebsequence.txt

If(AF1.Trig, High, Sequence.txt) → If the trigger of the instrument named AF1 is in the High state, load the subsequence defined in the file Sebsequence.txt contains in the folder C:\Users\Public\Documents\Elvesys\ESI\Sequence\ defined as default folder for sequences

Trigger

Trig**(**Instrument_Name**.TrigX**XX, | **High** | **)**
Low
High Pulse , Pulse length
Low Pulse

Instrument_Name is the name of the instrument. A dot (.) should be added to separate the instrument name and the type of condition. For this function, only Trigger are accepted. XXX is the channel or Trigger number. For most instruments (except OB1 or MUX Custom) the trigger number can only be one and can be therefore be ignored.

The second parameter should be the type of trigger (High, Low, High Pulse, Low Pulse)

For High pulse or low pulse, the pulse length should be the third parameter (in milliseconds).

Example:

Trig(OB1.Trig1,High) → Set the Trigger of the instrument called OB1 to high

Trig(MUX.Trig1,High Pulse,100) → Set the trigger of the instrument named MUX to High for 100 ms. After this time it will be switched back to low level.

Graph

Graph**(** | **Start** , Save_Path, acquisition_freq, ***Increment***, ***Wait***, Instrument_name.RegX/SensX, Instrument_Name2.RegY/SensY, Instrument_name3.RegZ/SensZ… **)**
Stop

The first parameter should be either be either **Start** or **Stop**. It indicates which action should be performed.

The start should be followed by the path/file where the data will be saved. If a file name is used, they will be saved in the default Graph folder. The third parameter should be the acquisition frequency. Two optional parameters can be added: ***Increment*** than activate the auto increment of the file name, and ***Wait***, that wait that the acquisition start before going to the next step. Then the selected channels should be added with the standard nomenclature. NB: there is no limitation in the number of channel to be added.

Example:

Graph(Start, C:/MyDocuments/Saved_graph.txt, 100, Wait, OB1:Reg3, OB1:Sens4) → Start a graph with 2 recorded data with a frequency of 100 Hz, and wait that the acquisition start to go to the next step.

Graph(Start, C:/MyDocuments/Saved_graph.txt, 10, Increment, OB1:Reg3, AF1:Sens1, OB1:Reg1) → Start a graph with 3 recorded data with a frequency of 10 Hz, and Increment the file name every time that this function is called.

Graph(Start, Saved_graph.txt, 10, Increment, OB1:Reg3, AF1:Sens1, OB1:Reg1) → Start a graph with 3 recorded data with a frequency of 10 Hz, and Increment the file name every time that this function is called. The data will be saved in a file named Saved_graph.txt in the default graph folder. (see General settings p.7)

SubSequence

Sub**(**File_Path**)**

The File_Path should be a valid path or the name of the sequence files. If the name is used, the file should be contains in the default Sequence folder (see General settings p.7)

Example:

Sub(C:\Users\Public\Documents\Elvesys\ESI\Sequence\SubSequence.txt) → Execute the sequence contains in SubSequence.txt

Sub(SubSequence.txt) → Execute the sequence contains in SubSequence.txt file that should be in the default sequence folder

OB1

OB1(Instrument_Name, Config_Path, ***Wait***, ***Beg***, *Channel_selected*)

The first parameter Instrument_Name is the name of the instrument. It should be followed by the path or the name of the target configuration file (*.rscfg). If the name is used, the file should be contains in the default configuration folder (see General settings p.7).

It can be followed by optional parameters that are:

- ***Wait***: wait the end of Ramp going to the next step. If omitted, the sequence goes directelly to the next step
- ***Beg***: Start the profile from the beginning. If omitted, all the channel keep their synchronization but they start at a random position in the profile
- Channel_selected: an integer that indicates to which channel the configuration should be applied. If omitted, the configuration is applied to all channels.

Example:

OB1(MyOB1, C:\Users\Public\Documents\Elvesys\ESI\Config\MyConfig.rscfg, Wait, Beg, 1) → Change the configuration of the first channel of the OB1 named MyOB1 to set the configuration MyConfig.rscfg. If this channel configuration is a ramp, it will wait until the end of it before switching to the next step, If this configuration use a profile, it will start from the beginning of the profile.

OB1(MyOB1, MyConfig.rscfg) → Change the configuration of all channels of the OB1 named MyOB1 to set the configuration MyConfig.rscfg. This file should be in the default configuration folder.

AF1

AF1(Instrument_Name, Config_Path, ***Wait***, ***Beg***)

The first parameter Instrument_Name is the name of the instrument. It should be followed by the path or name of the target configuration file (*.rscfg). If the name is used, the file should be contains in the default configuration folder (see General settings p.7).

It can be followed by optional parameters that are:

- **Wait**: wait the end of Ramp going to the next step. If omitted, the sequence goes directelly to the next step
- **Beg**: Start the profile from the beginning. If omitted, all the channel keep their synchronization but they start at a random position in the profile

Example:

AF1(MyAF1, C:\Users\Public\Documents\Elvesys\ESI\Config\MyConfig.rscfg, Wait, Beg) → Change the configuration of the AF1 named MyAF1 to set the configuration MyConfig.rscfg. If this channel configuration is a ramp, it will wait until the end of it before switching to the next step. If this configuration use a profile, it will start from the beginning of the profile.

AF1(MyAF1, MyConfig.rscfg) → Change the configuration of the AF1 named MyAF1 to set the configuration MyConfig.rscfg. This file should be in the default configuration folder.

MUX

MUX(Instrument_Name, Config_Path)

The first parameter Instrument_Name is the name of the instrument. It should be followed by the path or name of the target configuration file (*.mxcfg or *.mxcuscfg). If the name is used, the file should be contains in the default configuration folder (see General settings p.7).

Example:

MUX(MyMUX, C:\Users\Public\Documents\Elvesys\ESI\Config\MyMUXConfig.mxcfg) → Change the configuration of the MUX named MyMUX to set the configuration MyMUXConfig.mxcfg.

MUX(MyMUX, MyMUXConfig.mxcfg) → Change the configuration of the MUX named MyMUX to set the configuration MyMUXConfig.mxcfg. This file should be in the default configuration folder.

MUX Distributor

Dist(Instrument_Name, valve_position)

The first parameter Instrument_Name is the name of the instrument. It should be followed by the valve position.

Example:

Dist(MyMUXDist,3) → Change the valve of the MUX Distributor name MyMUXDist to position 3

N.B. For injection, only two positions are possible:

Valve position =1

Valve position =2

End

End()

This function does not require parameters

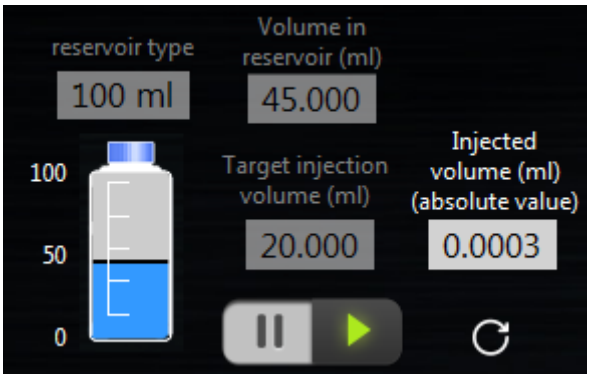
Modules

Modules are extra functionalities that could be added to instruments. They can be accessed from the add module button (See Control Instruments p. 14)

Injection module (AF1 and OB1 with flow sensor)

The injection module allows injecting a given volume of sample. To do so the user can select the reservoir type and the reservoir capacity (if reservoir type is "other"), the actual volume in the reservoir. The Target injection volume can be set in this window. The reset button resets the Injected volume value. The play/pause button allows you to start/pause the injection process.

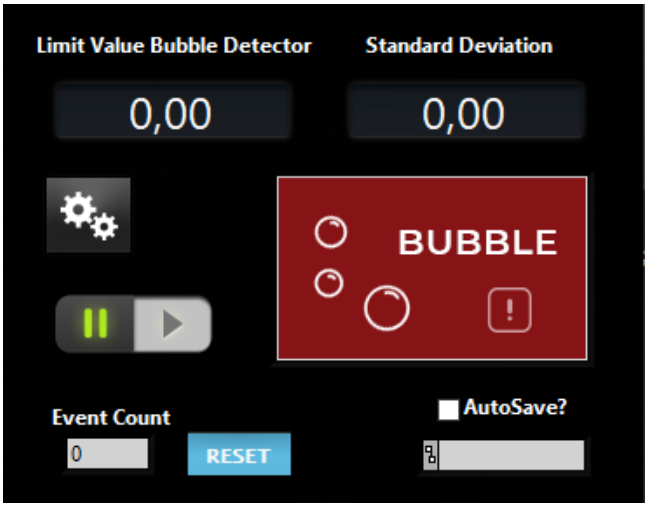
Important! At the end of the injection, the channel control mode is switched to "Sensor" (feedback control using flow sensor) and the target flow is set to zero.



Bubble detection module (OB1 with bubble detector)

The bubble detection module allows the user to detect if bubble are flowing into tubes. To do so you can select the Limit Value Bubble Detector. It is the value you obtain when there is no bubble in your system; if this value is 0 when your system is filled up with water, use the calibration button on your bubble detector. The Standard Deviation is the fluctuation around Limit Value Bubble Detector where you consider that the value still correspond to water.

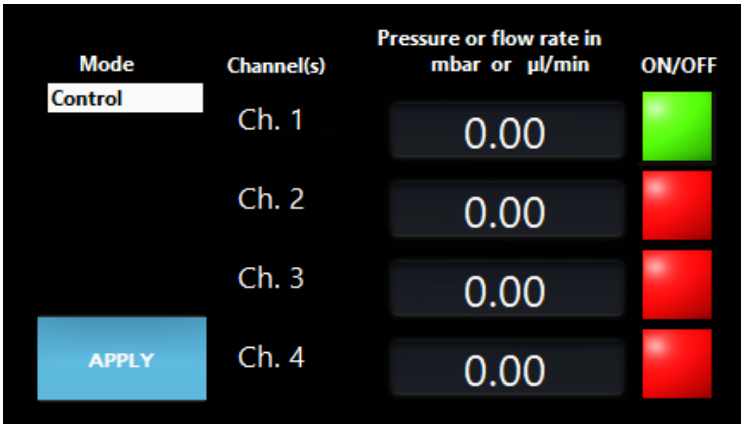
The gears open a parameter window. Event Count is the number of bubble events that happened after clicking on the Play Button. AutoSave? allows you to choose a file to record bubble events.



In the parameter window, you have 2 modes, Alert and Control.

In Alert mode you only have the Event Count and Bubble/Liquid image that is flashing when a bubble appear.

In Control mode you can select a pressure or flow rate to apply when an event occurs. Do not forget to select the channel by clicking on the ON/OFF button to turn it to green.

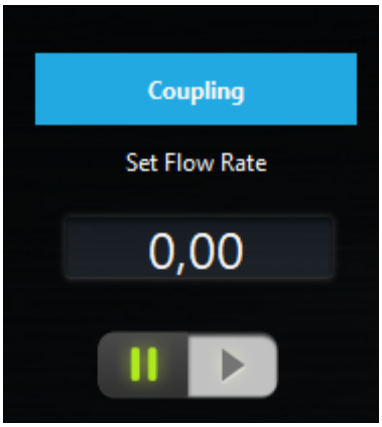


Coupled Flow rate module (OB1 with flow sensor)

Important! To open the coupled flow rate module, select the channel you would like to use as the main channel with a flow sensor. The control mode of this channel will automatically turn to “Sensor” mode.

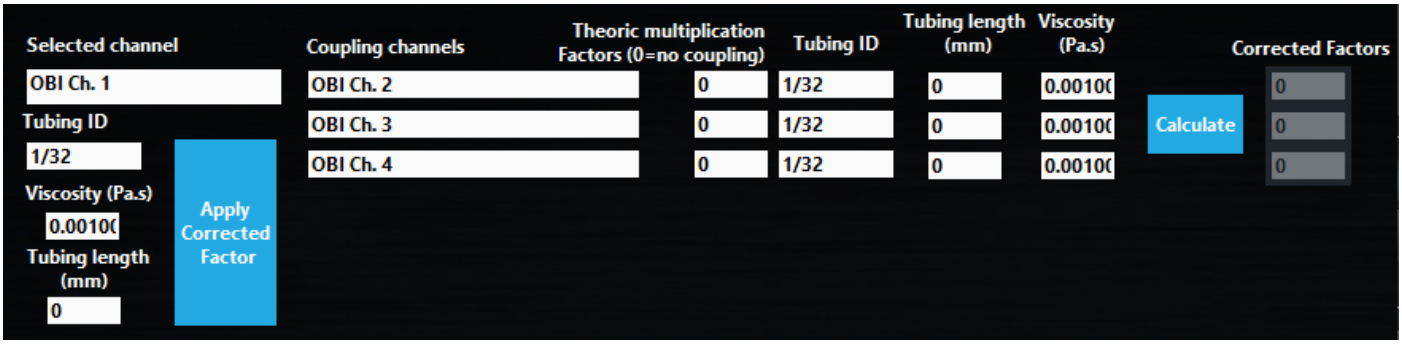
The coupled flow rate module allows the User to Set Flow Rate on the channel dedicated and modifies Coupling with other channels to do a feedback loop with one flow sensor and multiple pressure outputs.

Important! Remember to setup your PID parameters as usual in Sensor mode.



The Selected channel is the main channel you will use to couple other channels. Tubing ID, Viscosity (Pa.s) and Tubing length (mm) depend on the tubing/solution used to connect your main channel to your microfluidic system. Then Theoric multiplication Factors can be set (1 to have the same amount of pressure on each channel) as well as Tubing ID, Tubing length (mm) and Viscosity (Pa.s) for each other channels.

Then user can press calculate to obtain the Corrected Factors that will be used to regulate flow rate. User can click on Apply Corrected Factor and close the window to setup the corrected factors.

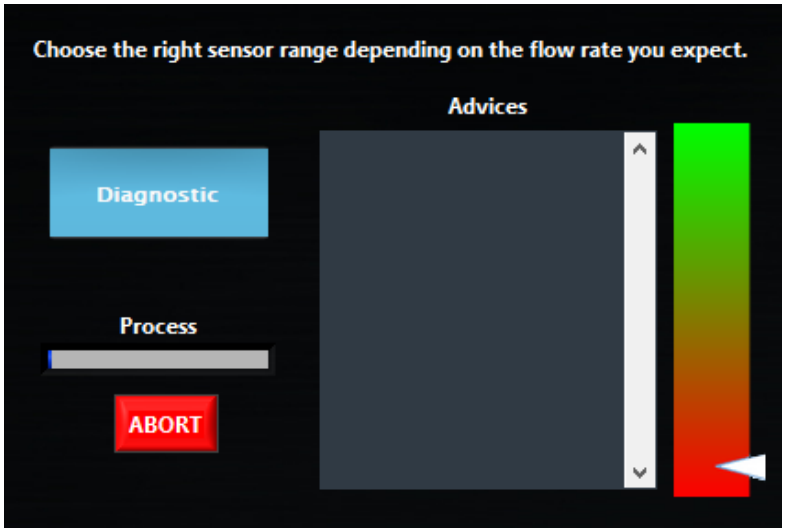


Tuning resistance module (AF1 and OB1 with flow sensor)

The tuning resistance module allows the user to realize a fine tuning of his setup to perform automatic tuning of PID parameters and improve flow control. This module allows the user to click on Diagnostic and eventually ABORT the process at any time.

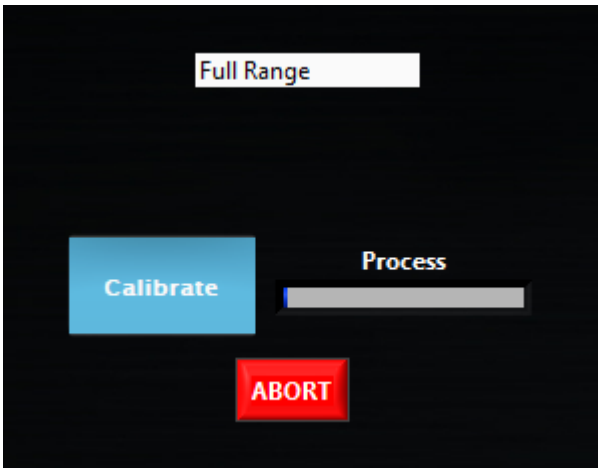
Important! Prior to click on Diagnostic, be sure that the system is filled up with water! There must be water into the whole system including flow sensor, tubing and resistance to work.

Then some Advices are displayed, recommending a certain length of tubing to be added or removed in order to increase or decrease the system's resistance. On the right, a cursor shows how well the system is dimensioned. Red means it needs improving, green means it is good.



Sensor calibration module (AF1 and OB1 with pressure sensor)

The sensor calibration module allows the user to calibrate easily the pressure value from a pressure sensor with pressure output by the OB1. It allows matching the OB1 pressure. To perform this calibration, a pressure sensor needs to be connected to an OB1 output and the air flow must be stopped to close the air path after the pressure sensor.



The pressure sensor can be calibrated over the full range or a custom range. The range will be automatically selected to avoid using a range that could damage the pressure sensor. For example, if you connect a 2 bar pressure sensor to an 8 bar pressure channel, the Full Range will be 2 bar and the process will stop at 2 bar.

You can stop the process and cancel the calibration at any time by clicking on ABORT.

If you performed a calibration and want to go back to original values before calibration, go to the pressure sensor parameters in the scaling tab and put back Scale Factor to 1 and Offset to 0.

Keyboard shortcuts

General

In any control window in which Configurations are available use Ctrl + <number> to switch between configurations. The numbers correspond to the position of each configuration on the list.

The space bar will toggle the ON button in an active channel or MUX control window.

AF1, OB1

Use the Shift+left and Shift+right arrows to navigate between channels.

Use the up and down arrows to increment/decrement the actual value.

The Escape key will switch off all channels.

AF1, OB1, MSR, BFS

To launch a graph, hit G.

Sequence

Arrow-up and arrow-down help navigating through the sequence steps.

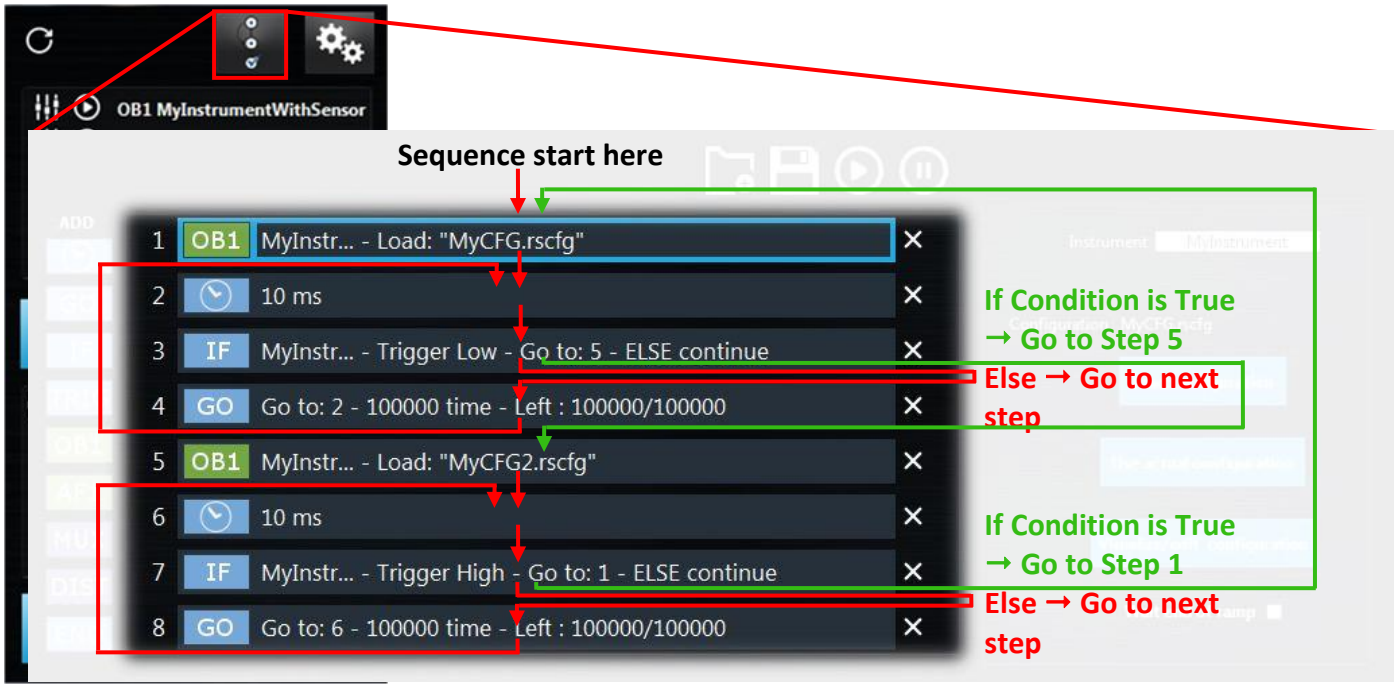
The delete key will remove the selected step from the sequence.

HOW TO...

... use “IF” and “Go To” Step

This section explains how to use condition and loops in the sequence using a simple example.

In our example, we connected an OB1 named MyInstrument. We would like to change the configuration according to the trigger state (trigger High → MyCFG.rscfg, Trigger Low → MyCFG2.rscfg) . The following sequence was build for that purpose.



Step 1 – Set the OB1 configuration to MyCFG.rscfg

Step 2 – Wait 10 ms (decrease CPU consumption time)

Step 3 – If the trigger is Low, change go to step (to change the OB1 State), else go to next state (To stay in the loop)

Step 4 – go back to step 2 – many times (depending on the experiment duration)

Step 5 – Change the OB1 State to MyCFG2

Step 6 – Wait 10 ms (decrease CPU consumption time)

Step 7 – If the trigger is High, go to step 1 (to change the OB1 State), else go to next state (to stay in the loops)

Step 8 – go back to step 6 – many times (depending on the experiment duration)