

**UVEX Motors module
PF0074
User Manual**



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Introduction

The UVEX Motors module has been designed to remotely control the UVEX spectroscope, specially UVEX focusing (to get the best resolution from the instrument) and the grating angle (to select the central wavelength of your spectra). We've also added a feature to control the calibration module : calibration lamp, flat lamp, and bias & dark frames. And by the way, we've included a temperature sensor in the module. This could be use to better control the focusing.

This documentation will help you to install the UVEX motors module (see Appendix B : UVEX motors installation, page 11), and to use it. We'll also describe in the next chapter the general principles of the device.

We sincerely hope that this device will open the door to new observations with your UVEX instrument. Please share with us all your discoveries !

What is in the box ?

When you receive the UVEX Motors module, you will see these elements in the box :

- Grating motor module (#SE0254)
- Main cover (#SE0255)
- Calibration cable (#SE0259)
- Spare parts (#SE0258) :
 - 1x Focus belt cover (#TO0181)
 - 1x Grating motor base (#PU0278)
 - 1x Gear (#PI0008) (33 tooth)
 - 1x Toothed belt (#EL0285) (module 2.5, width 6mm length 120mm)
 - 1x Headless screw M3x3 (#VI0045)
 - 2x Hex head screw M4x8(#VI0009)
 - 1x Hex head screw M3x20(#VI0035)
 - 3x Hex head screw M3x12(#VI0006)
 - 1x Hex head screw M3x16(#VI0039)
 - 1x Hex head screw M3x8(#VI0007)



FIGURE 1.1 – What is in the Box

2.1 Overview of the module

The UVEX Motors module includes three main features :

- Control the UVEX focus position, to get the best resolution of your instrument. The focus tuning is usually made while taking continuous calibration frames.
- Control the grating angle, to select the central wavelength of your spectra
- Control the Calibration module, and select which light source you send to the spectroscope ('sky' for stars, 'dark' for dark and bias frames, 'flat' for flat frames and 'calibration' for calibration frames).

The control of the calibration module is almost equivalent to the SPOX¹ module. If you are using the UVEX Motors module, you don't need any SPOX device.

The grating angle can be controlled either in degrees (this is the physical angle from 0th order), or in wavelength. If you're giving orders in wavelength (which is the 'natural' way), you must first make sure that the grating density (i.e. 600 g/mm) is properly set. This is because the central wavelength for a given angle directly depends on grating density.

Once installed on your UVEX spectroscope, the UVEX Motors module looks like in fig. 2.1.

You will find 3 connectors :

- Power supply, 12V, standard connector 5.5x2.5mm (positive in the center)
- USB port, for connection to the computer (remote control)
- Calibration module control.

On the top face (in the above picture), you'll see three buttons and four LEDs for manual control. These buttons & LEDs are mainly used when installing and testing the module. Once the installation is done, the normal usage is through the computer. The LEDs will show the activity of the module, even when used remotely.



FIGURE 2.1 – UVEX with the Motors module

2.2 Some technics

The UVEX Motors module uses two stepper motors. The first one is to control the UVEX focus position and the second one to control the grating angle.

The module is controlled by a dedicated electronic board, powered by a Raspberry Pi Pico micro-controller. The connection with the computer uses the Pico USB port.

There is no "Reference Position" sensor. Instead, we permanently keep the current position of the motors in memory (as soon as the power supply is interrupted, the current position is stored in EEPROM). Then, as soon as the motors positions are calibrated, the system knows where the motors are.

The UVEX grating can rotate indefinitely : there is no mechanical stopper. The calibration consists in looking for the 0th order in the spectrum image, and once it is in the middle of the image, you can calibrate

1. SPOX is a Shelyak external device to control calibration lamps.

the position to 0°.

The focus position has a mechanical range of 8mm. In this case, there are mechanical stopper in both directions, but there is NO RISK to damage any element if you go up to these ends. The worst that can happen is to lose the calibration (this is easy to redo). The right process is then to find the best focus position, and to calibrate it to the position 4 mm (the middle of the range 0 - 8 mm).

We'll show in chapter 'Controlling the UVEX Motors module' the different ways to control it ; the most basic one is to use the 'USIS controller' software (running under Windows).

The communication between your computer and the UVEX Motors module uses the USIS protocol. This is a serial protocol fully documented. This means that if the standard elements that we provide (USIS controller software or Demetra) do not cover your needs, you can develop your own tools, with no restriction. Refer to chapter 'Appendix D : USIS protocol'

When the UVEX Motors module is installed, we keep all the access to UVEX spectroscope itself :

- 3 screws around the camera adapter ring, to tune the camera orientation.
- 2 screws to fine tune the M1 mirror angle (for an optimal optical quality)

Once the UVEX Motors module is installed, you cannot manipulate the features 'manually' (by rotating buttons). But you can still activate or tune the position of the motors with the buttons on the box (you need the power supply to be connected).

We've made possible to upgrade the firmware of the module – even remotely. More details are given in Appendix C : Updating the firmware

Note : if you only plug the USB connector, the Pico micro-controller will start, and you can exchange orders with it, but you'll not be able to move the motors (a remote order to move a motor will return an error message 'No Power Supply').

Controlling the UVEX Motors module

In this chapter, we'll see the different ways to control the UVEX Motors module. Our intention is to provide quik and easy ways for people looking for an off-the-shelf solution, but we also want to cover any special case; we know that an observatory is a assembly of many different element, and each configuration has its own constraints.

We'll start with controlling the UVEX Motors module using buttons and LEDs, because this is the first one you face when installing the module. Note that in this case, only the power supply is required (USB and calibration module connectors can be let free).

Then, the basic way to - remotely - control the UVEX Motors module is to use the USIS Controller software, that you can find on Shelyak Instruments website¹.

The most recommended configuration is to use Demetra, which includes the USIS Controller feature. The advantage is that you can control the UVEX transparently during your acquisitions.

Directly using the USIS protocol to control the UVEX Motors module is the most advanced solution. This is also the most powerful to precisely adapt the control to your own setup.

Depending on the demand, we'll work on ASCOM and INDI drivers, to easily integrate the UVEX Motors in existing software (ASCOM is for Windows, wher INDI is for Linux). Please tell us if you have any feedback on this.

3.1 Manual control

During the installation of your UVEX Motors module, or for testing purpose, you need to have a local control on the module. This can be done using the buttons and LEDs on the module itself.

There are three buttons on the top face :

- 'Select' button is to switch from one feature to the next one : 'Grating angle', 'Focus', and 'Calib module'. The selected feature is displayed by the matching green LED. When you push on the Select button, the system will switch to the next feature.
- '+/Flat' button will either rotate the motor in Up direction (when Grating angle or Focus are



FIGURE 3.1 – Buttons and LEDs for hand control

selected), or activate the Flat lamp (if Calib module is selected).

- '-/Calib' button will either rotate the motor in Down direction (when Grating angle or Focus are selected), or activate the Calibration lamp (if Calib module is selected).

The Activity yellow LED indicates that an action is on going (when a motor is rotating, or a calib change is requested).

Both motors (Grating angle d Focus) need to be calibrated the first time you use them. It can be done by pushing on 'Select' button for 5 seconds. The motor position will be then calibrated to the position '0'. The usual process to calibrate is then as follows :

1. Grating angle calibration.
 - Take continuous images of the main camera, to see the spectrum. Chose for instance 0.5 exposure time (and adapt it to see the spectrum, without saturation).
 - Select the 'Sky' light source, and make sure that some light is entering in the UVEX slit. You can also use the Flat lamp to do this (but preferably not the Calibration lamp).
 - Select the Grating angle feature
 - Move step by step the grating angle until you can see the 0th order (sharp emission line) in the middle of your image (see below).
 - Then push for 5 seconds on the 'Select' button, to calibrate the module to the position '0'.
 - The grating angle is now calibrated.

1. <https://www.shelyak.com>

2. Focus position calibration.

- Remove the Focus motor gear cover.
- Rotate the Focus axis (tightening direction) until it is mechanically stopped. Then, release the axis by an half-round.
- Select the Focus feature
- Then push for 5 seconds on the 'Select' button, to calibrate the module to the position '0'.
- The focus position is now calibrated.

Of course, when moving the motors using the buttons, you cannot see the actual position of the motors. But the module keeps this information in memory, and you can get the information from the computer when it is connected.

3.2 Remote control

Remote control of the UVEX Motors module is the usual way to work. Let's see the different possible ways to do it.

3.2.1 Using the 'USIS controller' software

The 'USIS controller' software module is available in the Shelyak Instruments website (<https://www.shelyak-instruments.com/Web/Logiciel/UsisController/>). It runs under Windows (win 10 or above). Download the setup file (the name is like 'Setup USIS Controller XXX.exe'), and run it (double-click for instance) to install it. The first step is like fig. 3.2.

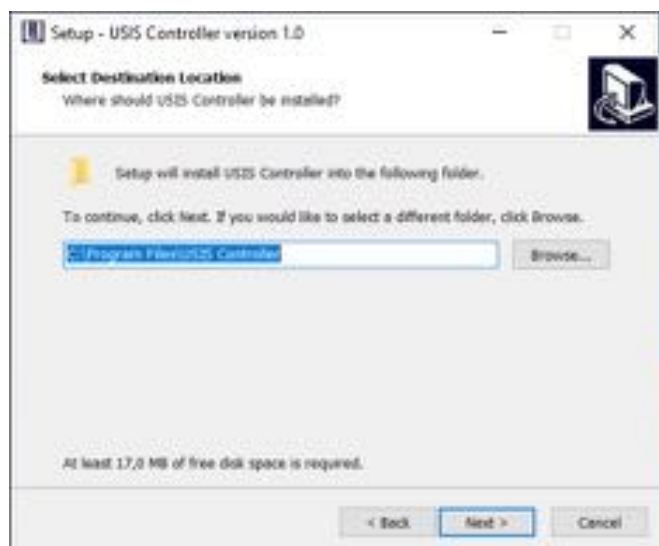


FIGURE 3.2

The software is called 'USIS controller'². You can start it by clicking on the 'USIS controller' icon. The initial window is like fig. 3.3.



FIGURE 3.3

In the 'Device' menu, select 'UVEX Motors' (fig. 3.4).

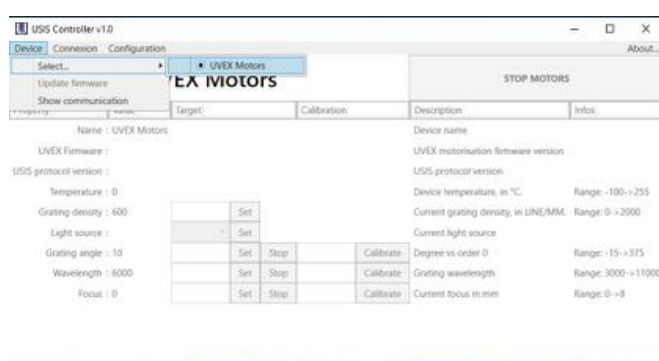


FIGURE 3.4

Then, go to the 'Connexion' menu, and select the serial port on which you've connected the USB cable for the UVEX Motors module (fig. 3.5).



FIGURE 3.5

When the configuration is made, you can click on 'Connect' button (still in 'Connexion menu', fig. 3.6).

When the connexion is done, you can see all the UVEX Motors module properties (fig. 3.7).

² We give this name because it uses the USIS protocol in a generic way. In the Future, the same software could control other USIS devices

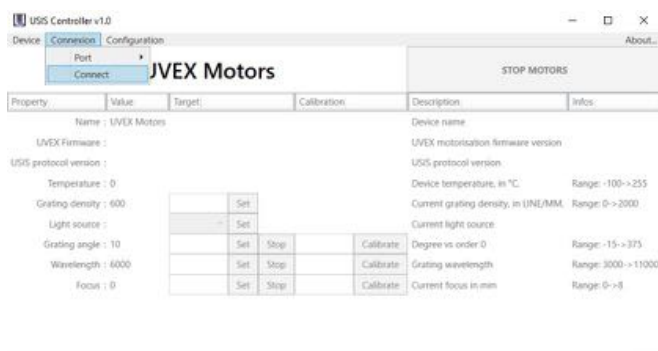


FIGURE 3.6

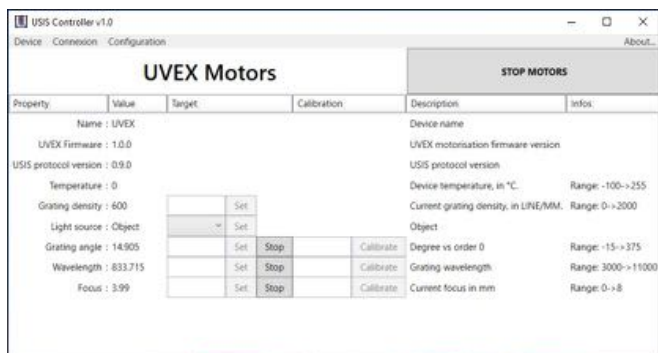


FIGURE 3.7

Each line refer to a property. For each property, you get the name, its current value (in real time, the value is updated every few seconds), the target if you want to change a property (like the grating angle or the focus position), the calibration value (for properties that can be calibrated).

If you want to change a property (grating angle for instance), just enter the target value you want, and click on 'set' button.

3.2.2 Using Demetra

Demetra is the recommended software to operate your UVEX. It is designed and edited by Shelyak Instruments. It covers from spectra acquisition to data reduction, and manages your whole observing session. Demetra is free. You'll find all the details on Shelyak website, for download and installation. To use it with UVEX and UVEX Motors module, download the 'UVEX' version (7.3.0.0 or above).

Demetra includes the same feature as the USIS controller for UVEX. Then all the information of the previous section (3.2.1) is applicable with Demetra.

The advantage of using Demetra with the UVEX Motors module is that the device is controlled transparently. For instance, if you take a Calibration frame, Demetra will automatically switch the light source to Calibration light.

Demetra can manage several devices during the ac-

quisition. The UVEX Motors module is such a device. You can go to the main window, and activate the USIS device. This will add some more data in the acquisition window.

3.2.3 Using USIS protocol

If, for any reason, you don't want (or cannot) use the USIS Controller or Demetra, you can use directly the USIS protocol. This is the basic protocol used to communicate between the computer and the UVEX Motors module.

You'll find more details about the USIS protocol in appendix 7. And the USIS specification can be found in this repository :

<https://github.com/FrancoisCochard/USIS-Protocol>.

This USIS protocol can be used in different ways. for instance, you can write the commands on a serial terminal (like putty, minicom, or others). You can also write high level functions in any language (we worked with Python commands during the development of the UVEX Motors module).

Appendix A : Technical specifications

The main UVEX Motors module specifications are as follows :

- Weight w/o UVEX spectroscope : 0.55 kg
- Weight with UVEX spectroscope : 1.45 kg
- Dimensions of the module : 140 x 130 x 80 mm
- Dimensions with the UVEX : see fig. 4.1, next page
- Power supply : 12V (1A min).
- Power supply connector : 5.5 / 2.5 mm (standard audio-video connector). Positive in the center.

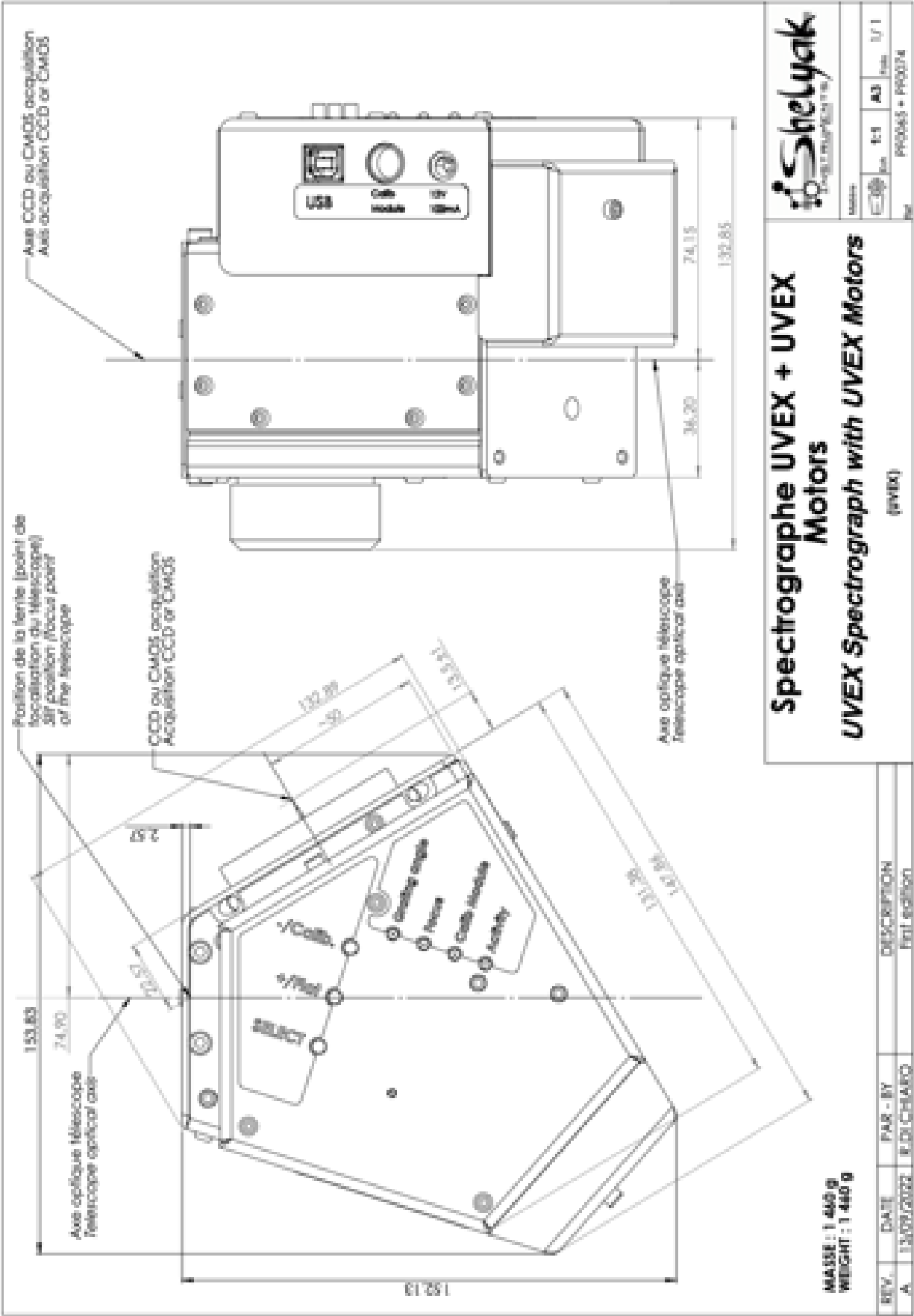


FIGURE 4.1 – UVEX dimensions with Motors module

Appendix B : UVEX motors installation

In this chapter, we give all the details to install the UVEX Motors module on your UVEX.

Note : Installing the UVEX Motors module is a **reversible** operation. To make it possible, please carefully keep all the elements (tools & parts).

There is NO NEED to open the UVEX itself while installing the UVEX Motors module. We highly recommend to remove the UVEX from the telescope to do it, and work in comfortable conditions on a bench. However, you can keep the main camera in place during the operation, then the instrument remains tuned.

5.1 Preparing the UVEX

Remove the grating cap from the UVEX and store it in its storage box (fig. 5.1).



FIGURE 5.1

Remove the grating itself from the UVEX and store it in its storage box (fig. 5.2).

On the opposite side, remove (fully unscrew) the blue grating lock button (fig.5.3).

Remove the screw on the blue index (fig. 5.4).

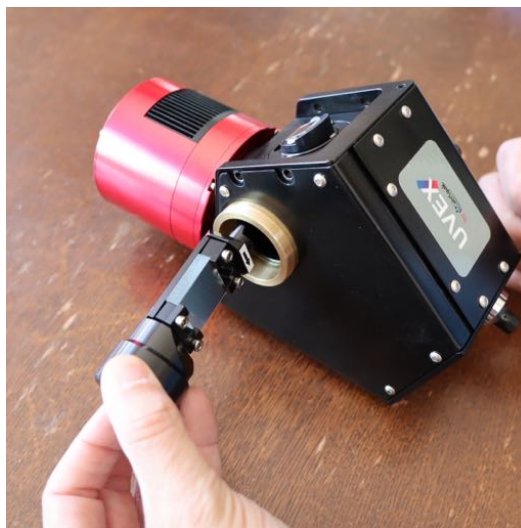


FIGURE 5.2



FIGURE 5.3



FIGURE 5.4

Remove the black ring around the brass part (fig. 5.5).



FIGURE 5.5

Remove the 3 screws that attach the brass part (index guide, see fig. 5.6).



FIGURE 5.6

Remove the whole index (fig. 5.7).



FIGURE 5.7

Remove the vernier fram and the vernier itself (fig. 5.8).

Put back the 2 knurled scrve on the UVEX, to prevent any light leakage (fig. 5.9).

Remove the screw of the turn-counter button (with the supplied wrench) and disassemble it (fig. 5.10 and 5.11).

The UVEX is now ready to install the Motors module.



FIGURE 5.8



FIGURE 5.9



FIGURE 5.10



FIGURE 5.11

5.2 Installing the motors

Mount gear (ref PI0008A) the focus axis (instead of the turn-counter button, fig. 5.12). Make sure that the

internal chamfer of the gear is aligned with the axis end (fig. 5.13). Gently tighten the screw on the axis (make sure that the screw pushes on the flat surface at the axis end).

Rotate the gear up clockwise to the maximum. When you've reached the maximum position, turn back on roughly half a turn.

The axis end must be aligned with the gear side surface.



FIGURE 5.12

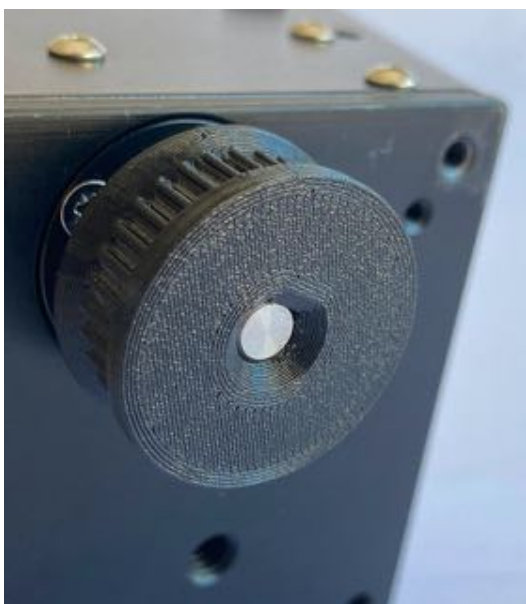


FIGURE 5.13

Mount the grating motor base (ref PU0278A) on the UVEX with three M3x12 screws. Tighten gently the screws (fig. 5.14).

Then, mount the grating motor module onto the base, and tighten it with one screw M3x16 and one M3x8 (fig. 5.15).

Take the main cover (that contains the electronic board) and connect the grating motor on the board (fig. 5.16).

The wires must pass under the motor (fig. 5.17).

Then, make the wires pass around the grating motor module (fig. 5.18).

Close the cover on the UVEX (fig. 5.19).



FIGURE 5.14



FIGURE 5.15

Attach the cover with 2 screws M4x8 (on the gears face, fig. 5.20), and one screw M3x8 on the opposite face (fig. 5.21).

Loosen the 4 small screws around the Focus motor (fig. 5.22), and push the small gear as much as possible towards the focus axis (fig. 5.23).

You can now install the toothed belt (ref EL0285) between the two gears (fig. 5.24), and move back the



FIGURE 5.16

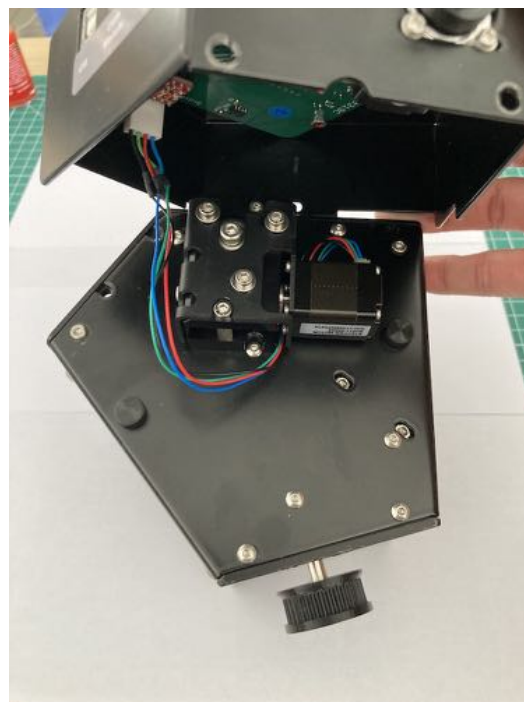


FIGURE 5.18



FIGURE 5.17



FIGURE 5.19

motor to tighten the belt (fig. 5.25). There must be no gap in the belt, but its tension must be 'just enough'. At the end, you must be able to rotate the gears smoothly. When the tension is good, tighten the 4 screws around the motor (fig. 5.26).

At this stage, you can test the motor – this is another way to check the belt tension. Plug the 12V power supply (fig. 5.27), select the 'Focus' function with the

'Select' button, and press '+' and '-' buttons to move the motor ((fig. 5.28). Refer to section 3.1 for detailed instructions. The motor rotation must be smooth (if not, re-do the belt tension step).

When all is OK, you can install the small belt cover with the M3x35 knurled screw (fig. 5.29)

And of course, think about putting back the grating in the UVEX, and tighten its cap.



FIGURE 5.20

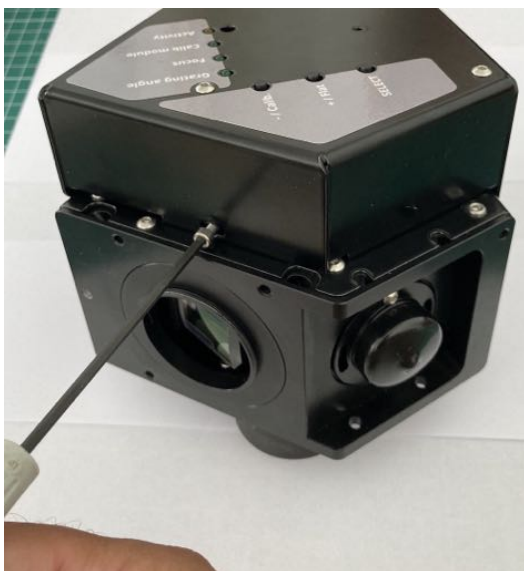


FIGURE 5.21

Your UVEX Motors module is assembled !

5.3 Installing the UVEX on the telescope

Once the UVEX Motors module is installed, the UVEX can be mounted on the telescope the same way as before (refer to the UVEX documentation, if needed).

What is new is that you've to plug the three cables to the UVEX Motors module :

- Power supply cable (12V, 1A min for motors and flat lamp)
- USB cable to the computer
- Calibration module cable. *Note* : On the cali-



FIGURE 5.22

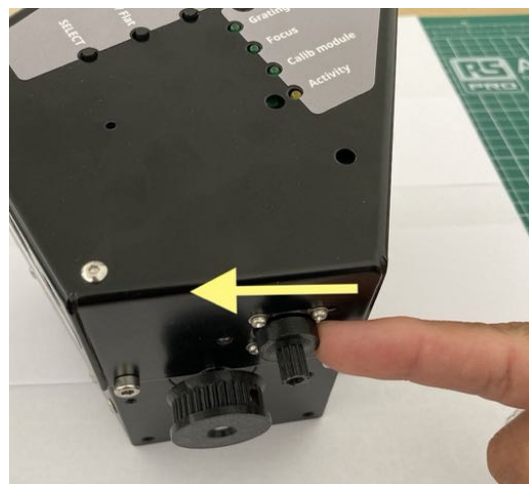


FIGURE 5.23



FIGURE 5.24

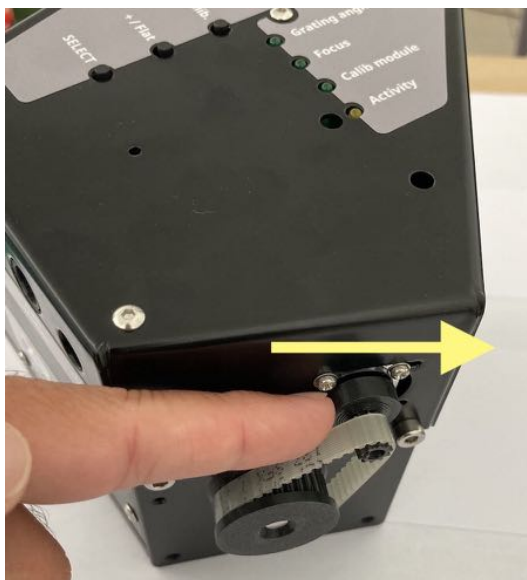


FIGURE 5.25



FIGURE 5.26

bration module side, the white connector is for flat (white lamp), the yellow one is for calibration (coloured lamp), and the black one is for the calibration module power supply (central connector).

Another important note : Even if you've not opened the UVEX itself, you have to check if the internal tuning is still OK. Specially, check that the M1 mirror tuning (to get a symmetrical spectrum in the vertical axis) is still OK. If you need to tune again the M1 mirror, beware that you can access the two screws through two small holes in the main face of the UVEX Motors module (see fig. 5.30). You have to use the hex wrench of 2.5mm (supplied with the UVEX).



FIGURE 5.27

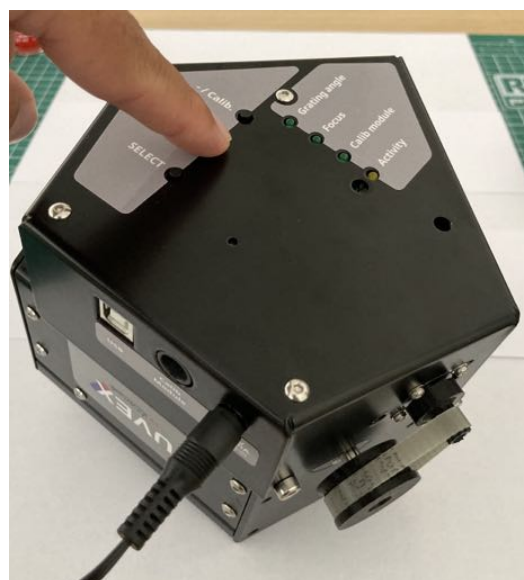


FIGURE 5.28



FIGURE 5.29

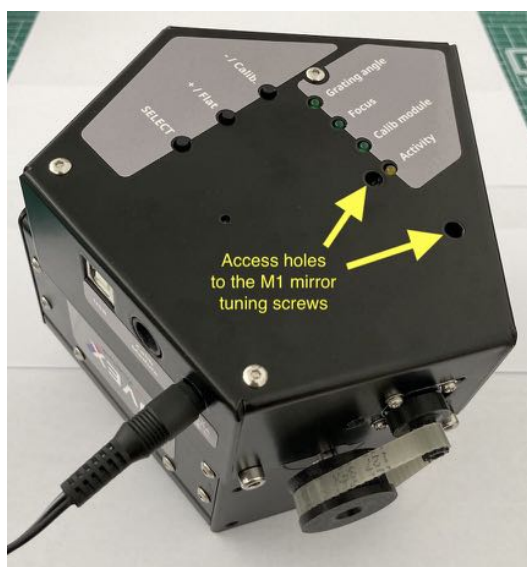


FIGURE 5.30

Appendix C : Updating the firmware

We all know that software is never perfect, and we could also add some new features in the future. Then this is important to be able to update the UVEX firmware. You can do that locally (when you're close to the instrument), or remotely.

The UVEX Motors module is powered by a Raspberry Pi Pico controller¹. Then, the way to update the firmware is given by the Pico rules.

You can download the latest firmware version from the Shelyak website (UVEX product page)². This is a file with .uf2 extension.

6.1 Local update

The principle is quite simple : you can start the Pico in 'Bootsel' mode, which is the firmware upload mode. To do it, you've to press the 'Bootsel' button while plugging in the power supply. This button can be accessed by using a thin tool (like a paper clip for instance), through the small hole in the middle of the main face of the Motors module (fig. 6.1)



FIGURE 6.1

When you enter in 'Bootsel' mode, the Pico appears in your file manager (whatever the operating system). At this stage, you can simply drag and drop the .uf2 file in the Pico. When the transfer is done, the Pico disappears from the file manager. You can restart the Pico by unplugging the power supply and the USB cable and re-plug them³.

6.2 Remote update

When you're far away from your UVEX instrument, you cannot press the 'Bootsel' button for real. But we've added a 'hidden' command in the USIS protocol to reboot automatically the Pico in 'Bootsel' mode.

The USIS command is

```
SYSTEM;REBOOT*
```

Running this command will have the same effect as pressing the 'Bootsel' button.

This command is also included in the 'USIS Controller' software (and then in the Demetra software). In the USIS Controller, you can select the Device menu and click on 'Update firmware' (fig. 6.2)

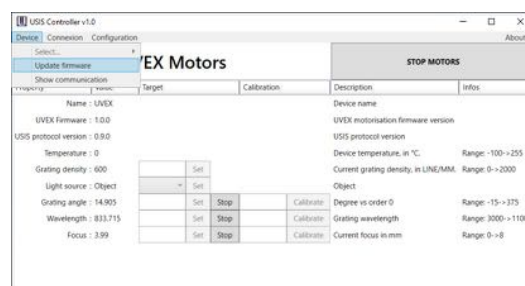


FIGURE 6.2

This will make the Pico appear in the file manager. The example in fig. 6.3 shows a Windows case.

Again, after the download is completed, the Pico disappears from the file manager and you must restart it by switching off and on the power supply. The latest firmware version is now up and running.

1. <https://www.raspberrypi.com/products/raspberry-pi-pico/>

2. <https://www.shelyak.com>

3. Remember that the USB cable is enough to supply the Pico itself. To actually switch off the Pico power supply you must unplug both USB and power supply cables

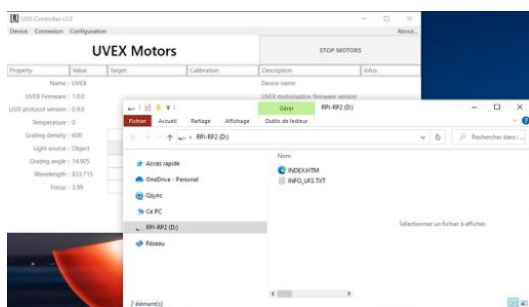


FIGURE 6.3

Appendix D : USIS protocol

The USIS protocol is designed to control any spectroscopy device in a standard way. This is a fully documented Open Source protocol. You can find all the details (specification and library for developers) on the USIS github page :

<https://github.com/FrancoisCochard/USIS-Protocol>

A USIS device includes a list of properties, that can be read or changed by using a few set of commands.

The UVEX Motors device fully complies to USIS protocol, and offers the following properties :

- FOCUS_POSITION gives the current position of the UVEX focus.
- GRATING_ANGLE gives the current grating angle from the 0th order.
- GRATING_WAVELENGTH is the conversion of the grating angle to actual central wavelength. Of course, both GRATING_ANGLE and GRATING_WAVELENGTH are closely linked together.
- GRATING_DENSITY gives the current grating density (lines per mm). When you change the grating (to change the resolution power of your UVEX), you must set the GRATING_DENSITY accordingly. Note that this value is only used to convert the grating angle to wavelength and vice-versa. If you only work with the grating angle, the grating density is not important. But if you control the grating angle through the wavelength (which is the 'normal' way), then the grating density must be properly filled, and updated each time you change the UVEX grating.
- LIGHT_SOURCE gives the current light source. It can be 'Sky' (when observing a star), 'Dark' (for bias and dark frames), 'Calibration' or 'Flat'.
- TEMPERATURE gives the current temperature inside the UVEX Motors module. This can be useful to precisely adjust the focus position while the temperature significantly changes. This is a read-only property.
- Several other properties are available, like the firmware version, USIS module name, and so on. Refer to the USIS specification for more details.

The protocol is a serial communication on the USB port. It can be used by sending commands on the serial port, and listen to the replies. This can be done

by using a serial console (like Putty under Windows, or minicom under Linux). It can also be used to integrate the control of the UVEX in any high level language (C++, Python, JS, and so on). There is no limitations.

The USIS protocol purpose is not limited to the UVEX Motors module, but we want to offer a standard way to control any spectroscopes properties. The protocol is open, and fully documented. It can be used by any hardware and software developers in spectroscopy environment.

Here is an example of an order sent to the UVEX Motors module (to ask for the grating angle position) :

```
GET;GRATING_ANGLE;VALUE*43
```

and the reply could be :

```
M00;GRATING_ANGLE;VALUE;OK;14.9053*78
```

which means that the grating angle is currently at 14.90° from the 0th order.

An interesting feature in USIS protocol is that you can introspect the whole device, to list automatically all available properties. Refer to the USIS page for all the details about the USIS protocol.