

FSPA35XS

## USER MANUAL

Version: 1.2

Date: 05/04/2019



## I. CAUTION: READ BEFORE OPENING

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

This driver board is dedicated to multilayers piezoelectric actuators.

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

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

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## II. GENERAL

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Piezoelectric Actuators from CEDRAT TECHNOLOGIES SA consists in a wide range of actuators, divided in four categories:

- Multilayer actuators, that are not mechanically prestressed,
- Parallel prestressed actuators, that are mechanically prestressed multilayer actuators and offer mechanical interfaces,
- Amplified piezo actuators, which use an elastic amplifier to both prestress the multilayer actuator and amplify the displacement.
- Piezoelectric Motor, using Cedrat Technologies actuators to perform millimetric stroke.

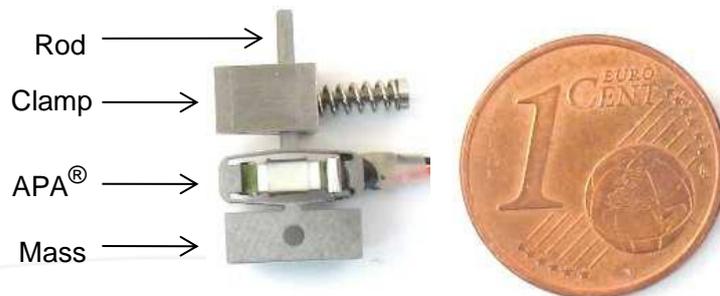
Piezoelectric Actuators must be handled carefully. Lifetime of Piezoelectric Multilayer actuators is not limited by wear. They can perform millions of cycles without loss of performance provided they are operating under suitable conditions.

The lifetime of a Piezoelectric Multilayer Actuators is a function of many combined parameters; the most influencing being the applied voltage, the temperature and the humidity. For maximum lifetime, operating voltage should be minimized, especially when they are used in static conditions.

## III. FINE STEPPING PIEZOELECTRIC ACTUATOR PRINCIPLE

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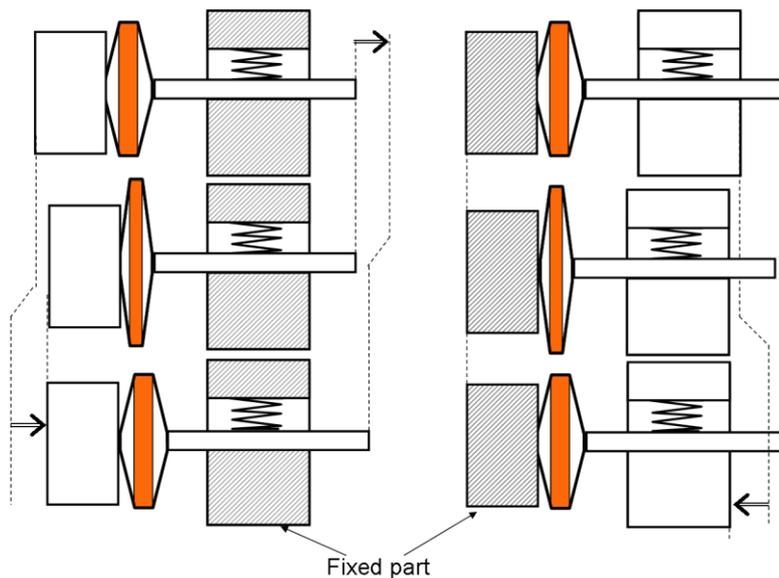
Fine Stepping Piezoelectric Actuators (FSPA®) are inertial stepper motors. Stepping Piezoelectric Actuators (SPA) are formed of only four parts (Figure 1): An Amplified Piezoelectric Actuator (APA®), a front mass, a clamp and a rod.



*Figure 1 SPA30uXS components*

The principle of such motors relies on stick-slip effect and dissymmetrical accelerations. Figure 1 shows the two phases needed to produce one step. By repeating this operation, stroke of several millimeters can be reached.

The opposite motion is done by inverting the two sequences. This motion is called “Stepping Mode”. The load can be fixed on different positions leading to two different motor capabilities according different modes.



*Figure 2 Working principles for 2 different configurations*

SPA Linear and rotating configurations have been developed. However, some applications may be limited by unpowered holding forces. The FSPA® exploits mechanical architecture in order to decouple external forces from the motor actuation force. Fine displacement resolution and large actuation force can be achieved.

## IV. THE FSPA35XS AND ITS DRIVING BOARD SPC45

### IV.1. DRIVING PRINCIPLE

The FSPA35XS is a one axis linear motor. It allows a minimum 5 mm stroke with mechanical end stops. Typical driver is the SPC45 board. The SPC45 controls the FSPA35XS and is configurable with a Graphical User Interface (GUI) through a USB plug. It is possible to add an incremental magnetic sensor to achieve a closed loop control of the motor. The input command can be done with the GUI or with an analogical signal (0..5V).

**WARNING! The FSPA35XS and its driving board SPC45 have no connection to the earth. There are serious electrical risks if the user reaches any part of the mechanism during and after working. It is up to the user to provide a ground connection of the product.**

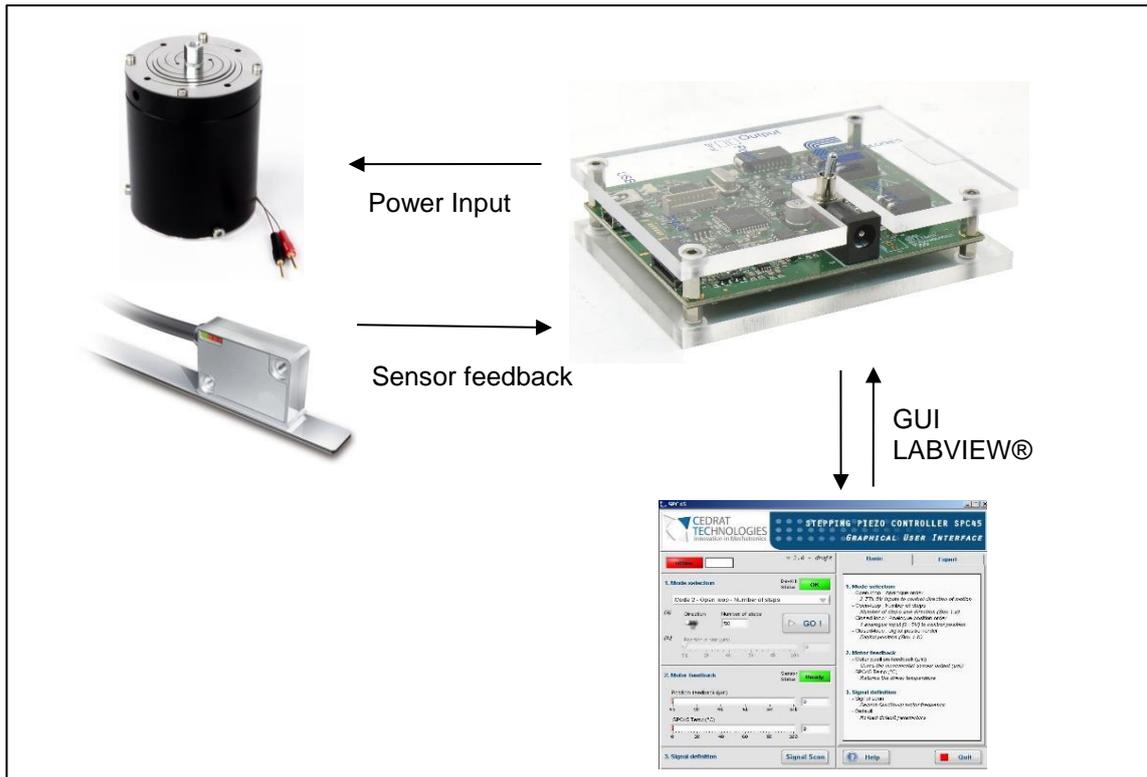


Figure 3 Synoptic of the FSPA35XS driving

## IV.2. FSPA35XS DESCRIPTION

### OVERALL

The FSPA35XS is a fine stepping piezo actuator using APA35XS. The APA® is a patented actuator from Cedrat Technologies. The FSPA® is a patented pending motor from Cedrat Technologies.

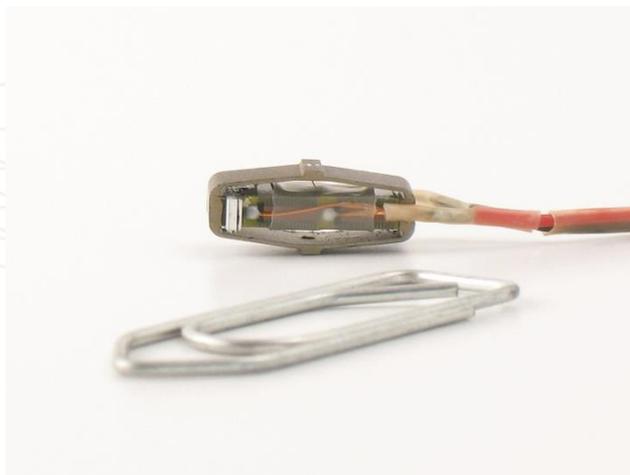


Figure 4 APA35XS

**INTERFACES**

The mechanical and electrical interfaces of the FSPA35XS are given below.

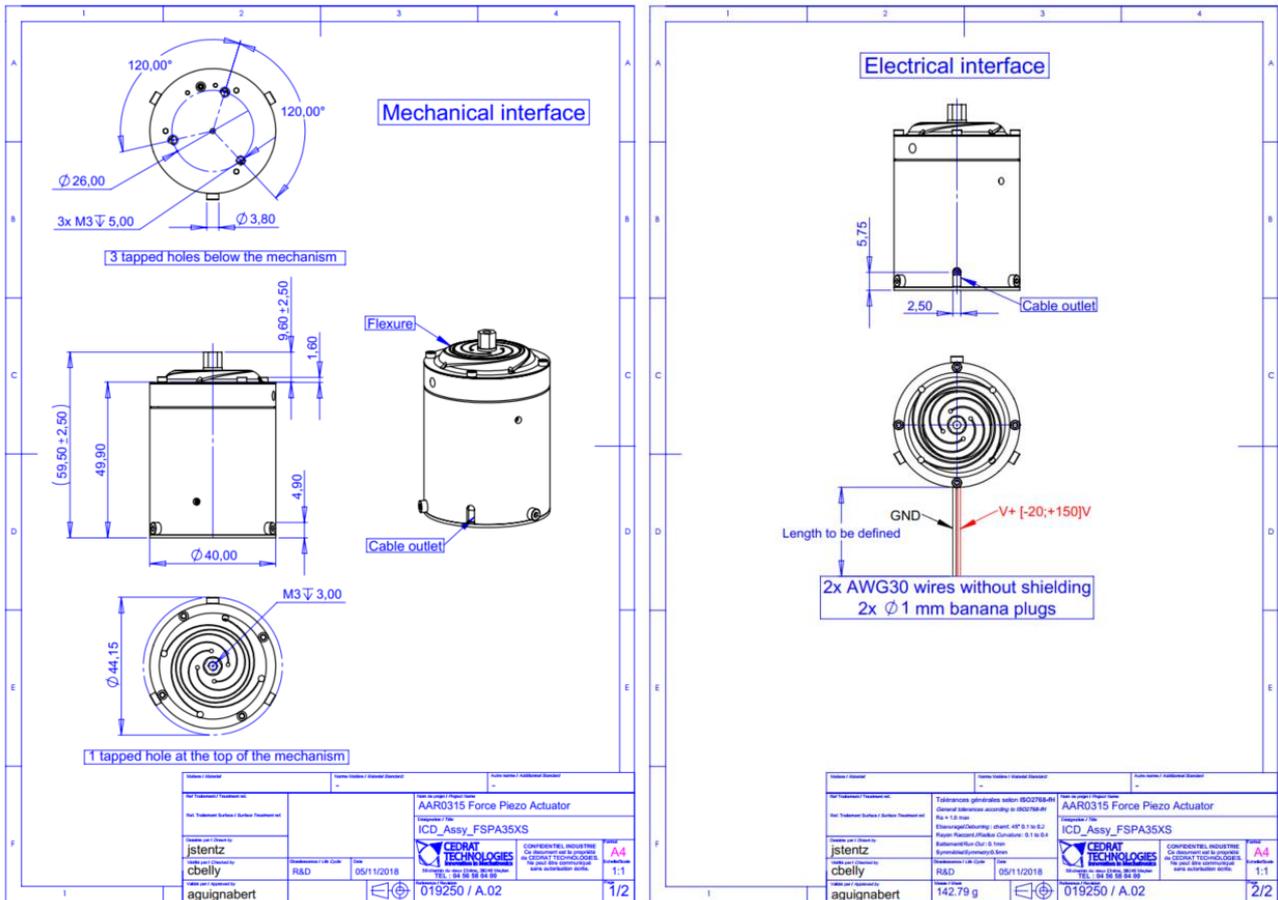


Figure 5 Interfaces of the FSPA35XS

To achieve an optimal working of the motor, it has to be clamped to a frame with the three tapped holes M3 (Figure 5 – Mechanical interface – 3 tapped holes below the mechanism).

The interface of the moving part is a M3 threaded spacer of 3mm depth. To avoid the rotation of the threaded spacer M3 (Figure 5 – Mechanical interface – 1 tapped hole at the top of the mechanism), it has to be locked with a wrench during mounting.

No sensor is integrated to the FSPA35XS, which means the motor works only in open-loop if any sensor is added by the customer.

**INCREMENTAL MAGNETIC SENSOR**

It is possible to add an incremental sensor. The magnetic sensor is supplied by a 5V voltage. Two output TTL channels are available (channels A and B) in order to be decoded to produce a count up pulse or a countdown pulse. The Index pulse is not managed by the SPC45 controller. The decoding operation is done by the proposed driver SPC45 (see §VIII.4).

This option is up to the customer, it is not available on the standard FSPA35XS.

### IV.3. SPC45 DESCRIPTION

The Stepping Piezo Controller SPC45 is the driver board of the FSPA35XS. It includes control functions, digital and analogue interfaces, and serial communication ports. The SPC45 is powered with the provided standard AC/DC adapter (24Vdc). Description of the SPC45 interfaces is given in Figure 6.

**WARNING! Be careful when plugging a cable to the SPC45 board. Connection of the input cable to the output connector (or reciprocally) could lead to severe damaging of the electronics. Always verify your connections before switching on the electronics.**

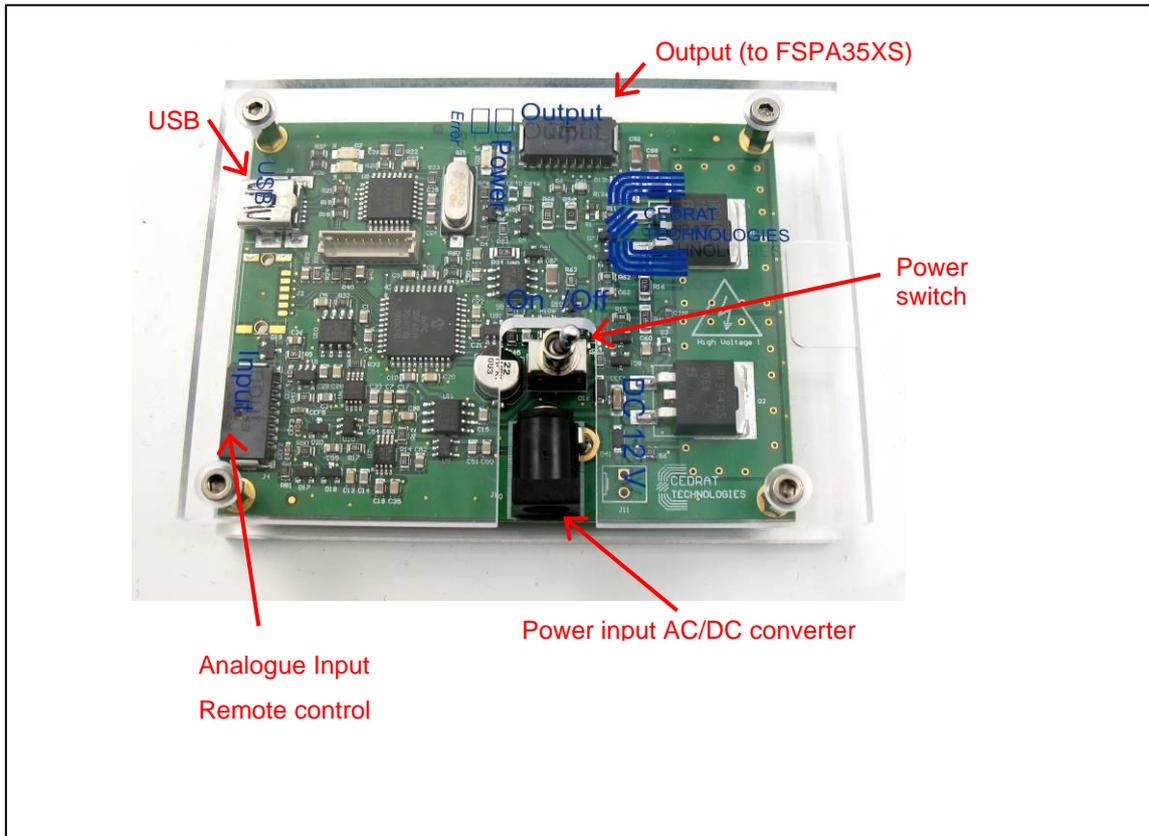
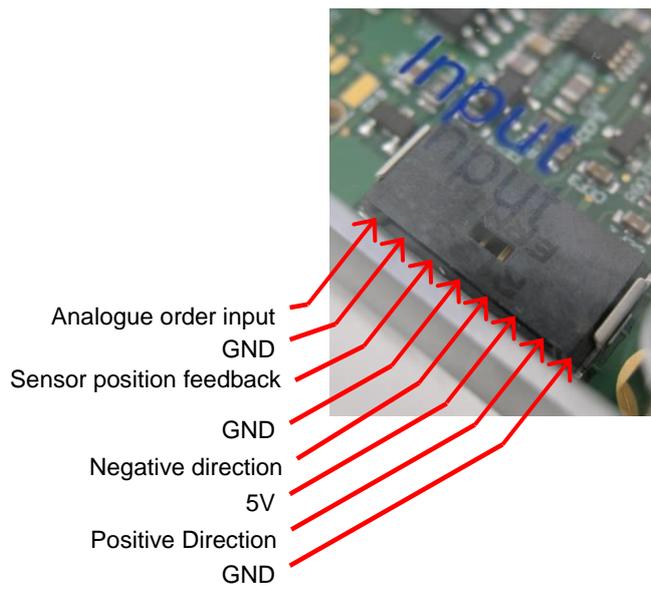
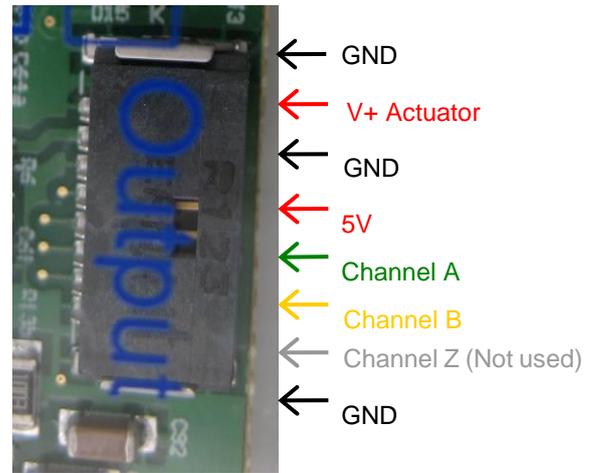


Figure 6 SPC45 description

Inputs and outputs of the board are detailed in Figure 7 and Figure 8 and detailed on Table 1.



*Figure 7 Input connector details*



*Figure 8 Output connector details*

Number	Description	Range	Nature
IN08	Analogue order input	[0 : 5 ] V	In
IN07	GND	-	-
IN06	Sensor position feedback	[0 : 5 ] V	Out
IN05	GND	-	-
IN04	Negative	TTL (0 or 5V)	In
IN03	5V	-	Out
IN02	Positive	TTL (0 or 5V)	In
IN01	GND	-	-
OUT01	GND Actuator	-	-
OUT02	V+ Actuator	[0 : 100] V	Out
OUT03	GND Actuator	-	-
OUT04	5V	-	Out
OUT05	Channel A	TTL (0 or 5V)	In
OUT06	Channel B	TTL (0 or 5V)	In
OUT07	Z index	TTL (0 or 5V)	Not used
OUT08	GND sensor	-	-

*Table 1 SPC45 port description*

Please notice that connector reference are the following one: ERNI 8b RA 1,27. Cables used are cables 1,27 mm ERNI Minibridge, 8 points.

#### IV.4. FSPA35XS PERFORMANCES

The performances presented in the following table are results of tests performed in lab conditions.

Parameter	Typical value	Unit
Actuation force	50	N
Travel range	5,2	mm
Typical min step size	< 100	nm
Typical max speed	240	µm/s
Dimensions	Ø 45 x 62	mm
Total mass	160	g

*Table 2 Performances of the motor*

#### V. ENVIRONMENT COMPATIBILITIES

Stepping Piezo Actuator has a few heritages from various environment compatibilities. Vacuum compatibility can be achieved with some precautions, with or without sensor.

Please contact Cedrat Technologies for any further information.

#### VI. GRAPHICAL USER INTERFACE

The Graphical User Interface (GUI) is built to give the user the opportunity to control the system, in open or closed-loop, but also to give feedback about system state.

##### VI.1. SOFTWARE INSTALLATION

This paragraph describes the different instructions to connect the SPC45 driver and to install the software.



Do not connect the USB driver on the PC before installing the software.

The installation is simple: Updated software SPC45 may be downloaded from Cedrat Technologies website. Please check:

<http://www.cedrat-technologies.com/en/mechatronic-products/soft-download.html>

It includes the installation of the drivers to dialogue with the SPC45 and the installer for the application software. It contains the autonomous application too.

##### REQUIRED EQUIPMENTS

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).

- Software is optimized for 1600x900 screen resolution.

FIRST TIME INSTALLATION

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

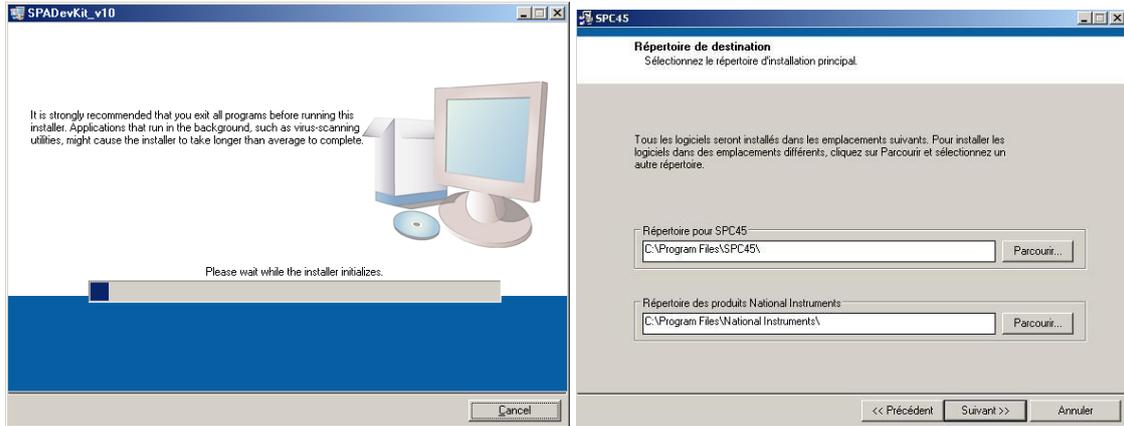


Figure 9 Destination directory

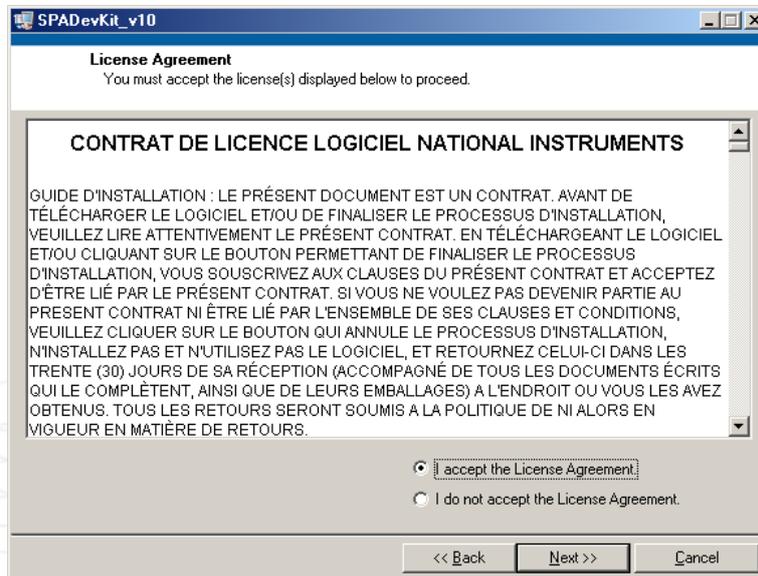
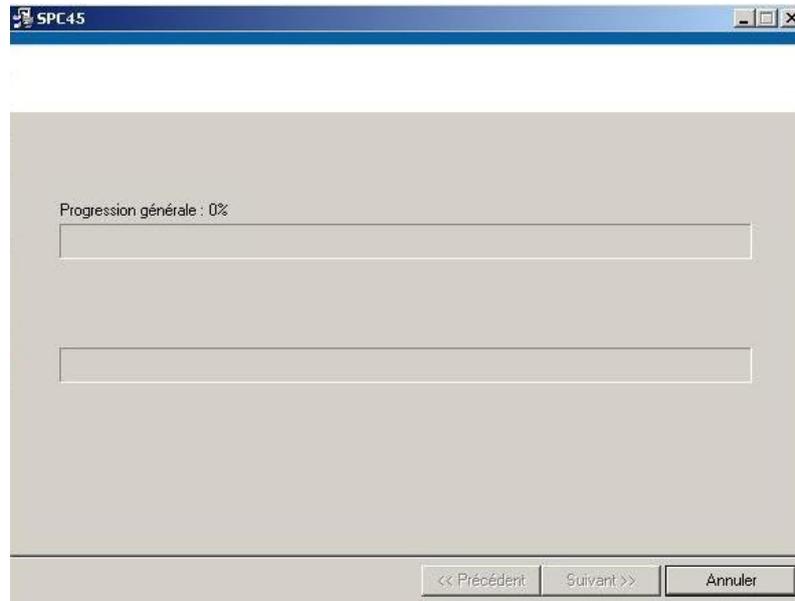
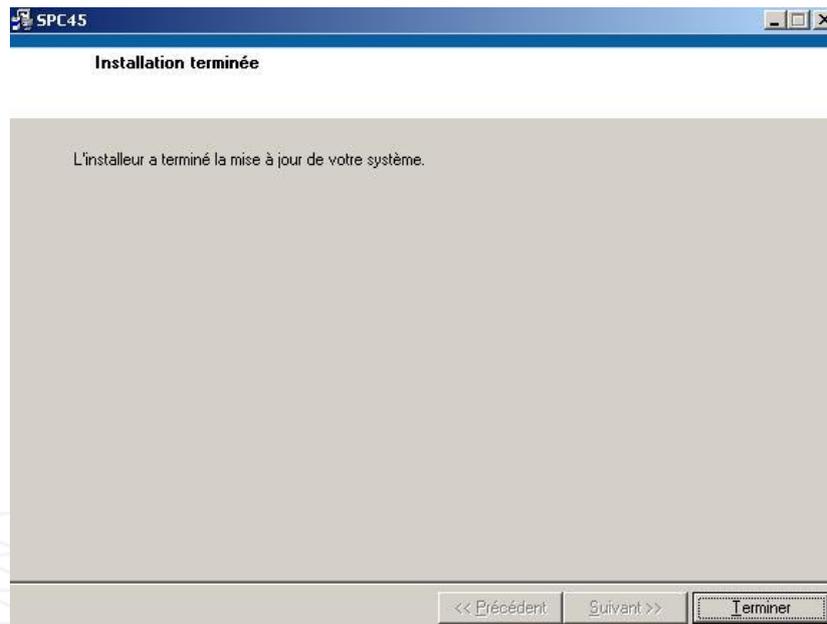


Figure 10 License Agreement



*Figure 11 Starting Installation*



*Figure 12 Installation finish*

- After this installation is finished, another driver is installed automatically. The system shall be **restarted**.
- Connect your PC with the SPC45 by USB cable and power on the driver.
- Now the operator can run the software “SPC45.exe”

VI.2. OVERALL DESCRIPTION

The control software interface is made of a few boxes.

The first one concerns the choice of the working mode of the system. Some modes need additional parameters definition, which are detailed further.

The second box corresponds to the parameters feedback from the system, and especially position.

The communication channel is automatically detected when the software starts.

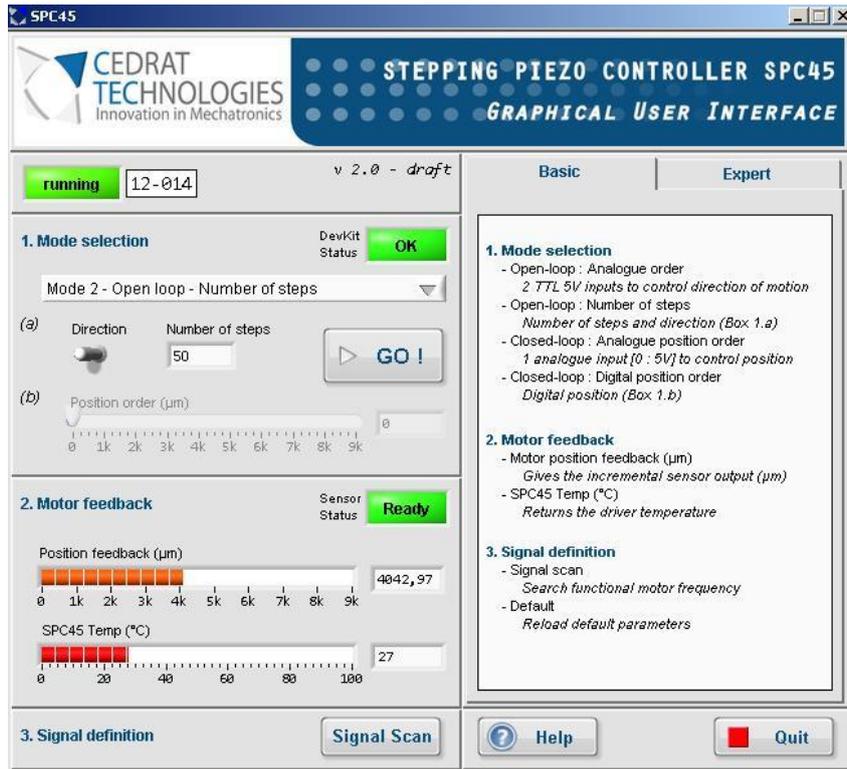


Figure 13 Graphical User Interface SPC45

COMMUNICATION

Before running the GUI, please plug the SPC45 driver, power it and connect the driver to the computer using provided USB cable.

The port COM is automatically detected by the software. If the communication is well established, the Running indicator turns green.



Table 2 Running display

If the driver is not available, not plugged, or not powered, the communication fails and status indicates “offline”. An additional warning message appears (Figure 14).

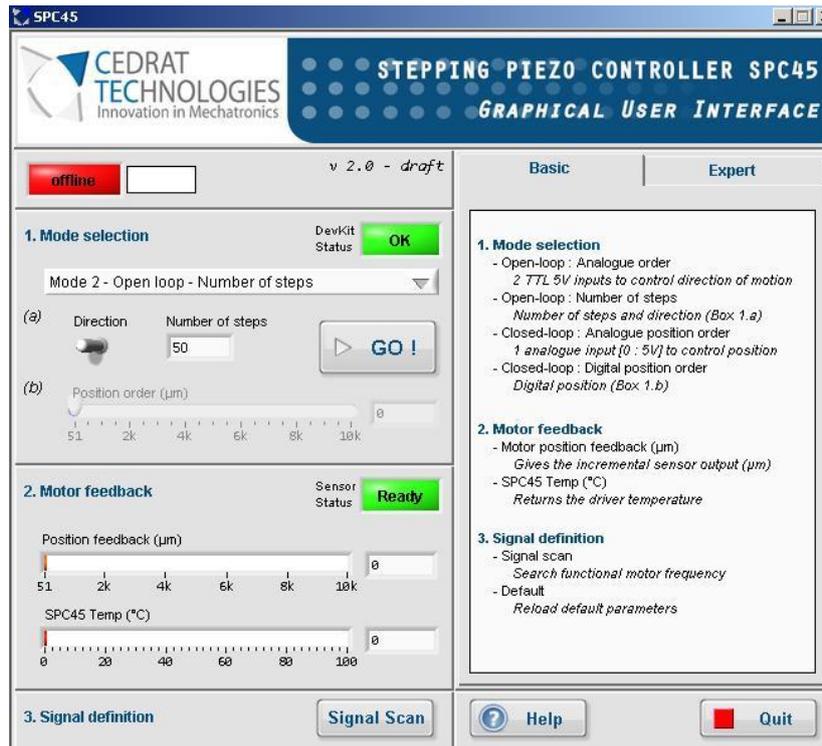


Figure 14 Waiting message

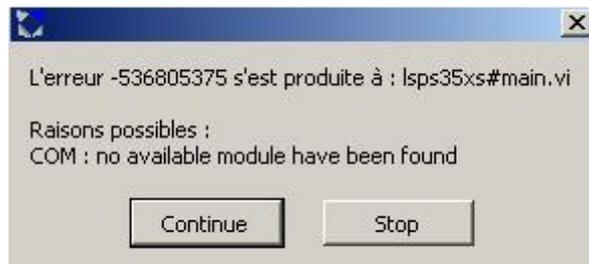


Figure 15 Communication error

If this problem occurs, you have to restart the software ensuring to connect the USB cable correctly and to power ON the SPC45 before launching the SPC45.exe.

## LOAD CONFIGURATION

The Graphical User Interface SPC45.exe can be used for several products from Cedrat Technologies. Consequently, it is needed to load the default configuration of your system item. For that, go into the "Expert" mode:



Figure 16 Expert mode

Click "OK" on the warning message

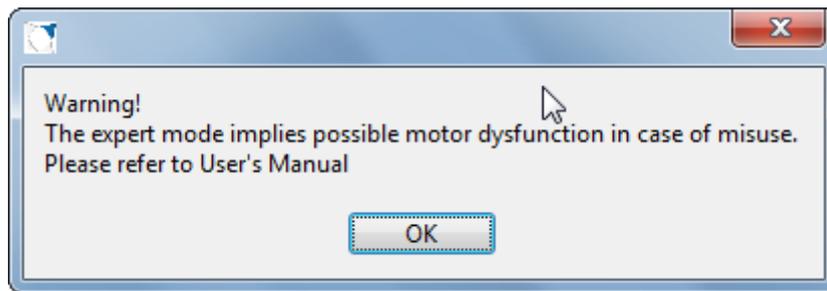


Figure 17 Warning

Click on "Load":

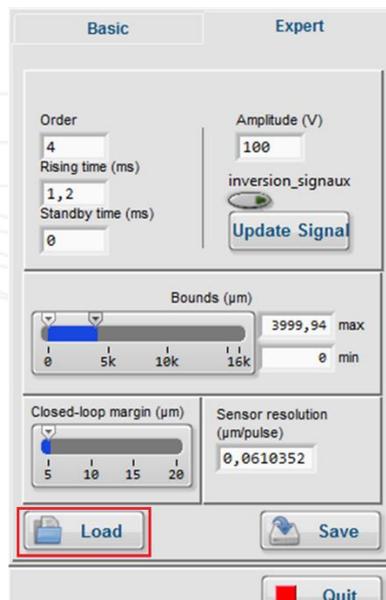


Figure 18 Graphical expert mode

Select and Open the file “xxxxConfigDefault” corresponding to your product:

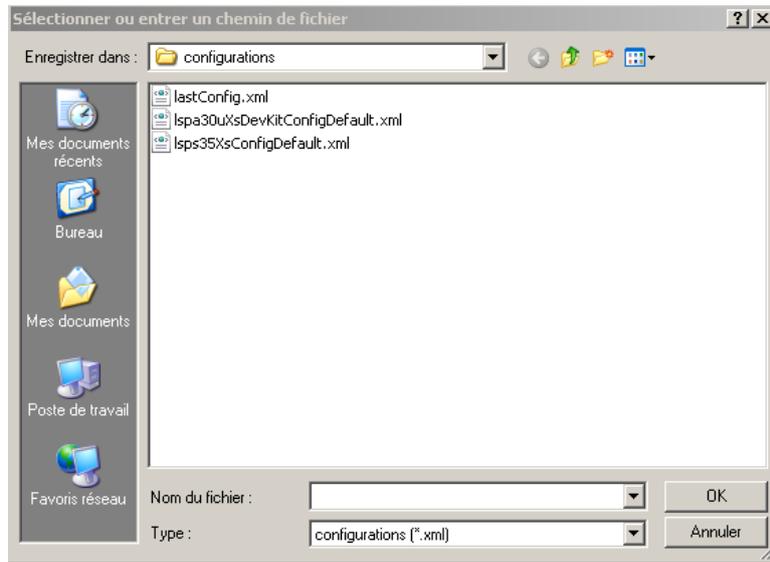


Figure 19 Folder selection

The GUI is now configured for your product. Leave the expert mode by clicking back on “Basic”:

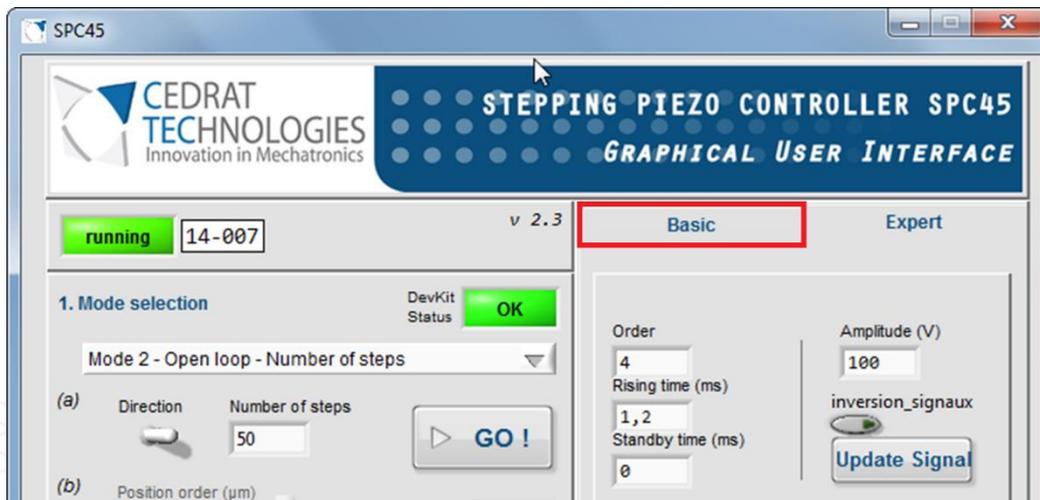


Figure 20 Basic mode

The GUI is ready to be used with your product.

#### MODE CHOICE

The user interface allows the user to choose the working mode. Each of them is detailed further.

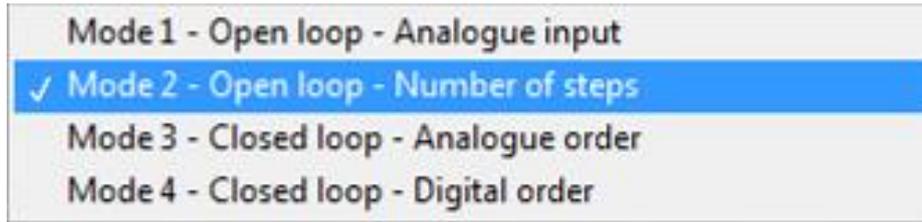


Figure 21 Mode choice

#### MODE 1: OPEN-LOOP: ANALOGUE INPUT

Especially designed for demo purpose, this mode allows using two TTL (0-5V) inputs, in order to control the direction of the system motion. Positive and Negative direction orders are communicated with a remote control.

#### MODE 2: OPEN-LOOP: NUMBER OF STEPS ORDER

This mode gives the possibility to send to the system an order as a specific number of steps in the chosen direction. The software updates and monitors automatically the position feedback.

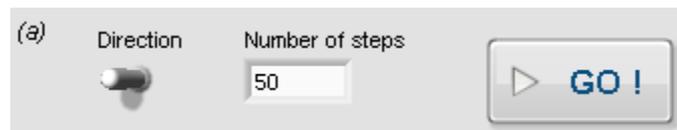


Figure 22 Direction and number of step definition

Enter Number of desired Steps, select direction and Run the motion. After the motion, the position feedback is automatically updated (see System Feedback).

#### MODE 3: CLOSED-LOOP: ANALOGUE POSITION

The “Closed-loop Analogue position” mode is available when a sensor is detected by the driver SPC45. This detection is done when the driver is turned on. If sensor is not detected, the Red LED on SPC45 driver lights.

The input range is [0 ; 5] V. The system automatically reaches the desired position.

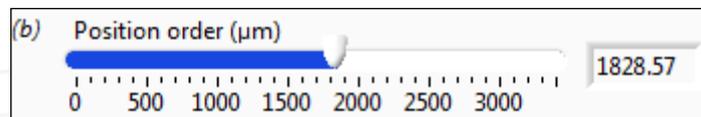


Figure 23 Digital closed-loop order

#### MODE 4: CLOSED-LOOP: DIGITAL POSITION

The “Closed-loop Digital order” mode is only available when a sensor is detected by the driver SPC45. This sensing is done when the driver is turned on. If no sensor is detected, the Red LED on SPC45 driver lights.

The desired position ( $\mu\text{m}$ ) is selected using the input bar cursor or the Digital control. Then run the system motion using RUN button. The Position feedback ( $\mu\text{m}$ ) is automatically updated after the motion.

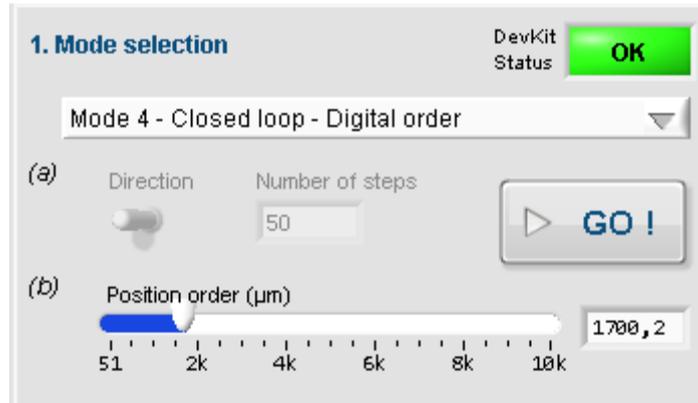


Figure 24 Closed-loop interface 1

If Mode 4 is the only mode available, please refer to § Required equipments to change regional configuration.

#### SYSTEM FEEDBACK

The user interface gives a feedback. This includes the position and driver temperature. During “Open-loop: Analogue input” mode and “Closed-loop: Analogue order” mode, system status update is done 5 times per second. This would also update values from Maintenance sheet (see §IX).

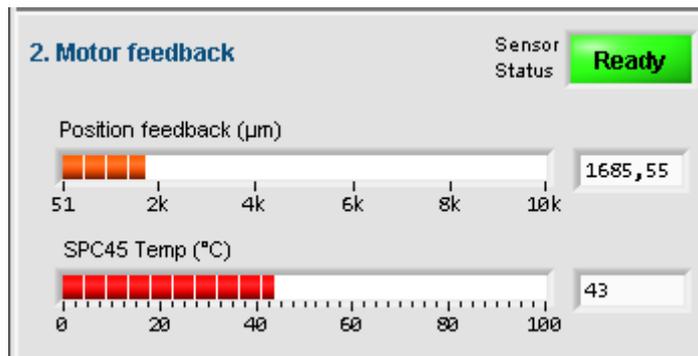


Figure 25 Closed-loop interface 2

#### MISSING SENSOR

If you are not using the provided sensor, or if there is connection problem, the SPC45 driver is not able to return position feedback from sensor. The GUI indicates a “sensor missing” message, next to the Position feedback indicator.

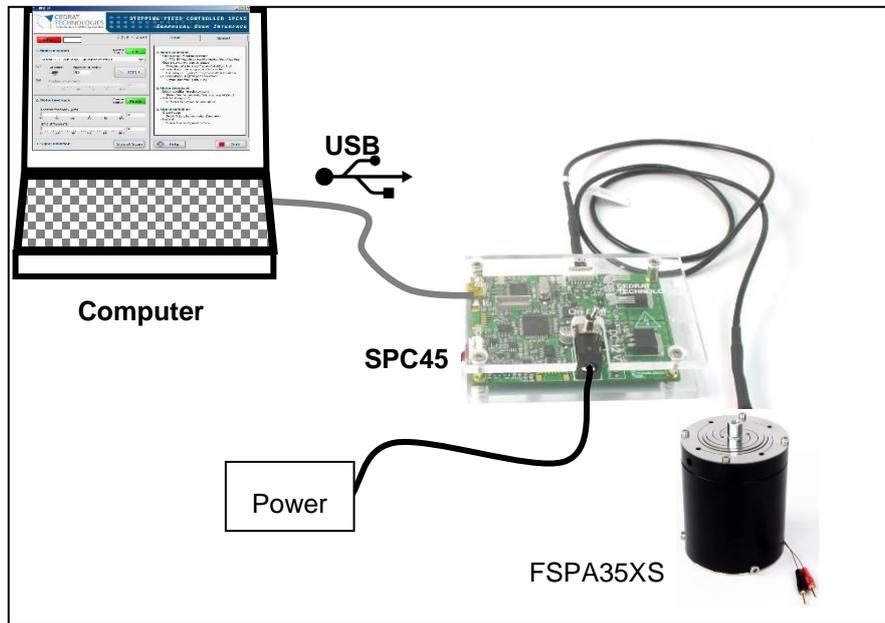


Figure 26 Sensor status

### VI.3. OPERATING THE SYSTEM WITHOUT GUI

Mode 1 and 3 (Analogue modes) are fully usable without GUI. For other modes: the SPC45 driver is commanded using serial digital inputs. Listing of the serial commands needed to communicate with the SPC45 driver may be furnished. Please contact us to get further information.

## VII. OPERATION OF THE SPC45



*Figure 27 Standard configuration*

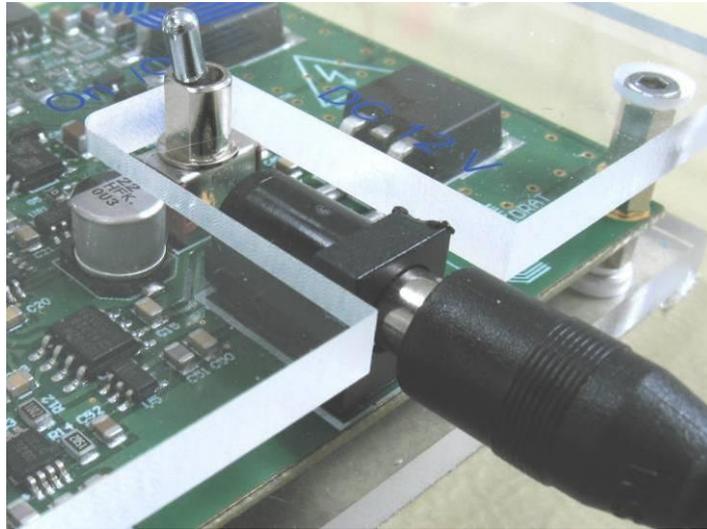
### PROCEDURE

- (01) Check the content of the delivery. If any component is missing, please contact Cedrat Technologies.
- (02) Plug the SPC45 driver to the FSPA35XS using the provided standard cable.
- (03) Plug the SPC45 driver to a computer using the provided USB cable.



*Figure 28 USB plug*

- (04) Plug the power adapter to the driver SPC45. Turn on the Power switch.



*Figure 29 Power plug*

- (05) Launch SPC45.exe. Please refer to § VI.1 to get information about software installation.
- (06) Wait for the communication between the computer and the driver is settled.
- (07) Choose the desired control mode (Open-loop - Number of steps order OR Closed-loop-Digital order). Note that the two other modes are unusable without analogue input, so they are not convenient in “plug-and-play” configuration.
- (08) Please refer to § Mode 2: Open-loop: Number of steps order and § Mode 4: Closed-loop: Digital position to obtain information about these modes way-of-working.

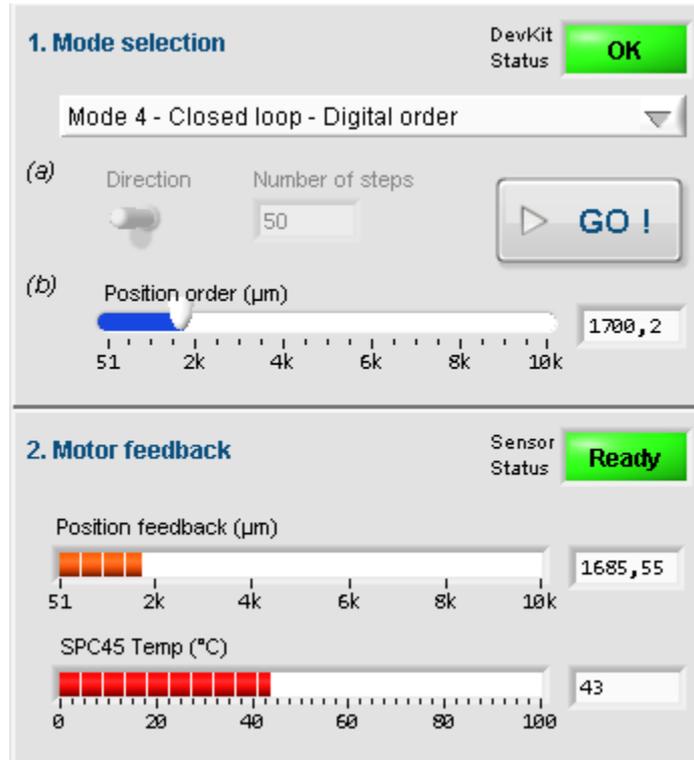


Figure 30 Software interface

## VIII. EXPERT MODE

This part details information about possibilities offered to expert, who wants to dedicate the system configuration to their own application. By the way, expert may adapt the system to fit their own mechanism specifications.

Do not try to change any of the following parameters if you are not sure to use the system in the correct way.

All of the possibilities described here are accessible by activating the “Expert Mode” tab on the GUI. When clicking on it, the following message informs you to refer to this part of the User’s Manual.

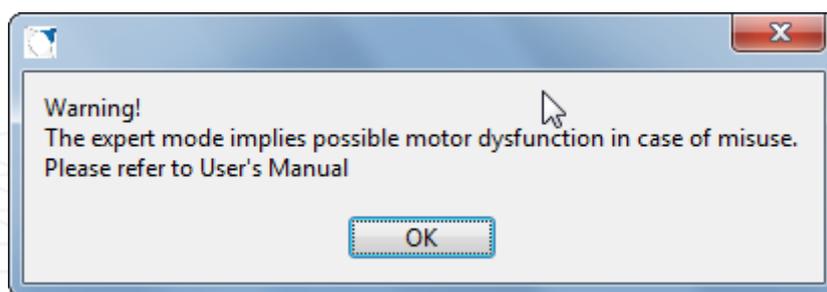


Figure 31 Warning message

### VIII.1. SYSTEM COMMAND SIGNAL DEFINITION

FSPA35XS systems are using a specific signal to generate the motion. The signal has been settled for an optimal working of the mechanism without payload. However, experts may manually improve the signal definition to improve system performances, for instance in the case of working with payloads.

The Figure 32 enables the expert to change the parameters of the system inputs signal. It consists in indicating 5 parameters defining the signal:

- Order → Degree of the polynomial rising slope
- Rising time → Time required for the signal to realise the stick/slip (up/down)
- Standby time → Dead time at constant voltage between two stick/slip steps
- Amplitude → Voltage amplitude with a highest value of 100V
- Inversion\_signaux → Signal direction (requested in closed-loop operation to fit customer implementation)

The influence of each parameter on the signal is clarified Figure 33.

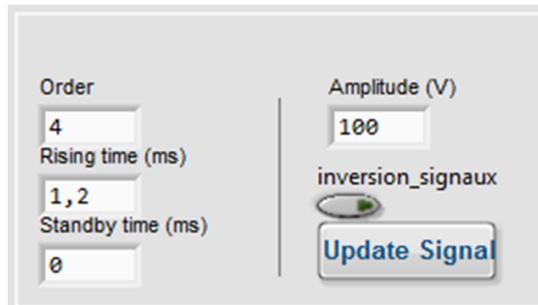


Figure 32 Signal Expert definition

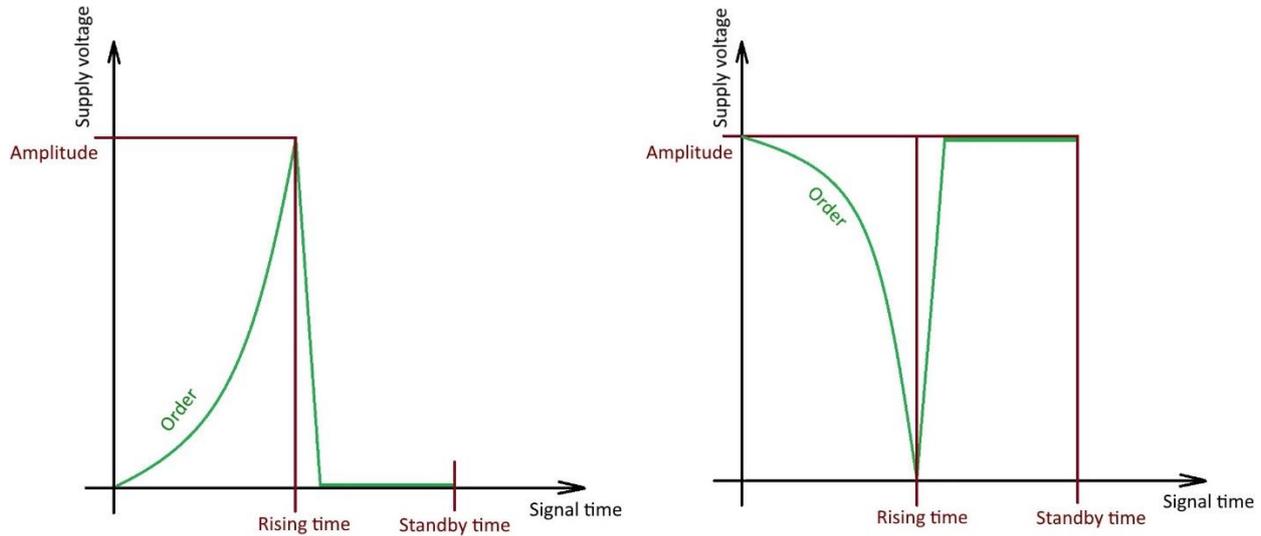


Figure 33 One step signal in the two signal directions (SPC45 driver automatically manages signal direction)

It is worth noting that because of current limitations of the SPC45 driver, discrepancies appear between the instructions and the signal output. Please refer to our catalogue for deeper understanding.

In case  $standby\ time = 0\ (ms)$ ,  $Signal\ period = Rising\ time$ , So  $Signal\ frequency = 1 / Signal\ period$ . The main rule of the frequency change is explained Figure 34. With payload, the optimal frequency decreases. According to user's payload, the signal frequency should be adapted.

“For default values set up of the “Order”, “Rising Time” and “Amplitude” parameters, please refer to the factory verification sheet delivered with the FSPA35XS model.”

According to your step resolution requirement, a trade off parameters set up may be required between the 2 different modes “Fast Displacement” and “high resolution displacement”.

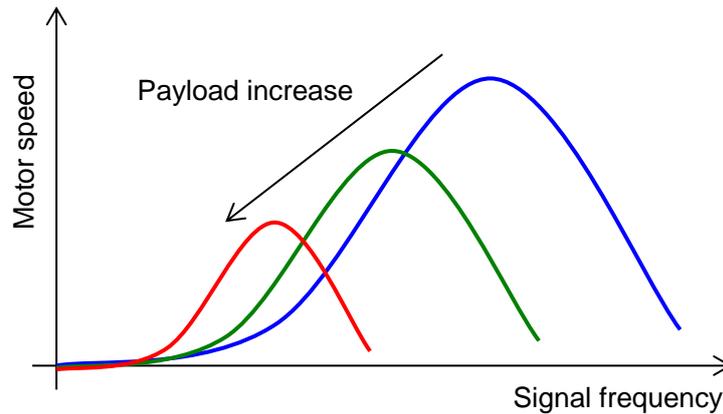


Figure 34 Example of signal frequency influence on speed for several loadings

### VIII.2. DEFINE BOUNDS

It is possible to define numeric bounds for the system. This option can be used in order to limit the motion of the system in a given window. The bounds will only be taken into account in "Mode 4 – Closed loop – Digital Order".

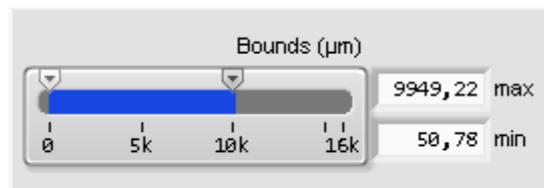


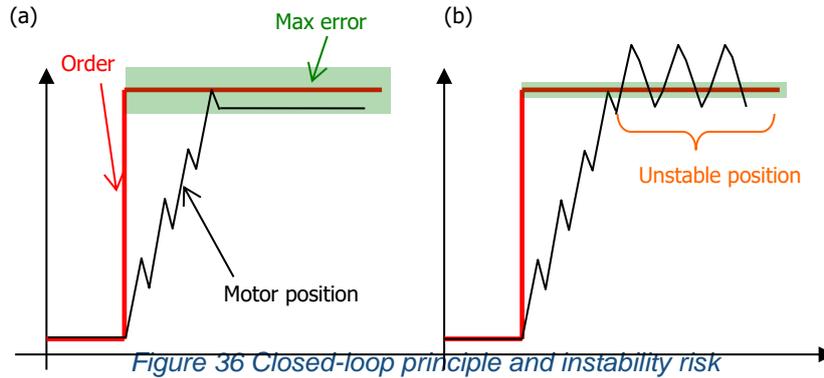
Figure 35 Numeric bounds definition

Please note that if entered bound is beyond the motor hard stop, this would lead to incorrect closed-loop behavior.

### VIII.3. CLOSED-LOOP MAX ERROR

**WARNING! Changing the value of the maximum positioning error might lead to unstable control.**

The closed-loop mode is done by an on/off control. While the error, defined as the difference between the position order and the position feedback is bigger than the max error, motion is performed. Figure 37 (a) explains this principle.



The main drawback of this control solution is the instability created by the discrete behaviour of the controller. Indeed, once the maximum error is below standard step size, the system may have major difficulties to reach the desired position. Figure 36 (b) presents an example of this situation.

The maximum error may be changed using the following cursor (see Figure 38), available at the front panel of the Expert tab.

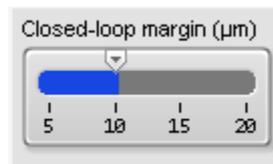


Figure 37 Max error setting

#### VIII.4. OTHER INCREMENTAL SENSOR INTEGRATION

**WARNING! When the sensor is changed, if the closed-loop control is unstable or direction of motion reversed, this might result from the inversion of the channels. Swap the channels connections and try again.**

The driver SPC45 allows interacting with any incremental sensor, using two 5V-TTL-Logic signals. Provided sensor gets a 1.95  $\mu\text{m}$  resolution. This gain, defined as the standard value is visible on the GUI (see Figure 35). It has no reason to be changed as long as the provided sensor is used.

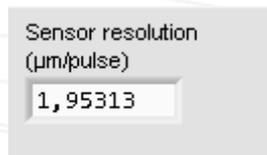


Figure 38 Sensor resolution setting

However, user's test bench may already have its own incremental sensor. In this case, sensor resolution can be changed in order to fit considered sensor resolution.

### VIII.5. “LOAD” OF “SAVE” CONFIGURATION

It is possible to load or save a given configuration thanks to the buttons “Load” and “Save”.



*Figure 39 Load or Save*

Please note that signal parameters are NOT saved within configuration. Therefore, it is recommended to record optimal signal parameters.

## IX. TROUBLE SHOOTING FORM

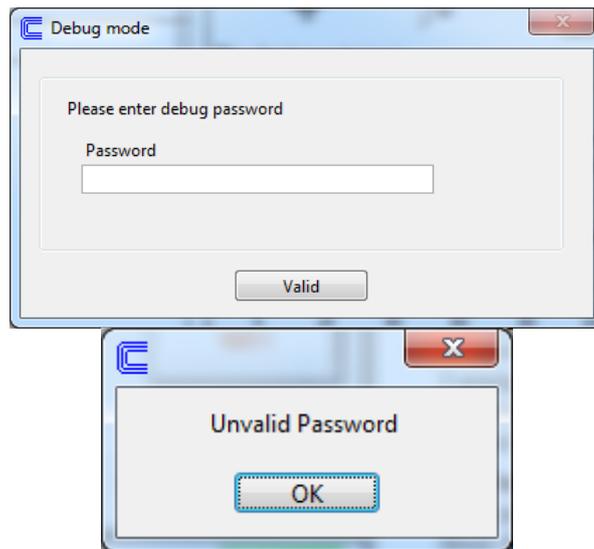
---

Error diagnostic may be helped using the following graphs. Please identify your problem and refer to the associated protocol.

Problem	Protocol
The system doesn't move when motion is requested	0
The system moves but not correctly	1
Communication with the SPC45 driver is not working	2
My problem is not fixed	3

*Table 3 Protocol possibilities*

For advanced debugging, Maintenance Tab includes information about SPC45. This Tab is locked by a password. Please contact Cedrat Technologies if you meet problems and want to unlock this Tab.



*Figure 40 Debug mode*

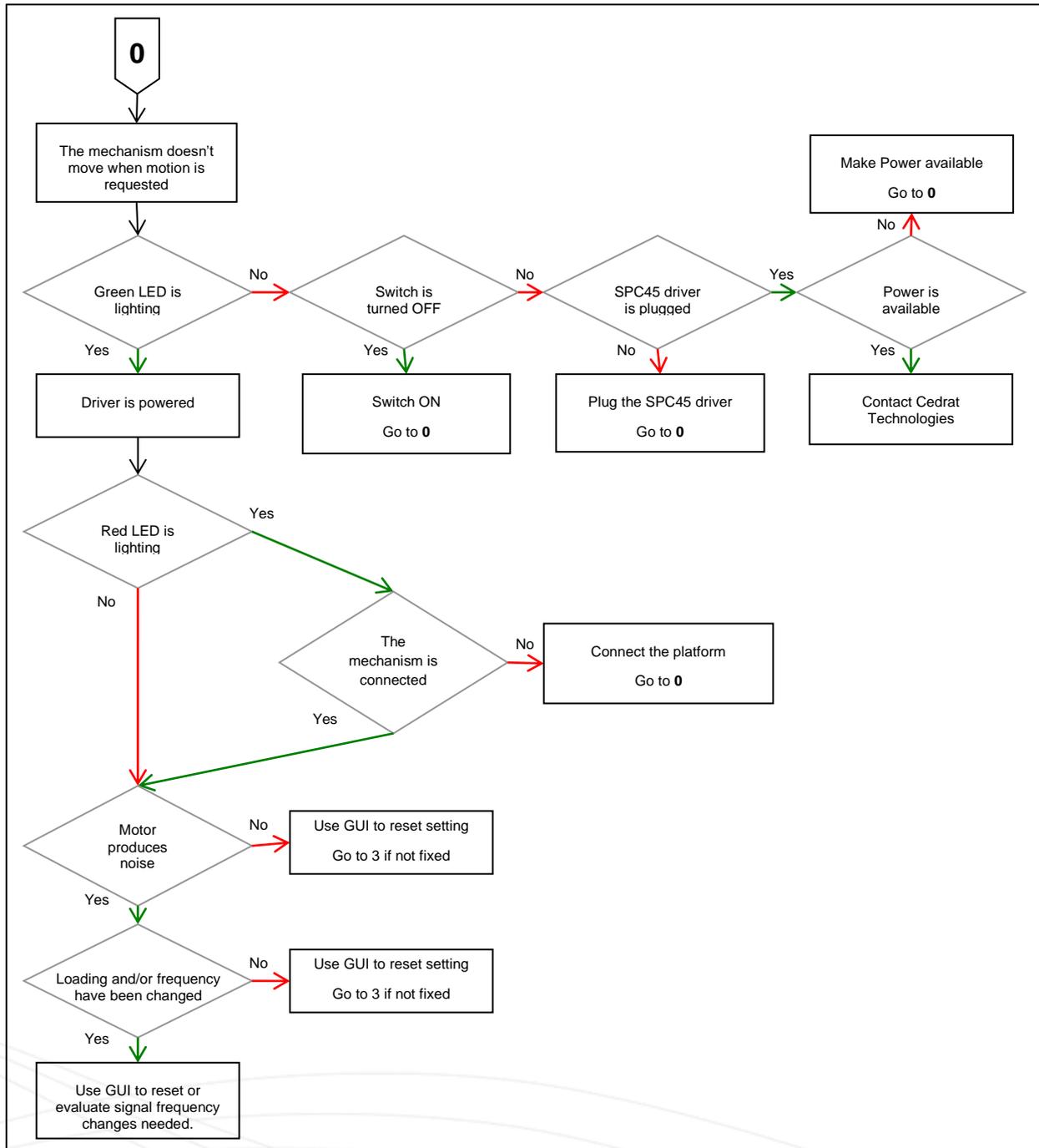
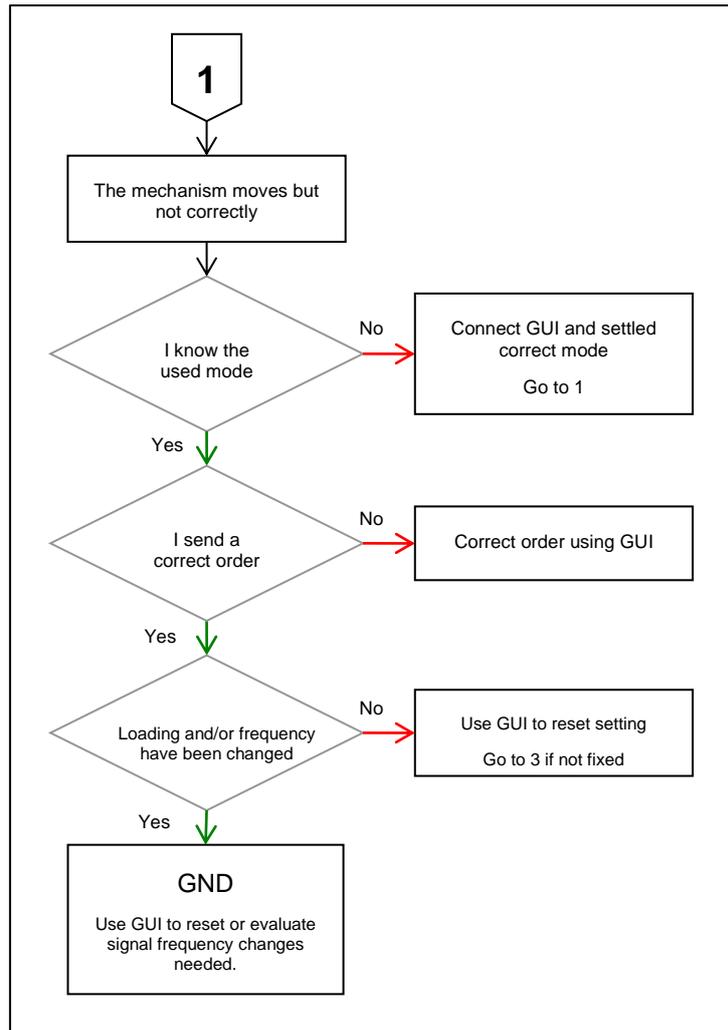


Table 4 Protocol 0



*Table 5 Protocol 1*

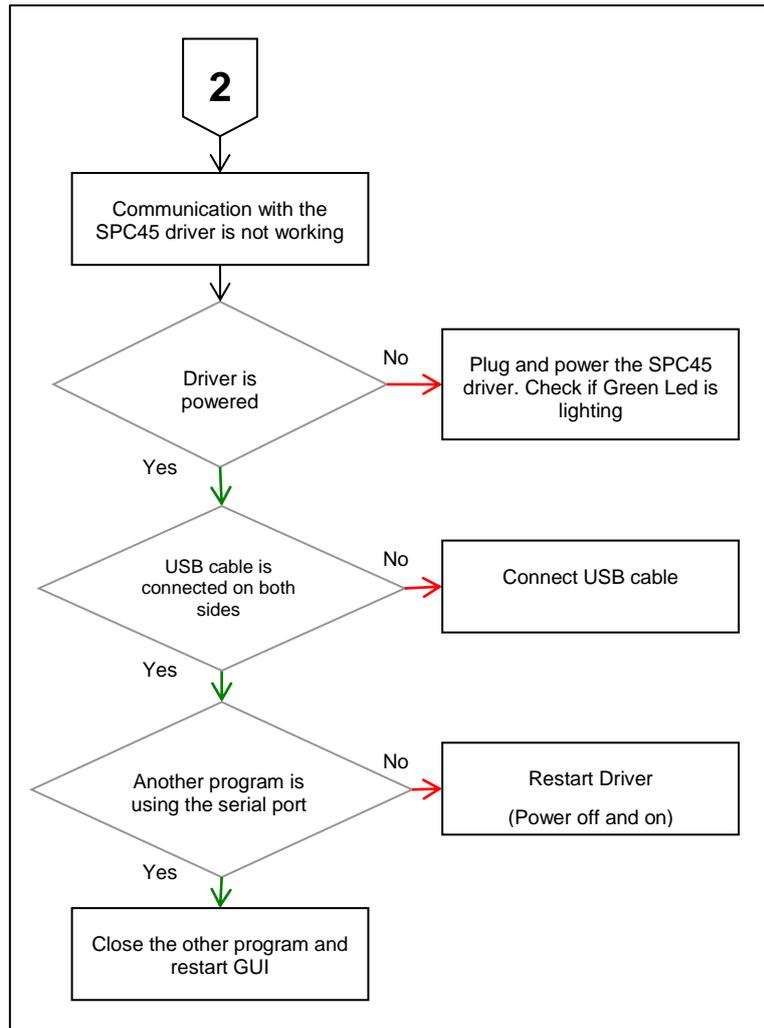
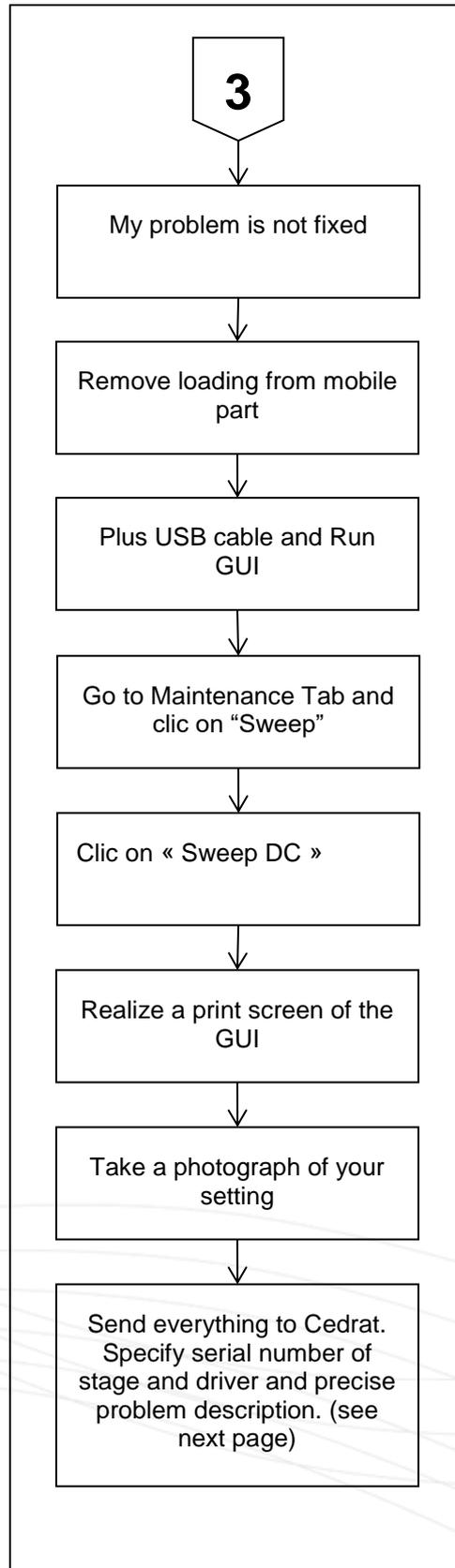


Table 6 Protocol 2



*Table 7 Protocol 3*

If you don't find the solution to your problem using the proposed trouble shooting form, please contact your vendor with the following information:

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

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

**Problem description:** Please describe here the problems faced with the electronics and which are not described in the paragraph 3,

**Notations:** Please define here the short term used for external devices plugged in the electronics in order to make the writing of "problem identification" easier,

**Problem identification:** Please summarise and describe here, using the "notations", the operation that could lead to problem identification,

**Action:** Please mention and update here every action undertaken by yourself, by Cedrat Technologies or by your local vendor,

**Please note that you need to get the authorisation from CEDRAT TECHNOLOGIES before sending back the hardware.**

## X. WARRANTY CONDITIONS AND EXCEPTIONS

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The equipment is warranted for a period of one year from 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, at its option, either repair or replace products which prove to be defective.

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

In addition, this warranty will not apply if the FSPA35XS or SPC45 Driver are 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

## XI. INSPECTION UPON RECEIPT

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This product has been inspected and shown to operate correctly at the time of shipment.

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.