ADVANCED RANGE QUICKSTART GUIDE

This document provides an introduction to the Elveflow Advanced ecosystem.

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Introduction

This document presents the Advanced range in its entirety, with particular emphasis on its architecture, communication language and main functions. It is recommended to read this concise and complete document first and foremost, it will help you **apprehend how the range functions** and **understand the possibilities it offers**.

Then, we advise you to refer to the documents related to each module for a complete understanding of the operation of the modules.

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The concept of the range

The range comprises a number of modules revolving around a main module called the Advanced Control Center. This module acts as the brain of the fluid handling brick with all of the communication protocol passing through it.

Up to five modules can be connected to the control center, among which:

- a pressure controller, for pressure management and flow regulation,
- a valve hub, for the control of up to 16 valves,
- a sensor hub, for the data acquisition of up to 4 sensors,
- a rotavalve, a rotary valve with either a 12 to 1 port option, which is called distribution valve or a 6 ports and 2 positions option, called a recirculation valve,
- and finally a hub, an additional module acting as a relay. With this module, you can connect 5 additional modules to a single port of the control center, allowing up to 25 module connections on a single control center.

The range can be **controlled directly through UART communication or via software.** The Advanced Control Center and the entire range is compatible with the Elveflow ESI software in which an Advanced module has been implemented.

One of the main advantages of the control center is its **embedded sequencer** with operation in parallel, synchronization of modules and conditional logic.
A sequencer is an integrated process that allows the creation, saving and execution of a series of instructions for microfluidics systems made of Elveflow Advanced devices. Commands to modules are organized in relation to each other thanks to logical commands like if conditions, wait times, loops. Multiple **sequencers** are available to run parallel sequences. There are 5 sequencer channels (0 to 4), each one with 128 steps. The minimum time period between 2 steps is 1 ms, which can be increased with a wait command. The sequencer helps streamline operations and improve system responsiveness. It can function autonomously without a computer. It also enables distributed flow control between modules.
Another feature that can be configured is the **start of a sequence when the instrument is switched on**. All the experiment can then start when it is powered up.
If you need more information and guidance to set up physically the different modules or to better understand the physical principles, we advise to refer to the user guides corresponding to the off-the-shelf instruments or contact our support team.

Communicating with the modules

Via the Control Center

If you want to create a system of modules (multiple modules interacting between themselves or with the same microfluidic system), it is made easier by the Control Center. It acts as the brain of your system, controlling the different modules connected to it.

Control Center and ESI software

The Control Center is compatible with the ESI software (refer to the ESI user guide, section Advanced to learn more about this software module). Once the Control Center is connected to your computer and the ESI software running, add the Control Center to the ESI software as a new instrument. From now on, all instruments connected to the control center will be automatically recognized by the software.

On the software, individual control of the modules is available as well as a sequencer in order to automate experiments. A UART command translator is also available to help you get to grips with this type of communication if you're unfamiliar with it.

Control Center and direct UART communication

The second option to control the Advanced range is to use direct UART communication. To do so, refer to the corresponding communication protocols of each module, starting with the one for the Control Center.

Here is some quick information to start with UART communication.

- The command syntax is the same for all the modules.
    - Start the query with the character '<'
    - Write the command name
    - To read a value, meaning to get a value, use '?' after the command.
    - To write, meaning to set a value, use '!' after the command.
    - Add the symbol ':' before adding the arguments. You can iterate over many arguments.
    - Every command should end with '\n' to be recognised by the Advanced module as such
- Each action corresponds to a command. The list of all the commands available for each module is listed in the communication protocols.
- Each command requires specific arguments. The different types of arguments used with the commands are listed in the table below and specified in the list of commands in each communication protocol.

Abbreviation type	Description type
int	integer value (1, -25, 50001, -32263, 0, 54)
float	floating value (-1.002, 0.004, 2005.40, -51.0)
string	string of character (“Sequence 1”, “test number 1”, “sentence”)
boolean	boolean value (True or False) represented here by 1 (true) or 0 (false)

- In the answer to any command, the first information displayed after the read / write character is the error code ‘|xx|’. It is two characters that indicate the error code associated with the request. ‘00’ means non error. Check each communication protocol to know the different error codes.

Via the adapter

The adapter is a tool to interface modules (except the Control Center) and a PC for rapid prototyping.

On one side you connect a USB cable and an appropriate power supply, on the other you connect an M12 cable. The other end of the M12 cable is connected to the module and the other end of the USB cable is connected to the PC.

This tool is not compatible with the ESI software. As a result, the only way to communicate with the modules by using the adapter is to use the UART communication. Refer to each communication protocol to learn how to communicate with each module.

Note: as the adapter acts only as a relay, it does not have an associated communication protocol.

When using the adapter, we highly recommend connecting the M12 cable between the adapter and the device before connecting the USB cable and the DC power supply. Also, please remove USB cable and DC power supply from the adapter before the M12 cable between the adapter and the device.

The Advanced strength: creating your custom system

The Control Center has 5 connection ports (M12). You can link a module to the control center with an M12 cable, and the module is automatically recognised. Then it is possible to communicate with the module by sending commands to the Control Center. Commands to be sent to the module need to be associated with the module's serial number, in order for the command to be transmitted to the correct device.

We recommend physically connecting all the modules to the control center before switching the modules on.

Each module is identified by its serial number, which is constructed as follows: a first letter followed by 5 numbers. The first letter refers to the type of module. The serial number is indicated on the sticker placed on each module.

Device type	SN's first character
Control Center	M
Hub	X
Pressure Controller	A, B, C, Y or Z (according to pressure range)
Sensor Hub	S
Valve Hub	V
RotaValve	R

If your system needs more than 5 modules, you can use the Hub. It acts as a module extending the number of connections with 5 M12 connection ports per Hub.

This allows you to create systems of up to 25 modules, all controlled via one Control Center i.e. one USB (or RS232) connection. All commands are sent to the same place, the Control Center, with the serial number of the addressed module associated with each command. The Control Center then takes care of distributing the commands where they need to go.

Note: as the Hub acts only as a relay, it does not have an associated communication protocol.

Quick set up of a UART communication (with Python)

This section explains how to use a Python script to interact with an Advanced system using a simple example. You need to have Python installed on your computer. You also need to use the pyserial library.

In our example, we connected an Advanced PRESSURE CONTROLLER. We would like to get the pressure and sensor values. To do so, we are going to use the PINGA command (cf Advanced Pressure Controller communication protocol). The following python script was built for that purpose.

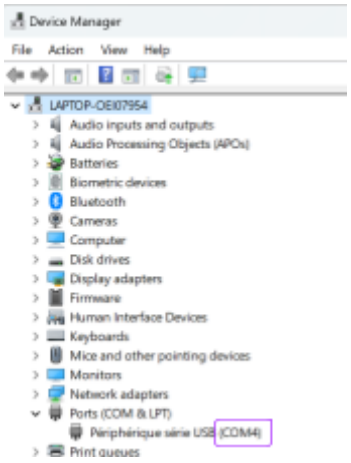
If you don't already have a preferred coding IDE, we recommend using VS Code. Create a new file with the file extension '.py', for instance : 'main.py'. Write the following code inside. Click on the 'Run Python File' button on the upper right corner.

```python
import serial
from time import sleep

com_port = 'COM3'
baudrate = 230400

with serial.Serial(com_port, baudrate, timeout=1) as ser: #opening a serial communication port with the specified parameters :
# - com_port : com port name corresponding to the device (cf device manager)
# - baudrate : communication speed corresponding to the device (cf device communication protocole
# - timeout : how long to wait for a response before aborting communication
    ser.write(f'<PINGA?:1\n'.encode('utf-8')) #send the command '<PINGA?:1\n'
    sleep(0.05) #wait for the device to receive, apply and respond to the command
    reads = ser.readline()       #read the reponse
    print(reads)   #display the reponse in the terminal
```

To identify the com port where your device is connected to, go to the Device Manager app and look at the 'Ports (COM & LPT)' section. You can unplug and replug your device (via USB) to your PC and look at which port it corresponds to.

Advanced range examples of classic applications

Workflow automation



Every fluidic experiment can be designed using the Advanced range. Here are some examples: sequential injection, droplet generation, cell perfusion...

The Advanced range is strongly advised when working with a complex system (more than 3 different instruments) as you can connect up to 25 modules on a single Control Center. When automation is a key parameter of the experiment, it is also a huge advantage.. Using this range, the fluidic experiment can be considered as a brick and can easily be integrated with other optical or pneumatic bricks. All in all, should you require versatility and integration into complex ecosystems, the Advanced range is designed for you.

Autonomous touch design

Thanks to its characteristics (UART communication protocols, RS232 connections and embedded sequencer), the integration of a touch screen into the Advanced ecosystem is possible. Without any computer connection, by touching the play button on the screen, a sequence can be launched and then stopped by touching the stop button.
You can then transform your benchtop experiment into a full independent system.

Programmable Logic Controller (PLC) Systems Integration

Thanks to its serial communication, the Advanced range can be compatible with PLC.

Automating valves for systems integration

The Valve Hub module can be used as a complex switch to all kinds of valves or devices, as long as they support 12 or 24V supply. We can therefore imagine connecting all kinds of units, such as third-party pumps.