

ACTIVE CONTROL OF VIBRATION EDUCATIONAL KIT

USER MANUAL

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CAUTION: READ BEFORE OPENING

For safety purposes these instructions must be read before using this product.

Piezoelectric products are not warranted against mechanical damage resulting from improper use, wherein excessive forces or voltages that are outside specified ranges are applied.

High voltage is present in this product.

Only qualified personnel should work on or around this equipment and only after becoming thoroughly familiar with all warnings, safety notices, and procedures contained herein.

The successful and safe operation of this equipment is dependent on proper handling, installation and operation.

A "qualified person" is someone who is familiar with the installation, construction and operation of the equipment and the hazards involved. In addition, he/she has the following qualifications :

- trained and authorized to energize, de-energize, clean, and ground equipment in accordance with established practices,
- trained in the proper care and use of protective equipment in accordance with established safety practices.

1. DESCRIPTION OF THE EQUIPMENT

The Educational Kit includes:

- An electronic rack including
 - A linear amplifier CA45
 - The accelerometer power supply
 - A digital PID controller UC45
- A complete mechanism including
 - A mechanical beam
 - An Amplified Piezo Actuator APA60SM
 - An accelerometer
 - An electromagnet and its driver
- A GUI software to configure the digital controller UC45 through USB connection.
- Cables

Not included:

- Low frequency sine generator to provide the input for the electromagnet driver
- 24VDC power supply

Figure 1 and 2 show a mounted educational kit:

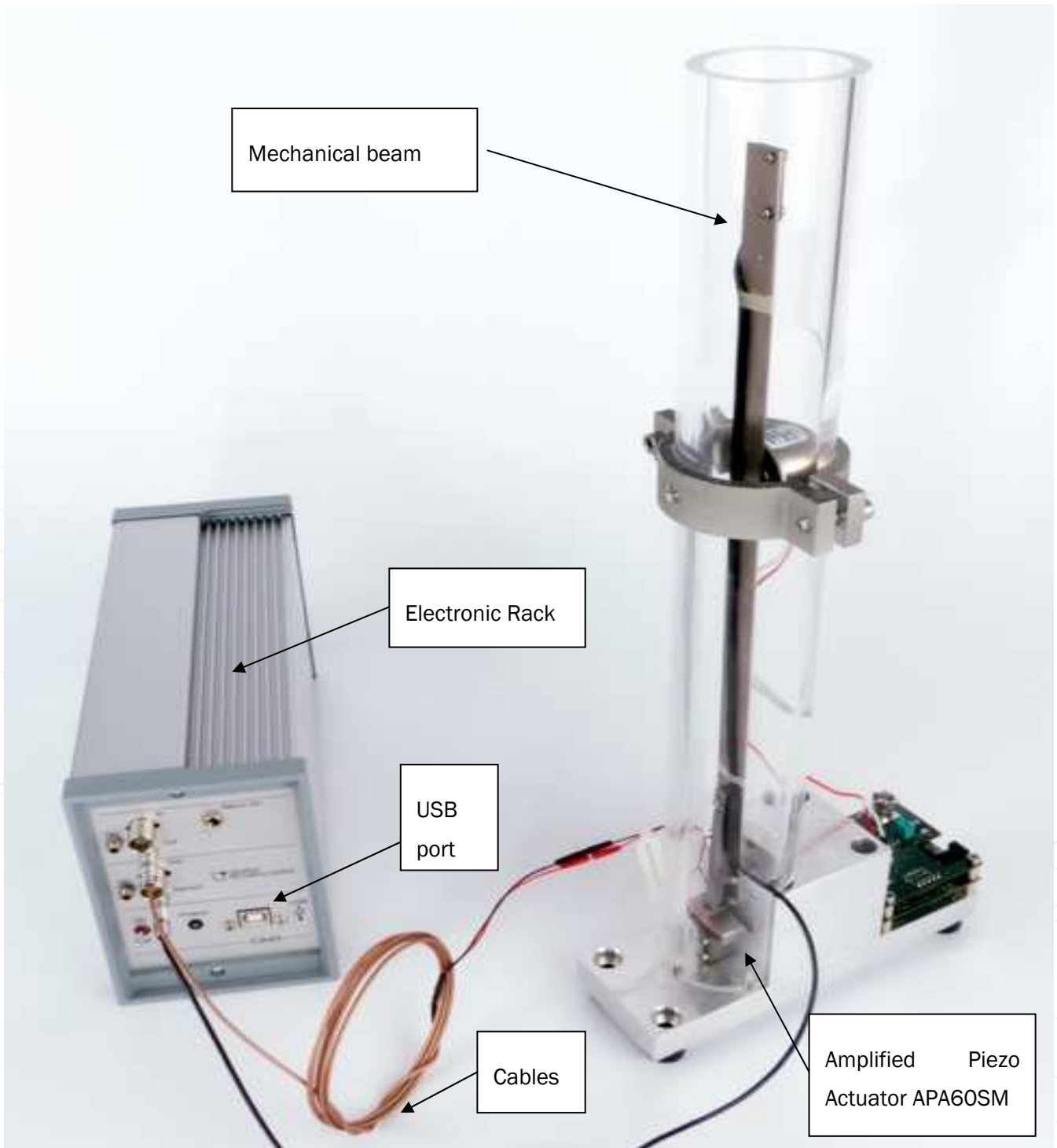


Figure 1: Educational Kit of Cedrat Technologies, front view

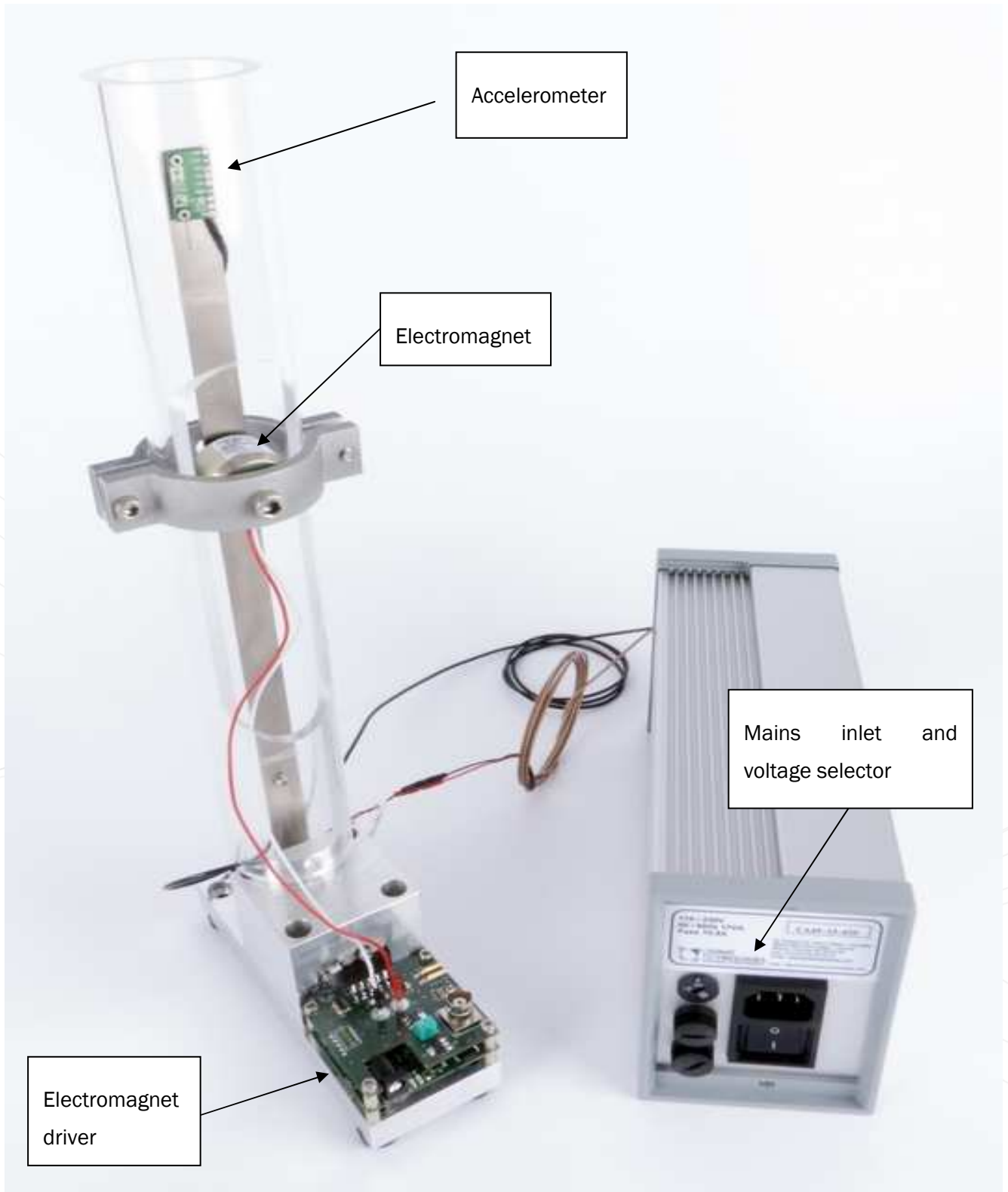


Figure 2: Educational Kit of Cedrat Technologies, rear view

Figure 3 explains the connections of the CA45 electronic rack:

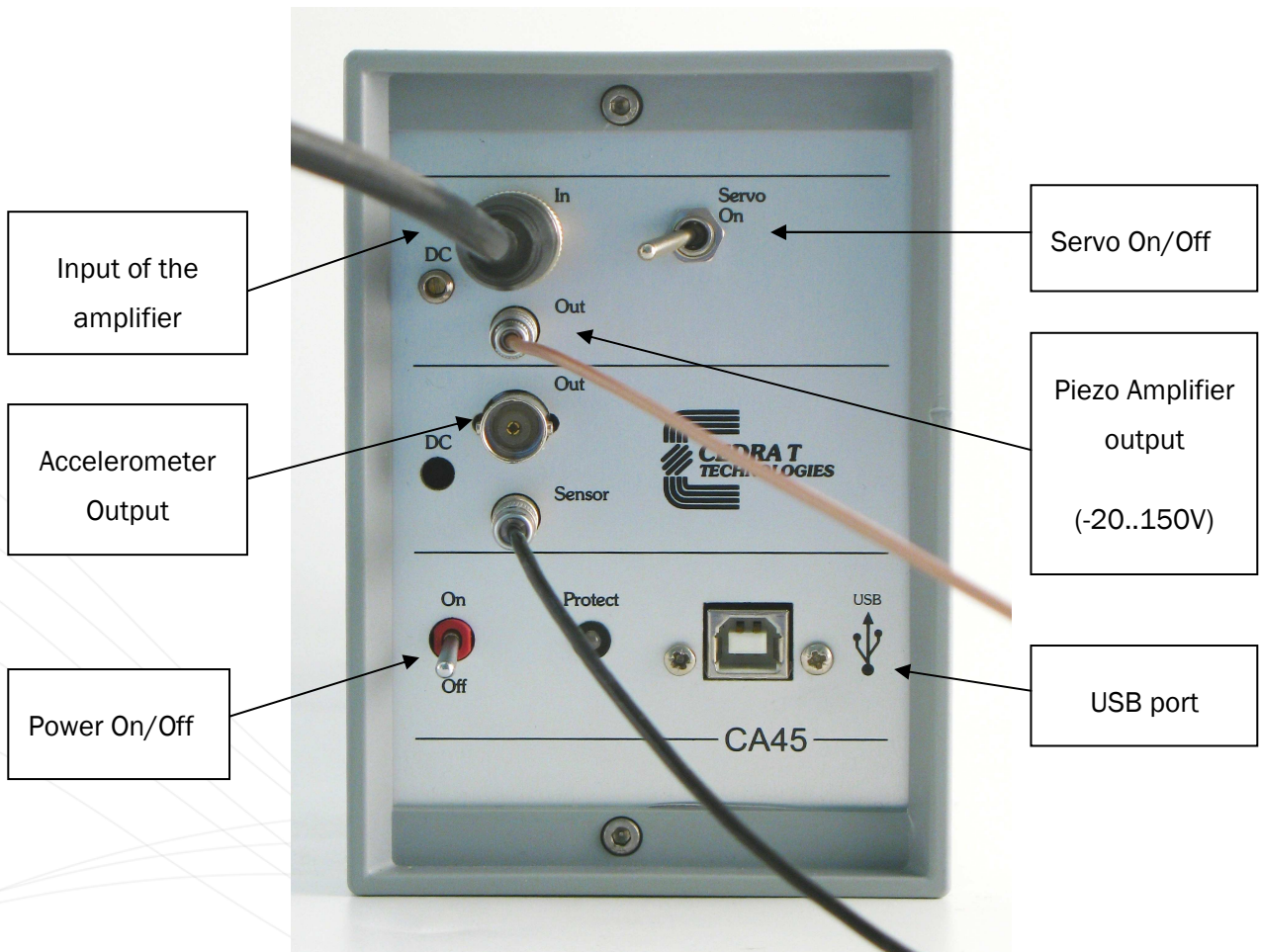


Figure 3: CA45 front panel description

Figure 4 shows the GUI Interface of the controller UC45:

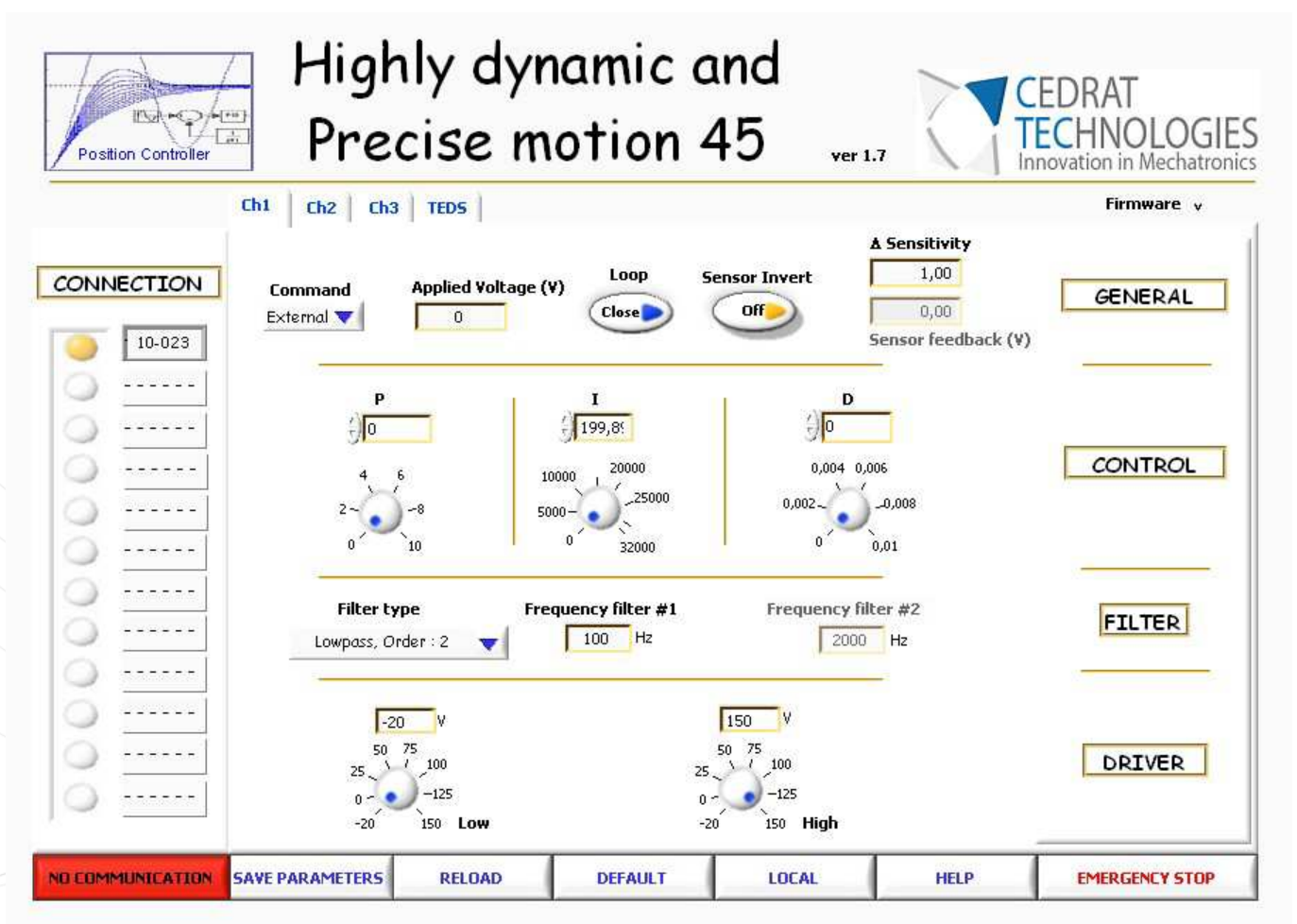


Figure 4: GUI Interface of the controller (HDPM45.exe)

Description of the parameters is given in 4.1.2

2. USER MANUAL OF APA60SM PIEZO ACTUATOR AND CA45 ELECTRONIC RACK

The APA60SM actuator and the CA45 are standard industrial products of Cedrat Technologies.

The relative user manuals can be found at: <http://www.cedrat-technologies.com/en/products/users-manual.html>

3. INSTALLING THE EDUCATIONAL KIT

The educational kit is easy and fast to install.

3.1. INSTALLING THE SOFTWARE

This paragraph describes the different instructions to connect the UC45 microcontroller and to install the software. The operator in the same time must connect the mechanism to the rack following the instruction in the user manual **“LA75 - Linear amplifier for piezoelectric actuators CA45 Compact standalone amplifier - Product and warranty information”**.



Do not connect the CA45 USB driver to the PC before installing the software.

3.1.1. REQUIRED EQUIPMENT

You must install the Software on the following Personal Computer configuration:

- Change “,” in “.” in the regional configuration of your PC if it is not the case. (Settings/ Controls Panel / Regional and language Options / Customize / Decimal symbol).

Required files:

- A single CD or a downloaded file (HDP45vxx.zip) on the Cedrat Technologies website (<http://www.cedrat-technologies.com/en/mechatronic-products/download/graphical-users-interface.html>) includes the installer for the application software.

3.1.2. FIRST TIME INSTALLATION

1. The operator has to run the “setup.exe”, following the instructions.

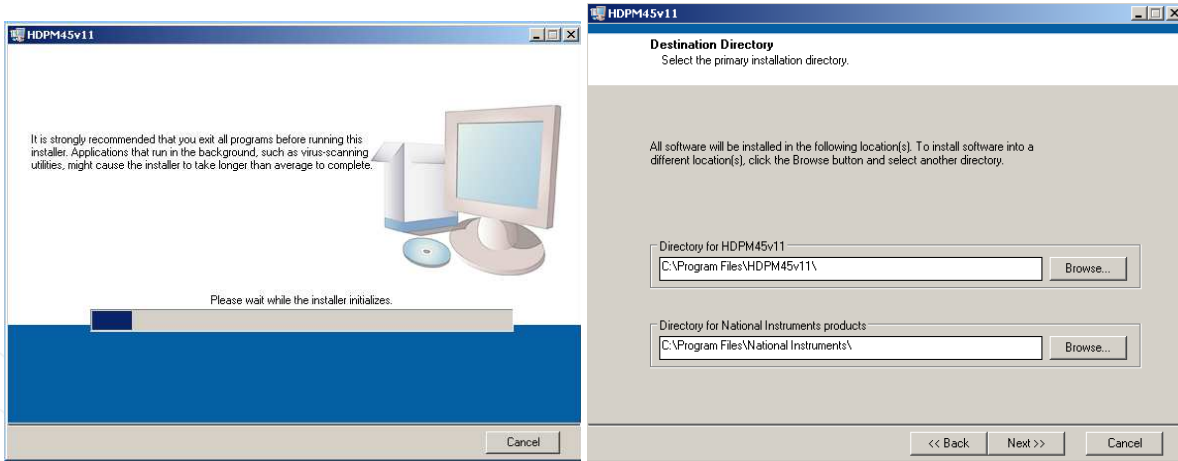


Figure 5: Destination directory

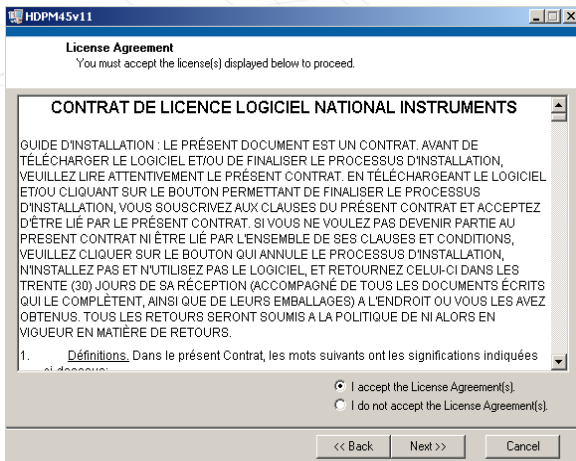


Figure 6: License Agreement

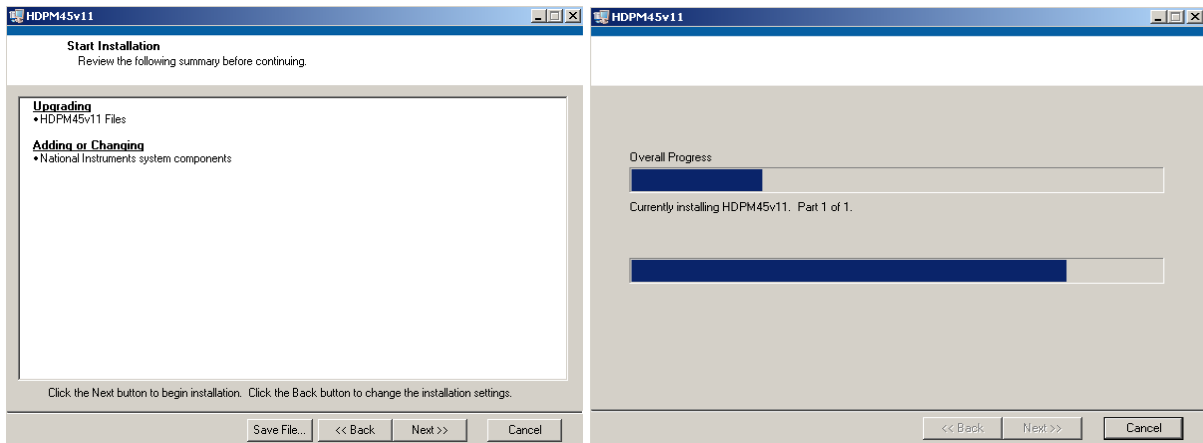


Figure 7: Starting Installation

2. After the installation is finished, another driver will be installed automatically. The PC needs to be restarted. An icon “HDP45_vxx.exe” is normally on the desktop.

3.2. INSTALLING THE HARDWARE

Follow the procedure:

- Connect the CA45 to the grid/mains
- Connect the brown LEMO cable to the “Out” plug of the CA45 and into the actuator.
- Connect the dark LEMO cable to the “Sensor” plug.
- Connect the USB plug to the PC
- No cable needs to be connected to the “In” BNC plug
- Switch “Servo On” to the right position
- Switch ON the CA45. The front LED should be green.
- Start the software HDPM45. The software connects to the controller.
- The system is ready. By shaking the beam manually, you can observe that the system is actively damped.

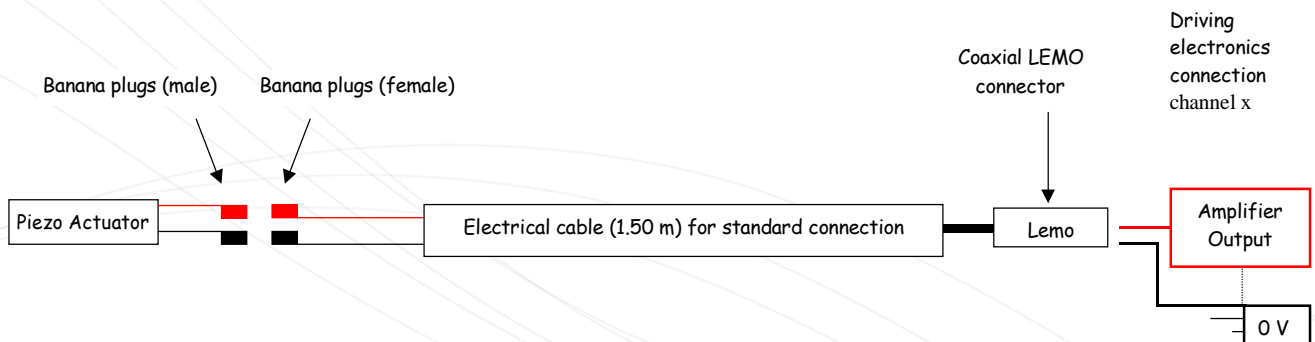
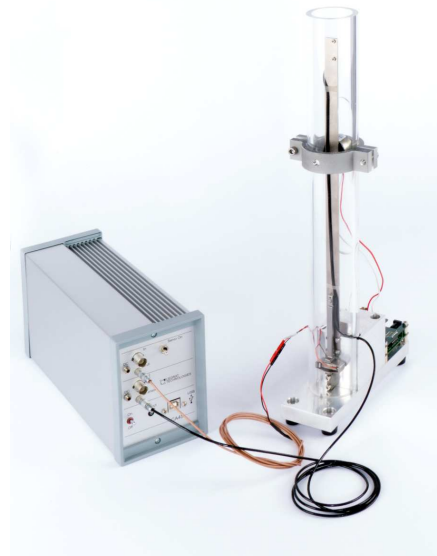


Figure 8: piezo actuator connection

4. USING THE SOFTWARE

4.1. INTRODUCTION

This is a guide on how to use the “Highly dynamic and precise motion 45” software with a piezo actuator associated to a sensor. The software allows to tune some of the controller parameters.

The screen is divided in three areas, surrounded in green on the figure below:

- The “CONNECTION” section manages the selection and communication to the boards.
- In the parameter section (center of the screen) one can monitor and adjust the parameters of the controller.
- The foot of the screen contains several main commands to manage the configuration of the software.

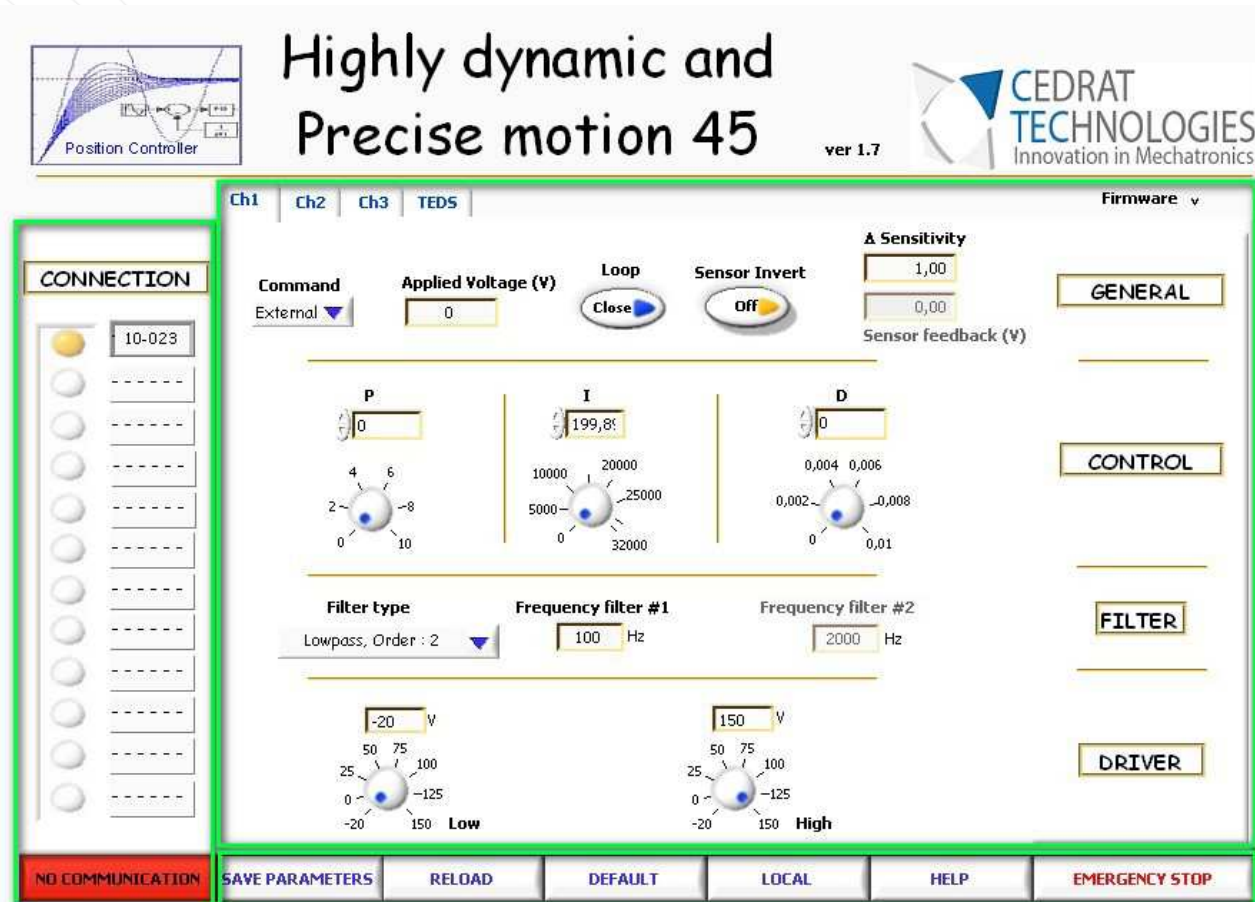


Figure 9 : Human Machine Interface description

4.1.1.1. CONNECTION SECTION

The area is composed of twelve possible boards (maximum number, the ACV kit contains only one).

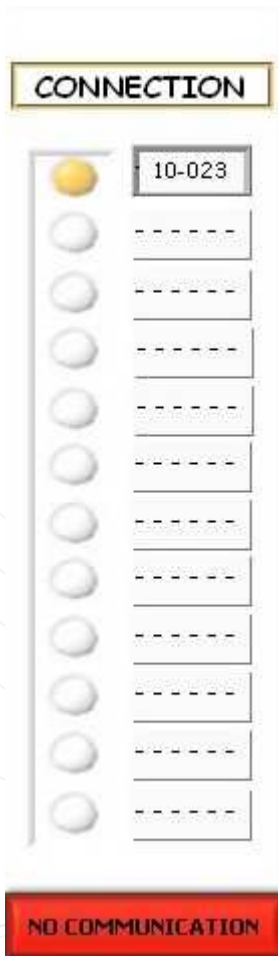


Figure 10: Left section of the HMI : Connection section

During lanch, the software performs a search of the various boards which could be connected. During this first step, a button “LOADING...” appears. This first step can last 1 or 2 minutes.



Figure 11: First step

In a second step, the software will read the parameters on the boards, during which a button “NO COMMUNICATION” appears. When those two steps are finished, the Human Machine Interface is ready to use, the button “RUNNING” appears.

Until the connection is established correctly (button “RUNNING / NO COMMUNICATION” stay in the state “NO COMMUNICATION”), no action can be performed except clicking on the “EMERGENCY STOP” button.

4.1.2. PARAMETERS SECTION

The main part of the screen is composed of four sections where the operator can monitor and edit different parameters of the digital PID controller:

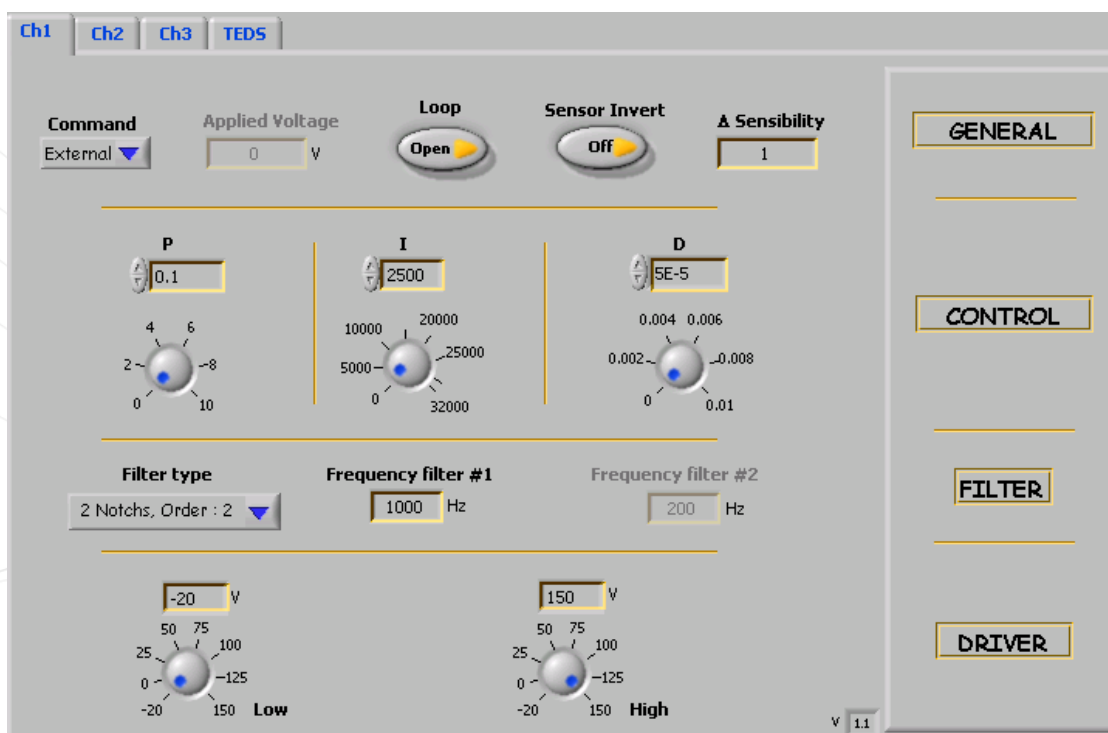


Figure 12: Right section of the HMI: parameter section

GENERAL:

- **Command** is a selector to choose between two possible command sources for the actuator:
 - **Internal:** In this case the command is issued from the **Applied voltage** command. The operator can select the voltage that he would like to send to the actuator from -1 to 7.5 Volts.

- **External:** In this case the command is issued from the Input BNC connector of the CA45 to command the actuator. This command must be adjusted between -1 and 7.5 Volts.
- **Applied voltage** command is used to send to the actuator directly a static command in Volt between -1 and 7.5V.
- **OL/CL** is a command to close or to open the control loop: OL indicates that the controller works in open loop and CL indicates that the controller works in closed loop (i.e. the regulator is on with the parameters set in the control section)
- **Sensor Invert** is used to invert the sensor's data.
- **Δ Sensibility** is used to attenuate/ amplify the sensor feedback signal.

CONTROL:

- **P, I, D** commands adjust the PID parameters
 - The **P** parameter can be adjusted between 0 and 10 by steps of $1e^{-5}$.
 - The **I** parameter can be adjust between 0 and 32000 by steps of $1e^{-5}$.
 - The **D** term can be adjusted between 0 and $1e^{-2}$ by steps of $1e^{-5}$.

The command can be sent either by rotating the button or by typing the number.

FILTER:

- **Filter type** indicates the kind of filter which is in series with the PID regulator:
 - **Low pass, Order: 2** is a filter based on a 2nd order low pass filter. In this case only the **frequency filter #1** can be changed.
 - **Notch, Order: 2** is a filter based on a 2nd order stop band filter. In this case only the **frequency filter #1** can be changed.
 - **Notch, Order: 4** is a filter based on a 4th order stop band filter. In this case only the **frequency filter #1** can be changed.
 - **2 Notches, Order: 2** are two filters based on a 2nd order stop band filter. In this case the **frequency filter #1** and the **frequency filter#2** can be changed.
 - **None** indicates that no filter is added to the PID controller.
- **Frequency filter #1, #2** are integer values and can be adjusted between 50 to 2000 Hz.

DRIVER:

- **Low** indicates the lowest value of the driver voltage output.
- **High** indicates the highest value of the driver voltage output.

The values can be adjusted between -20 and 150V.

4.1.3. FOOT OF SCREEN

It contains 6 buttons.

“SAVE PARAMETERS”, “RELOAD” and “DEFAULT” buttons aim to manage different sets of parameters.

The rightmost button “EMERGENCY STOP” ends the software execution.

4.2. SUMMARY

Each parameter is summarized in the following table including their status.

Name	Range
Connection Section	
COM	1 to 12
Parameters Section	
Command	Internal: Command from HMI / External: Command from BNC
Applied Voltage	-1 to 7.5V in Internal mode
OL/CL	OL: Open loop / CL: Closed Loop
Sensor Invert	On : data's sensor invert / Off : data's sensor not invert
Δ Sensibility	0 to 10 - resolution 1e-5
P	0 to 10 - resolution 1e-5
I	0 to 32000 - resolution 1e-5
D	0 to 1e-2 - resolution 1e-5
Filter type	Low pass, Order : 2 Notch, Order : 2 Notch, Order : 4 2 Notchs, Order : 2
Frequency filter #1	Frequency of the filter number 1 - 50 to 2000Hz

Frequency filter #2	Frequency of the filter number 2 – 50 to 2000Hz
Low	-20 to 150V
High	-20 to 150V
TEDS	Not available in ACV kit
Serial Number – UC45	
Channel – UC45	
Sensor	SG75/ECS75
Serial Number of sensor	
Last Calibration	DD/MM/YYYY
Calibration Period	month
SNR in dB	
Low cut off frequency	at -3dB in Hz
High cut off frequency	at -3dB in Hz
Calibration for SG75	Strain Gages gain ($\mu\text{m}/\text{V}$); Amplifier Gain (V/V); System Gain ($\mu\text{m}/\text{V}$)

Calibration for ECS75:	Gain in $\mu\text{m}/\text{V}$; Linearity error in %
General command section	
RUNNING / NO COMMUNICATION	Displays the state of the communication between the PC and the boards.
SAVE PARAMETERS	Saves the parameters displayed on the screen.
RELOAD	Calls back the parameters from the SAVE PARAMETERS action.
DEFAULT	Calls back initial parameters.
HELP	Displays a short form of the user manual
LOCAL / REMOTE	REMOTE: The USB link is disabled and the HMI is disconnected from the UC45 controller / LOCAL: The USB link is enabled and the HMI is connected to the UC45 controller
EMERGENCY STOP	Stops the software

5. OPERATING MODE OF THE EDUCATIONAL KIT

5.1. ELECTRO MAGNET OPERATION

5.1.1. INTRODUCTION

The beam oscillates under the action of the electro magnet mounted on the protective tube. The frequency and amplitude of the oscillations are determined by the input signal supplied to the electro magnet driver.

The operator can apply a sine or square signal to the electro magnet driver. The operator should apply maximum 1.4V to avoid damaging the electronic driver.

The electro magnet is powered with a current driver able to provide +/-30V maximum voltage.

The vertical position of the electromagnet can also be adjusted by sliding it along the protective tube.

When performing a frequency sweep, the user should take care to select a low amplitude signal to take into account resonance phenomena.

5.1.2. FIRST TIME OPERATION

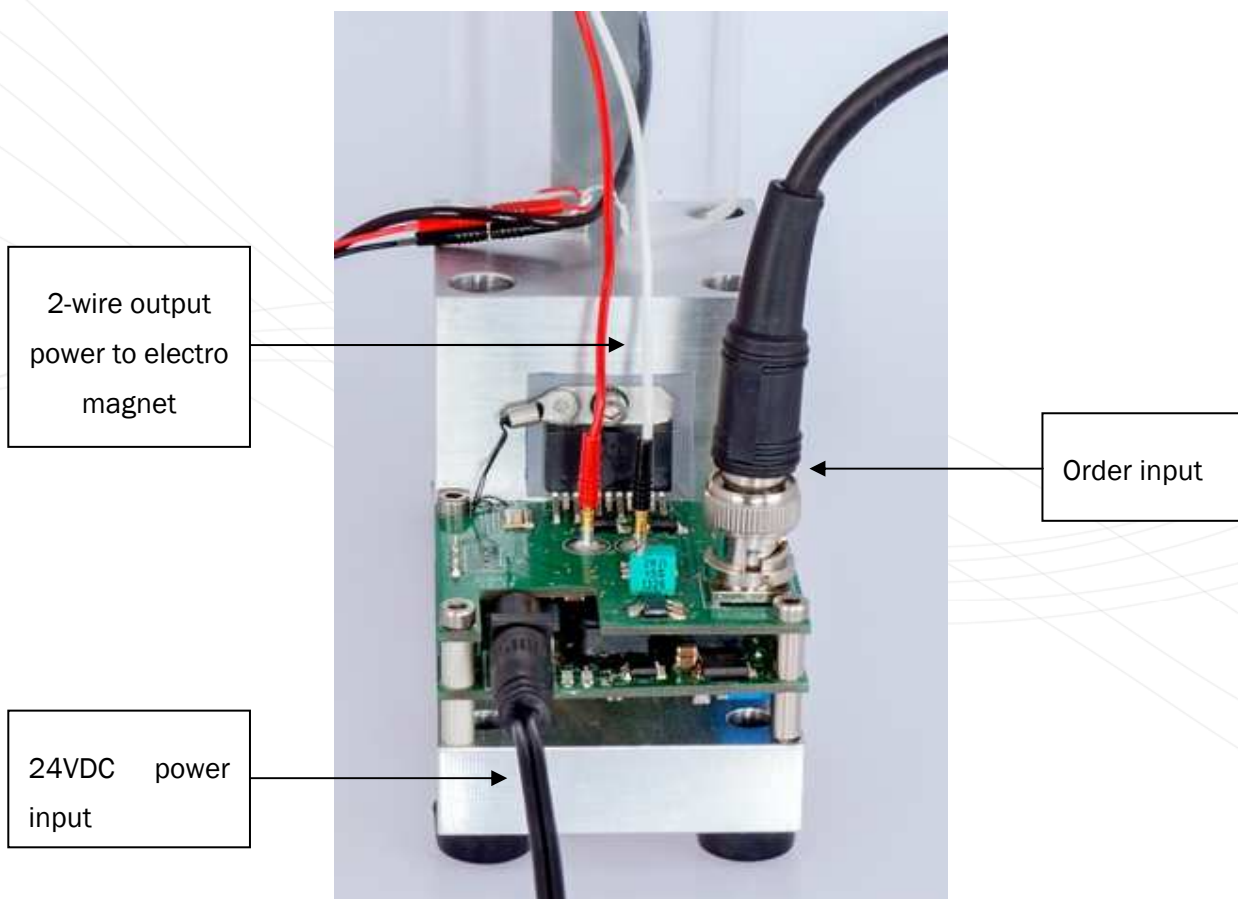


Figure 13: Electromagnet driver connections

Setup the excitation according to the picture above:

- Slide the electro magnet near the top end
- Check the banana wires of the electro magnet are plugged on the electromagnet driver output (no polarity)
- Plug the 24v power adaptor to the electromagnet driver
- Set the low frequency generator output to 1V peak to peak, 9.5Hz sine (for 1st mode excitation) and connect it to the BNC electromagnet driver input
- Fine tune the frequency to the resonance and adjust amplitude to obtain steady oscillations of the beam without beam collision.

5.2. SYSTEM CONTROL

The system controls and damps the vibrations of the beam.

The input of the electronics (reference signal) is set to null. That means no signal on BNC input if “External command” is selected, or “0” in the “Applied voltage” input field if “Internal command” is selected.

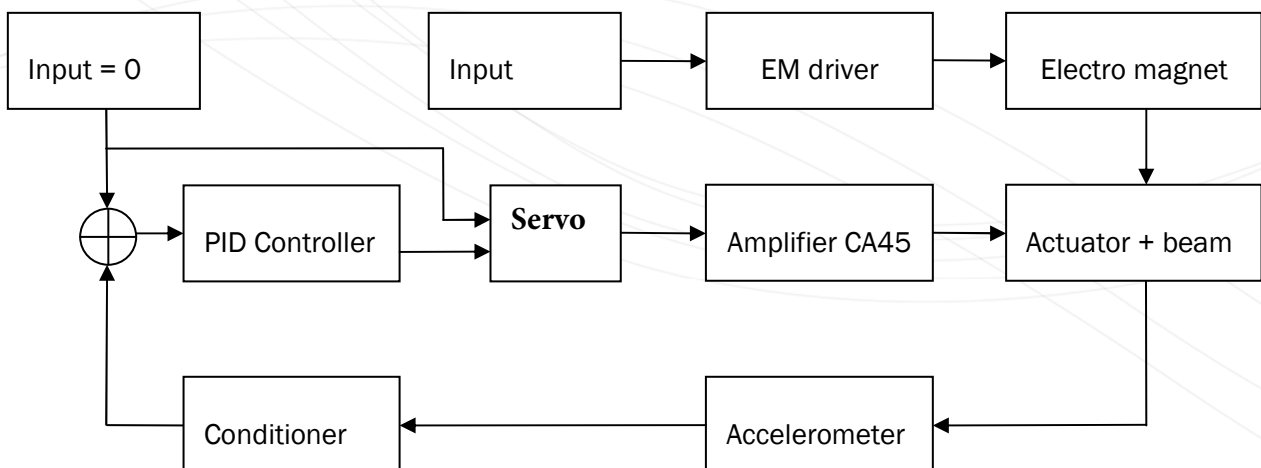


Figure 14: schematic of the system

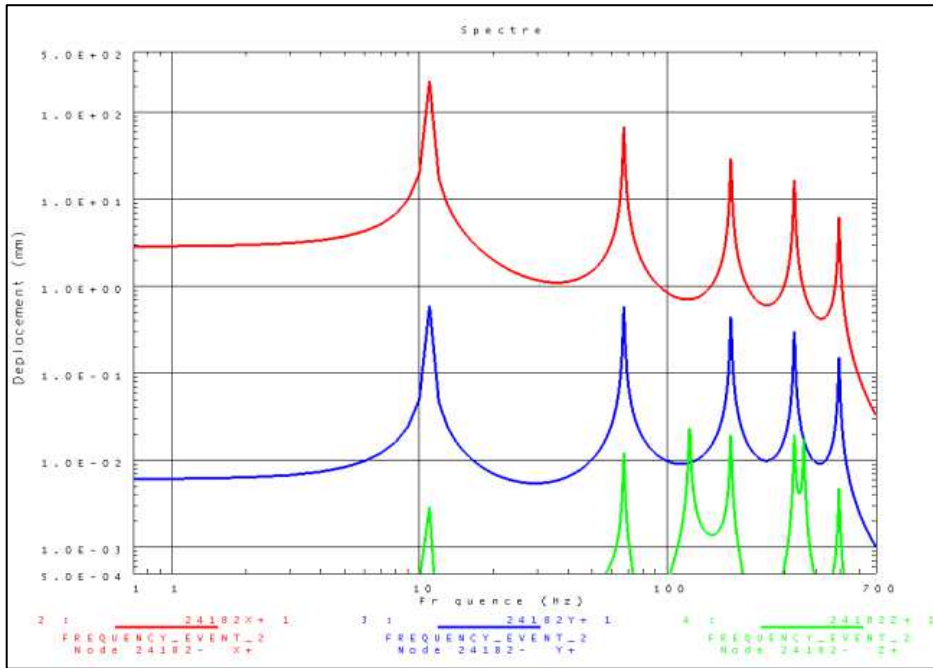


Figure 16: frequency response of the beam

Depending on the signal type, the excitation of one or more modes is possible. The control will reduce the oscillations amplitude if the modes are in the tuned bandwidth, mainly by adjusting the I parameter.

6. WARRANTY CONDITIONS AND EXCEPTIONS

The equipment is warranted for a period of one year from the date of shipment, including parts and labor, and only under standard technical conditions as outlined above and expressly mentioned in the technical data sheet. Repairs will be carried out at Cedrat Technologies or through your vendor. During the warranty period, Cedrat Technologies will, on its own initiative, either repair **or** replace products which prove to be defective.

Interventions or attempts to service or repair the actuators or electronics by any unauthorized persons will invalidate this warranty.

In addition, this warranty will not apply if the actuator is subjected to any of the following:

- improper handling, including, but not limited to, shocks and abrasions
- improper installation, including, but not limited to, excessive mechanical forces and moments, failure to use the standard electrical and mechanical interfaces
- excessive voltage, including, but not limited to, peak values outside the recommended operating range, DC values applied for excessive time periods
- inappropriate environmental conditions, including, but not limited to, high temperatures or high humidity
- attempt to modify the standard electrical connection of the APA (soldering out of electrical wires, plugs change,...) or the standard mechanical interfaces

No other warranty is expressed or implied. Cedrat Technologies specifically disclaims the implied warranties of merchantability and fitness for a particular purpose

7. INSPECTION UPON RECEIPT

This product has been inspected and shown to operate correctly at the time of shipment, as verified by the Factory Verification form that accompanies the actuator.

Immediately upon receipt of the product, it should be inspected carefully for any signs of damage that may have occurred during shipment. If any damage is found, a claim should be filed with the carrier.

The package should also be inspected for completeness according to the enclosed packing list. If an order is incorrect or incomplete, contact your distributor.

8 . AFTER - SALE SERVICE

If a device requires service, please contact Cedrat Technologies or your local vendor. Please include the device model and serial number in all correspondence with Cedrat Technologies or your vendor.

9 . ANNEX 1 : TROUBLE SHOOTING FORM

In case of trouble or breakdown with the piezo actuator,

- please check the electrical impedance (capacitance and insulation resistance) of the actuator and communicate it to your vendor.

This form must be completed by the customer in order to :

allow Cedrat Technologies to authorize the product return back to the factory,

help Cedrat Technologies in repairing it.

Product: Please give mention here the references and delivery date,

History: Please summarize here every action which has been performed with the device since the delivery,

Problem description: Please describe here the problem