Harmonic Generator

HarmoniXX THG

User Manual

Manual of **HarmoniXX THG**

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IMPORTANT ▫ READ CAREFULLY BEFORE USE ▫ KEEP FOR FUTURE REFERENCE

This user manual contains user information for the HarmoniXX THG . Read this manual carefully before operating the HarmoniXX THG . The HarmoniXX THG has only to be used as described in this manual. Differing use may endanger safety and voids warranty.

CAUTION - USE OF CONTROLS OR ADJUSTMENTS OR PERFORMANCE OF PROCEDURES OTHER THAN THOSE SPECIFIED HEREIN MAY RESULT IN HAZARDOUS RADIATION EXPOSURE

Symbols Used in This Manual

This symbol is intended to alert the operator to the danger of exposure to hazardous visible and invisible laser radiation.

This symbol is intended to emphasize the presence of important operating instructions.

Warranty

The warranty conditions are specified in the sales contract. Any unauthorized modification of the **HarmoniXX THG** system components or software will void the guarantee and service contract.

Disposal Hints

All electrical and electronic products should be disposed separately from the standard municipal waste system. Proper disposal of your old appliance prevents potential negative consequences for the environment and human health.

Some components of your **HarmoniXX THG** system are marked with the crossed-out wheeled bin symbol covered by the European Directive 2002/96/EC on waste electrical and electronic equipment (WEEE) of the European Parliament and the Council of January 27, 2003. These items must be disposed via designated collection facilities appointed by government or local authorities.

Contents

1 Safety Instructions

1.1 Safety Features and Compliance to Government Requirements

US government requirements are contained in 21 CFR, Subchapter J, Part II administered by the Center for Devices and Radiological Health (CDRH).
The European Community requirements for product safety are specified in the ¤Low Voltage Directive¤ (2006/95/EC). The ¤Low Voltage Directive¤ requires that electronic products comply with the standard EN61010-1:2010 ¤Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use¤.
Compliance of this product is certified by the CE mark.

1.2 Optical Safety

Because of its special properties, laser light poses safety hazards not associated with light from conventional sources. The safe use of lasers requires that all laser users ¤ and everyone else near the laser system - are aware of the dangers involved. The safe use of the laser depends upon the user becoming familiar with the instrument and the properties of intense and coherent beams of light.

Direct eye contact with the output beam of a laser will cause serious damage and possible blindness.

The greatest concern when using laser equipment is eye safety. In addition to the main beam there are often many smaller beams present at various angles near the laser system.
These beams are formed by specular reflections of the main beam at polished surfaces such as lenses and beam splitters. Although weaker than the main beam, such beams may still be sufficiently intense to cause eye damage. Laser beams are powerful enough to burn skin, clothing, or paint. They can ignite volatile substances such as alcohol, gasoline, ether, and other solvents, and can damage light-sensitive elements in video cameras, photomultipliers, and photodiodes.
The laser beam can ignite substances in its path, even at a distance. The beam may also cause damage if contacted indirectly from reflective surfaces. For these and other reasons, the user is advised to follow the precautions below:

1. Observe all safety precautions in the user manual.

2. Extreme caution should be exercised when using solvents in the area of the laser.
3. Limit access to the laser to qualified users who are familiar with laser safety practices and who are aware of the dangers involved.
4. Never look directly into the laser light source or at scattered laser light from any reflective surface. Never sight down the beam into the source.
5. Maintain experimental setups at low heights to prevent inadvertent beam-eye contact at eye level.
6. As a precaution against accidental exposure to the output beam or its reflection, those using the system should wear safety glasses as required by the wavelength being generated.

Laser safety glasses can present a hazard as well as a benefit; while they protect the eye from potentially damaging exposure, they block light at the laser wavelengths, which prevents the user from seeing the beam. The user should therefore use extreme caution even when using safety glasses.

7. Avoid direct exposure to the laser light. The intensity of the beam can easily cause flesh burns or ignite clothing.
8. Use the laser in an enclosed room. Laser light will remain collimated over long distances and therefore presents a potential hazard if not confined.
9. Post warning signs in the area of the laser beam to alert those present.
10. Advise all those using the laser of these precautions. It is good practice to operate the laser in a room with controlled and restricted access.

1.3 Electrical Safety

The **HarmoniXX THG** uses DC voltages. All units are designed to be operated with protective covers in place. The device complies with protection Class I / EN 61140:2007, degree of protection IP20, according to EN 60529:2010. Certain procedures in this manual require removal of the protective covers. These procedures are normally used by a qualified trained service personnel. Safety information contained in the procedures must be strictly observed by anyone using the procedures.

1.4 Electromagnetic Compatibility

The European requirements for Electromagnetic Compliance (EMC) are specified in the EMC Directive 2004/108/EC. Conformance (EMC) is achieved through compliance with

the harmonized standards EN 61000. The **HarmoniXX THG** meets the emission requirements for Class A, Group 1 as specified in EN 55011 (05/2010).
Compliance of this product with the (EMC) requirements is certified by the CE mark.

1.5 Laser Pump Source

Observe all safety precautions associated with the pump laser. Refer to your pump laser operator's manual for additional safety precautions.
The governmental standards and requirements specify that the laser must be classified according to the output power or energy, and the laser wavelength. The **HarmoniXX THG** is classified to emit laser radiation Class 4 based on 21 CFR, Subchapter J, Part II, Section 1040-10(d) dependent upon the pump laser.
According to the European Community standards, the **HarmoniXX THG** is classified to emit laser radiation Class 4 based on EN 60825-1, Clause 9, dependent upon the pump laser. In the manual and other documentation of the **HarmoniXX THG** , the classification will be referred to as Class 4.

1.6 Protective Housing

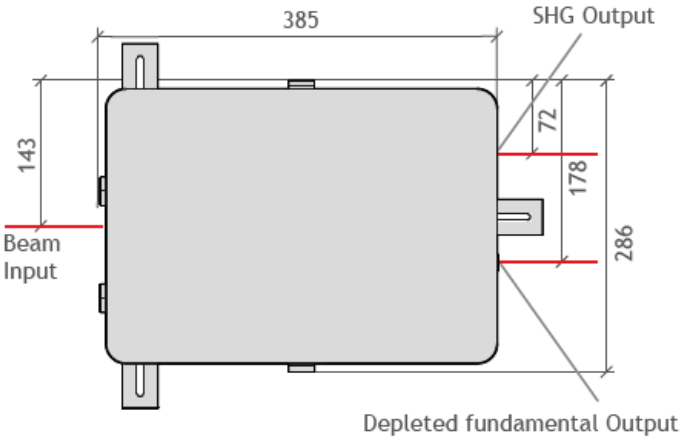
The **HarmoniXX THG** is enclosed in a protective housing that prevents human access to radiation in excess of the limits of Class 1 radiation, which is dependent upon the pump laser, as specified in the Federal Register, July 31, 1975, Part II, Section 1040.10(f)(1) and Table 1-A/EN 60825-1, Clause 4.2 except for the output beam, which is laser radiation Class 4 dependent upon the pump laser.

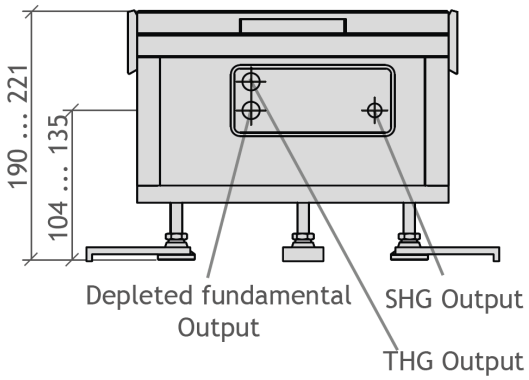
Use of controls or adjustments or performance of procedures other than those specified in the manual may result in hazardous radiation exposure. Use of the system in a manner other than that described herein may impair the protection provided by the system.

1.7 Location of Safety Labels

When the pumping beam is allowed to impinge on the crystal, both laser and collateral radiation are produced. The laser beam is emitted from the laser aperture which is clearly labeled.
The **HarmoniXX THG** is designed to be used with the covers in position and this cover shields the operator from all collateral radiation. During initial alignment and maintenance operations, such as mirror alignment, it will be necessary to remove the covers. The covers are not interlocked with the circuitry of the pumping laser but a label provides a warning about exposure to the radiation.

Operation of HarmoniXX THG with covers removed will allow access to hazardous visible and invisible radiation. The HarmoniXX THG should only be opened for the purposes of maintenance and service by trained personnel aware of the hazards involved. Extreme caution must be observed in operating the HarmoniXX THG with covers removed. There are high power reflections which may exit at unpredictable angles from the HarmoniXX THG when the pumping laser is activated. These beams have sufficient energy to cause permanent eye damage or blindness.





2 Description

2.1 Description and intended use

Figure 2.1: Photograph of the **HarmoniXX THG** optical unit.

APE offers a wide range of harmonic generators designed to complement ultrafast lasers, either with fixed central wavelength or widely tunable, as well as optical parametric oscillators. Its main intention is to enlarge the available tuning range towards the visible and ultraviolet wavelength range.

Item	Dimensions (L x W x H)	Weight	Power
Harmonics head	385 x 286 x 207 mm	15 kg	1 x 100-240Vac single phase
Harmonics controller	205 x 126 x 100 mm	2 kg	N/A

The standard unit is equipped with motorized drives for the nonlinear crystals. Optionally, sensors for measuring the harmonic output are available to enable automatic adjustment of the actuators.

2.2 Scope of Delivery

- **HarmoniXX THG** optical unit (including both focussing and collimation lens)
  - **HarmoniXX THG** units for high energy systems include a telescope for focussing the input beam and possibly no or an external collimation lens
- mounting clamps and screws
- **HarmoniXX** controller unit
- power supply including power cord
- connector cable for controller unit
- RS-232 cable
- USB drive with **GUI** software
- additional THG Separator mirror
- Optics Set Box containing:
  - SHG crystal
  - SHG compensator
  - THG crystal
  - THG compensator (optional, only for certain optics sets)
  - alignment prism
  - 2.5mm allan wrench and knob (for alignment of delay compensator)
  - slip-on target (for L2)
- This Manual

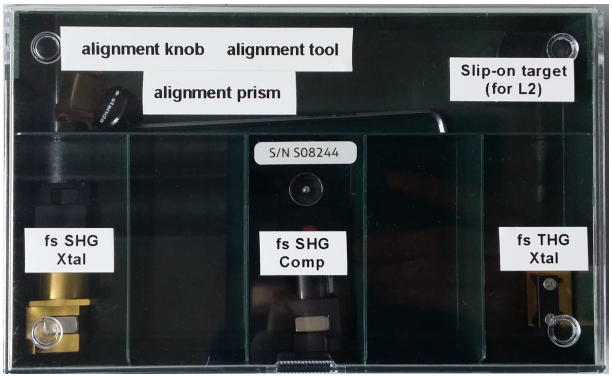


Figure 2.2: Optics Set box for a typical **HarmoniXX THG** .

2.3 Environmental Requirements

The HarmoniXX THG is intended for operation in dry and dust reduced rooms. It has to be firmly installed on an optical table or a similar solid, vibration-free board. During storage and transportation as well as for the installation and during operation, the ambient conditions must be observed. Ensure reasonable transport conditions, free of major shocks, jolt or fall; protect against frost. Use original packing material for transportation. Before unpacking the device wait for at least six hours to allow for acclimatization of all components.

- Ambient temperature during transportation: -30 ... +50°C
- Relative humidity during transportation: <80%, no condensation
- Ambient temperature during operation: +18 ... +27°C
- Relative humidity during operation: <60%, no condensation

2.4 Specifications

Due to the vast number of possible **HarmoniXX THG** models, only the typical values for femtosecond mode-locked titanium-sapphire lasers are shown. Please refer to your official quotation and test protocol in case you have a differing laser. Note that the specifications only apply for horizontally polarized light.

Input wavelength range	680 ... 1080 nm	
Output wavelength	340 ... 540 nm	
Configuration	fs	ps
Input pulse width	~ 130 fs	~ 1.6 ps
SHG Efficiency @ 800 nm	20 %	10 %
THG Efficiency @ 800 nm	10 %	3 %

2.5 Construction and Function

2.5.1 Optical Unit

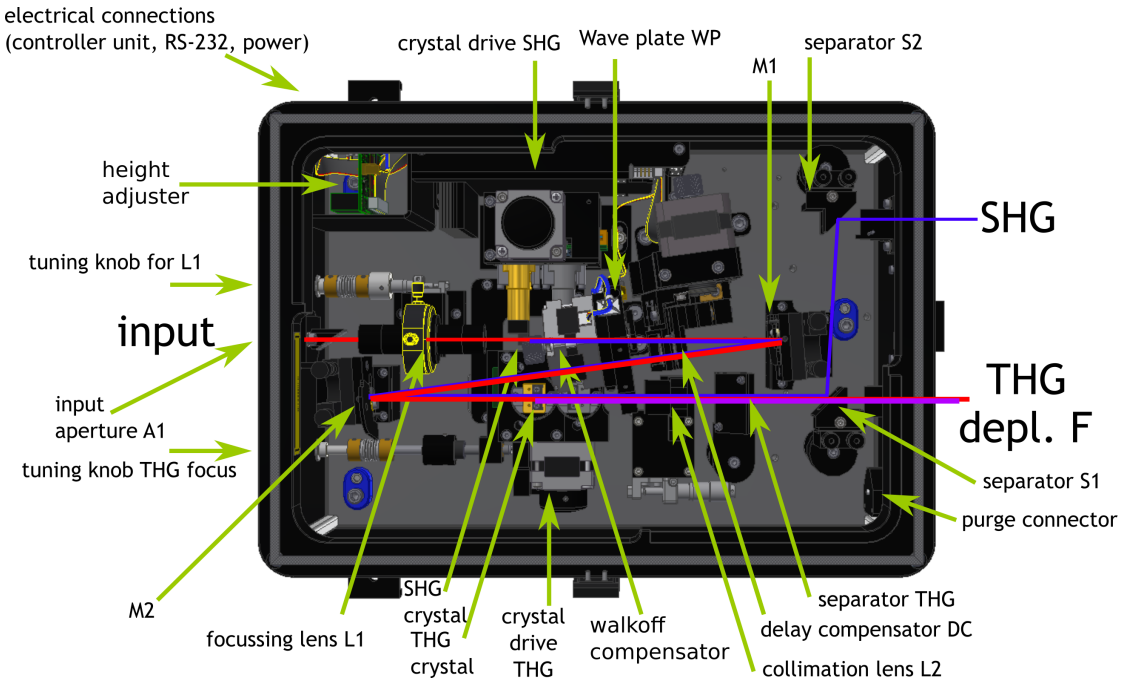


Figure 2.3: Optical Layout of the **HarmoniXX THG** .

Figure 2.3 shows the layout of the **HarmoniXX THG** optical unit. After passing the input aperture A1 the laser beam is focused by the lens L1. This generates a beam waist with high energy density in the doubling crystal (SHG crystal). An efficient non-linear optical interaction takes place if the phase matching condition is fulfilled (optical axis of the birefringent crystal under a certain, wavelength defined angle with respect to the incoming beam and input beam in horizontal linear polarization), and frequency doubled radiation is generated (SHG).
If the input wavelength (and thus the SHG wavelength) changes the tilt angle of the crystal has to be changed in order to adapt to the new phase matching requirements. When tilting the crystal a beam displacement is introduced that depends on the actual wavelength. To compensate for this displacement the beam passes a compensator block that is made out of a transparent medium with a refractive index similar to that of the crystal and that is tilted in the opposite direction with respect to the crystal. The crystal drive (see Fig. 2.4) simultaneously tilts the crystal and the compensator in opposite directions for wavelength tuning.
Both, crystal and compensator (also called “crystal set”) are mounted on connectors with magnetic sockets which allow for a simple exchange in order to adapt to different pulse widths or wavelength ranges. For distinction they are marked with colored posts. With the tuning knob the crystal and the compensator can be tilted to a well defined angular position to optimize the phase matching angle according to the actual wave-

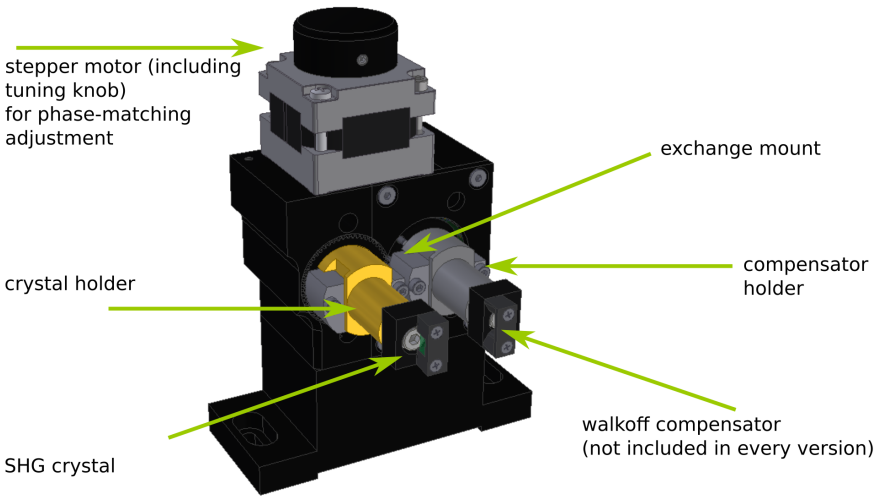


Figure 2.4: Crystal drive of SHG. THG crystal drive is identical only changed in mounting direction (not shown).

length. The crystal drive is also equipped with a stepper motor to enable motorized wavelength tuning.

Do not turn any actuator by hand when the HarmoniXX THG is switched on as damage may occur.

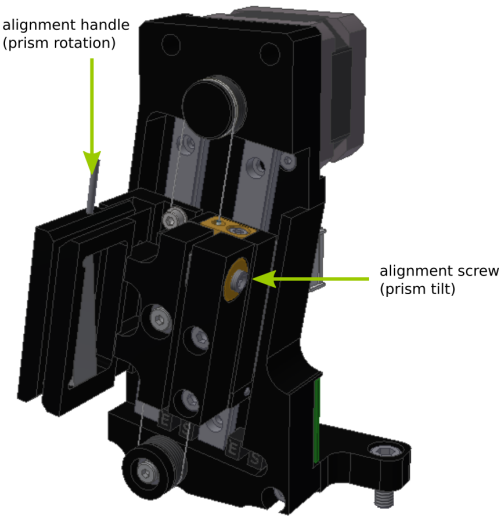


Figure 2.5: Delay compensator of the **HarmoniXX THG** . Note the alignment possibilities.

After passing crystal and compensator the SHG and the fundamental beams are re-collimated by the curved folding mirror M1. It directs the light towards the focussing

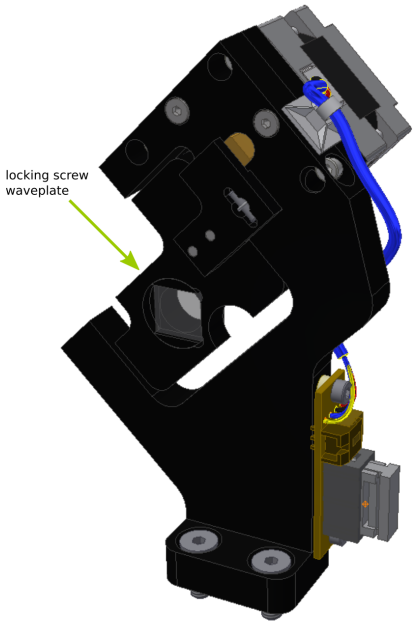


Figure 2.6: Wave plate assembly of the **HarmoniXX THG** . There are no manually adjustable parts.

mirror M2. In the collimated beam between these two mirrors there are two additional optical elements. The first is the optical delay compensator **DC1**, see Figure 2.5. It allows to compensate for the temporal walkoff between fundamental and second harmonic that is aquired during propagation through the optical crystals and compensators due to dispersion. It is made from two birefringent wedges that are moved in the vertical direction.
After passing **DC1**, the beam passes through a wave plate (**WP**) to adjust the polarisation, see Figure 2.6. It rotates the fundamental by 90° without changing the second harmonic polarisation.
The second folding mirror M2 focusses the beam into the third harmonic crystal (**THG**) to perform sum frequency generation. It is placed in another crystal drive similar to the first one but in a lying position within the enclosure. The collimation lens L2 then collimates all beams.
Right after the collimation, the THG separator is placed. It consists of two dichroic mirrors that are in a holder on top of each other. The THG beam leaves the **HarmoniXX THG** unit from an output port right above the depleted fundamental beam. Depending on the desired wavelength it might be necessary to exchange the THG separator. The standard Ti:sapphire THG needs two different separators, termed **long** and **short**. Please refer to the **HarmoniXX** test protocol for the actual wavelength ranges of the separators.
The dichroic mirror S1 separates the SHG beam (90° reflection) from the depleted fundamental beam (transmission to output ”Depl. F”). A second dichroic separator mirror S2 directs the SHG beam to the ”SHG” output.

2.5.2 Labelling of Crystal holders

Holder	fs	ps
SHG crystal	yellow long	red long
SHG compensator	black long	silver long
THG crystal	yellow short	red short
THG compensator		silver short
FHG 2+2 crystal (optional)	blue short	

2.5.3 Controller unit

All the optical elements necessary for tuning the wavelength are equipped with stepper motors. They are controlled by a controller unit which is shown in Figure 2.7. It is connected to the optical unit by a 25-pole sub-D cable.

Figure 2.7: Photograph showing the **HarmoniXX** controller unit.

2.5.4 Menu Structure of HarmoniXX Controller

Main Menu of HarmoniXX :

Menu	Description	available without AT-Option
Search	search for SHG signal	No
Optim	optimize SHG signal	No
Lock	- empty function -	-
GotoWl	set wavelength (from calibration)	Yes
Manual	move motor stepwise	Yes
Settng	change settings	Yes

Submenu of GotoWl:

Menu	Description
return	go back to main menu
λ: xxxx	set desired input wavelength in nm

Submenu of Settng:

Menu	Description
Limits	- empty function -
Xt-Set	change crystal set
Rekali	start recalibration procedure of stepper motors

Upon start-up of the **HarmoniXX** controller, the **XtSet**-Menu is shown (submenu of **Settng**) where the approriate calibration curve of the chosen crystal set can be selected. In case only one crystal set has been purchased it will always be “Xtal Set #1”. Select the item with the **menu** wheel and push the wheel button to select.

2.6 AT-Option

Every **HarmoniXX** can be equipped with additional optical sensors, which is called the **AT-Option**. In most cases it consists of a large position-sensitive diode for the SHG light. A small portion of the SHG and light is reflected off an adjustable window at the exit port.

The **AT-Sensor** will be recognized by the Firmware automatically upon startup and additional functions will be available as can be seen in the first table in section 2.5.4.
To prevent the sensor from false readings by stray light or residual light from the laser, a magnetic filter mount is attached to the sensor.

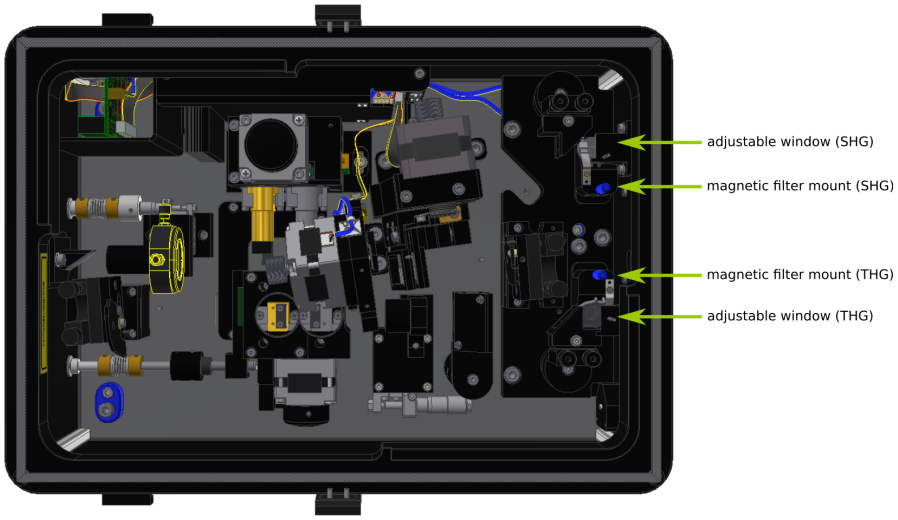


Figure 2.8: **HarmoniXX THG** with the AT-Option installed.

Having the **AT-Sensor** installed, enables the User to use the **Search** and **Optim** Functions available, to automatically either search for the right actuator positions or optimize its output power, if possible. Again, these functions are selected by pushing the small menu button (rotation to select, push to enable).
Ensure that the adjustable output window is set in a way that its reflection hits the optical sensor directly below. The window can be adjusted by loosening the two M3 fixing screws and moving the window mount.

2.7 FHG 2+2 Option

All **HarmoniXX THG** units can be equipped with an optional option to extend the wavelength range into the fourth harmonic of the input wavelength. Both wavelength range and conversion efficiency are stated in the system test report and are subject to change (depending on the parameters of the input laser).
The option, which can either be purchased with the unit or later on, contains:

- FHG crystal
- FHG dichroic wavelength separator
- optional: focusing lens
- optional: FHG angle walkoff compensator

2.8 High energy Version

The focussing lens of the **HarmoniXX THG** is chosen according to the peak power of the laser. When using lasers with several µJ of pulse energy, a single lens in the focussing assembly would cause too high intensity in the doubling crystal and would result in damage of the material. This could be circumvented by either using a lens with very long focal length mounted outside of the optical unit or by using a telescope assembly as shown in Figure 2.9. Here, the lenses of the telescope are referred to as **L1** and **L2**, while the collimation lens is referred to as **L3**. In some models where the beam diameter in the crystal is very large, a collimation lens is not needed and thus its assembly might not be installed.

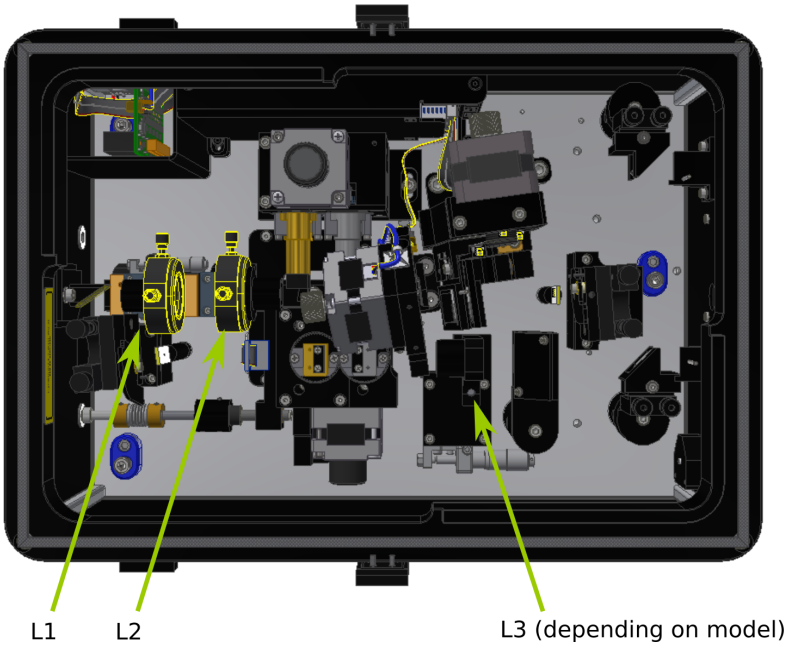


Figure 2.9: Top view of a **HarmoniXX** with a telescope assembly for focussing. Depending on the power of the pump laser, the collimation lens assembly might not be included. In these cases an external collimation lens might be delivered.

Attention: Usage of the telescope version of the **HarmoniXX THG** differs from the ordinary units and will be described in Section. 3.3.2.

2.9 SHG-Mode

When only the SHG output is used, it is possible to increase its power.

- Remove the THG crystal from its crystal drive.
- Loosen the Delay Compensator (see Figure 2.5) from the baseplate and move it out of the beampath to its park position. Fix it there.

- Remove the THG separator from the beam path.
- Remove the Waveplate **WP** from the beam path. It is glued into a metallic holder and clamped by a 2 mm locking screw in the mount, see Figure 2.6.

In the next step, proceed with the **HarmoniXX** controller to enable SHG optimization.

- Go to **Settng** and choose **Config**.
- Choose **SHG** instead of **THG** with a push of the Menu Button.
- Choose **return** with the Menu Button.

The **HarmoniXX** will now reboot automatically and switch to the SHG-Mode. To go back to THG-Mode, choose **THG** in the **Config**-menu.

2.10 Exchange of optics sets

The **HarmoniXX** optomechanical unit can be used for different lasers. There are different possibilities, more than one item may apply:

- Change of pulse duration (femtosecond or picosecond)
- Change of wavelength range (Ti:Sa laser or OPO)
- Change of average/peak power (attenuated beam, pulse picker)

For purchasing a different optics set, please inform your local **APE** distributor about serial number of your **HarmoniXX** unit and the desired new laser parameters. Depending on the change to the input beam, the following changes to the **HarmoniXX** need to be made:

Change of pulse duration

- Exchange the magnetic crystal mount
- Exchange the walkoff compensator
- Exchange the mounted focussing lens (screwed adapter in the xy lens mount) if necessary. See the device test protocol

Change of wavelength range

- Exchange the magnetic crystal mount
- Exchange the walkoff compensator
- Exchange the mounted focussing lens (screwed adapter in the xy lens mount)
- exchange the wavelength separator mounts (using 2mm hex wrench)

Change of power

- Exchange the mounted focussing lens. Depending on the power needed, remove the focussing lens assembly and exchange it with the telescope assembly. Refer to 2.9 if necessary.

3 Installation

3.1 Inspection of delivery

On receipt of the **HarmoniXX THG** :

1. Inspect the packing crate for signs of rough handling or damage directly at arrival. If you discover any irregularities:
   - **Do not refuse to accept the package!**
   - Take photographs of the condition of the package, the labels and the inside of the box, if necessary.
   - List all defects on the shipping documents and let the delivery company countersign.
   - Inform your **HarmoniXX THG** vendor immediately.
2. Use safe lifting practices.
3. Before unpacking the **HarmoniXX THG** wait at least six hours at environmental conditions mentioned in Section 2.3 to allow for acclimatization of all components.
4. Retain the packaging for future use.

3.2 Installation of the optical unit

Caution! Block the input beam each time you remove or install an optical component in the beam path! Make sure to have the beam shield in place when crystals and compensators are installed to protect your eyes. Hazardous beam reflections from crystal and compensator which could cause serious damage of your eyes can emerge out of the top of the HarmoniXX THG without beam shield in place!

- **Note:** The distance between the laser and the **HarmoniXX** optical unit is assumed to be 0.3-0.5m as default. Other options are possible, however, if your planned configuration deviates significantly from this then this should be discussed with your **APE** Sales representative.
- Tune the laser to a well visible wavelength, if not possible apply IR-viewer or converter card, and set the laser to low power (cw-mode - if possible - is sufficient).

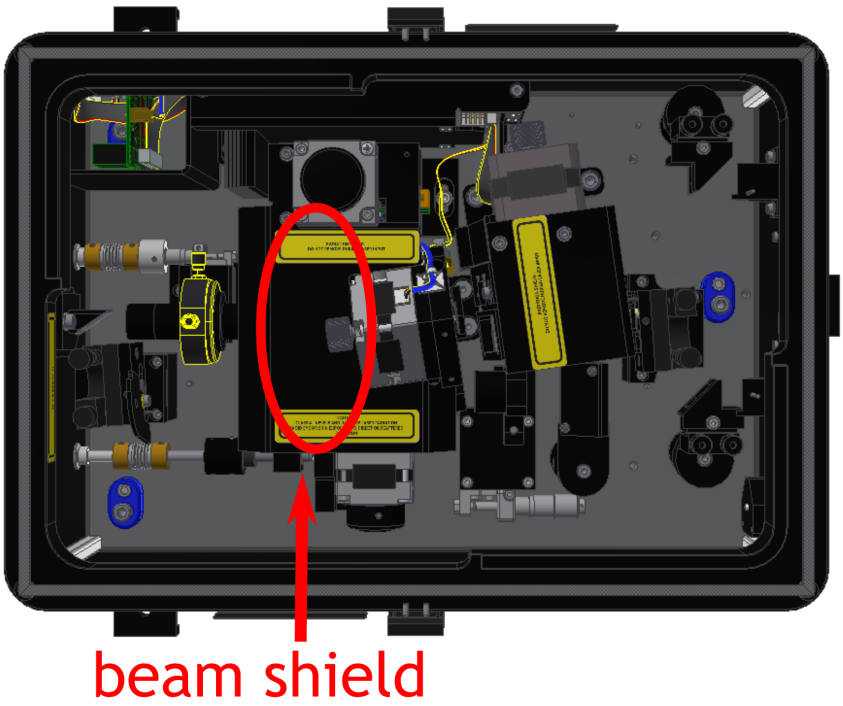


Figure 3.1: Optical Unit (top view) with Beam Shield installed.

- Place the **HarmoniXX THG** optical unit at the desired place in the laser beam.
- Remove top cover.
- Place beam traps behind the outputs of the optical unit.
- Remove focusing lens L1 (unscrew lens tube) and the nonlinear crystals if they are present. Upon first installation, the crystals should still be properly packed in the crystal set box.
- Level the optical unit to the height of the laser beam using the three height adjusters inside the optical unit (marked blue in Fig: 2.3 and 3.1).
- Close input aperture A1 to a diameter similar to the laser beam diameter.
- Use external mirrors or move the entire optical unit to direct the input beam through the input aperture A1 and to the center of the flip target in front of collimating mirror M1.
- Fix the optical unit with the foot clamps.
- Direct the beam reflected by M1 to the center of the flip target in front of M2.
- Direct the beam reflected by M2 to the center of the collimation lens L2. Use the slip-on target provided with the optics set box to do so.

- Install the appropriate THG separator, for the use of a Ti:sapphire laser S: 680 ▫ 870 nm, L: 840 ▫ 1080 nm. If another laser is used, please refer to your **HarmoniXX** test report.

- Now connect both power and controller unit to the optical unit.

Do not connect the power cable before the optical unit is leveled and fixed as you might cause short circuiting the electronic components.

- If several optics sets were delivered, insert correct focusing lens L1 according to pulse width and wavelength range. Watch mounting direction (► = direction of laser beam).

- Adjust the lens to center the beam at the flip target in front of mirror M1 with transverse movements of the L1 lens mount. Check if the beam still passes the center of M2 and L2.

- Install SHG crystal and SHG compensator according to actual pulse width and wavelength range.

To protect your eyes make sure to have the beam shield in place, see Figure 3.1!

- Insert THG crystal and the optional THG compensator.

- Make sure to use the appropriate THG separator for your laser wavelength. Change it by removing the 3 mm screw on top of the THG Separator mount.

- Open input aperture and unblock the input beam.

- Increase laser power to its normal value and activate pulsed operation (mode-locking).

- Tune the crystal angle until SHG light is generated. This can be achieved either using the **GotoWL** menu (recommended) if the wavelength is known or the **Manual** menu. If an AT-Option was ordered, the **Search** Menu is also possible.

- Place a power meter in the SHG output beam and optimize SHG intensity with focus position of L1 and fine tuning of phase matching angle of SHG.

- Now observe the residual reflection of SHG from the THG separator. This can be done by observing fluorecence on a piece of white paper next to the THG output. To increase the contrast of detection, place the alignment prism (contained in the optics set box) at the THG output. Make sure to put it at an angle that the

deflected beams are in the horizontal plane and are near minimum deviation.

Placing the prism in the beam path will lead to a plethora of laser beams, leaving the prism at many different directions. Place appropriate beam dumps.

- Either move the waveplate by **Manual** control so that the fluorescence is minimal or use the **GotoWL** Function (recommended). In the latter case, also **DC** and **THG** crystal will move close to the optimal position and THG will be generated.
- Place a power meter at the THG output and optimize the output power by iteratively using delay compensator **DC**, waveplate **WP**, **THG** crystal and THG focussing drive to optimize the power if needed.

Do not generate more than 10% o to the input power as otherwise da occur.

3.3 Installation of FHG 2+2 option

The installation of the optional FHG 2+2 option (see Section 2.7) is simple and follows these steps:

- Block the laser beam.
- Remove the THG crystal from the crystal drive.
- Remove the THG wavelength separator.
- Insert both the FHG crystal and FHG dichroic wavelength separator at the respective positions.
- Choose the appropriate Crystal set from the “Xtal Set Menu” shown upon startup of the electronics. Refer to your local AÂ·PÂ·E distributor if the FHG 2+2 optics set was purchased separately for recalibration information for the optics set.

3.3.1 Installation of AT-Option

- Install the sensor unit into the optical unit, remove the separator mirrors to do so.
- Check the beam alignment, see if the light hits the center of the SHG sensor.
- Block the input beam.
- Loosen the screws of the **SHG** window mount (metric 2.5 mm allan wrench) so that movement is possible.

- Unblock the beam and now observe the beam position shown on the Controller display.
- Steer the beam near the center of the Sensor (X and Y position values between -50 and +50) shown on the **HarmoniXX** controller unit.
- Fix the window mount again.
- Insert the ND-Filter mount to prevent over exposure of the sensor.

Either over- or underexposure will lead to blinking of the power value shown on the HarmoniXX controller display.

- Proceed with the **THG** window in the same way.

3.3.2 Installation of high energy version

- Ensure that the laser beam is well collimated and has the diameter described in the device report.
- Proceed with the installation according to section 3.2 until connection of the controller unit and power cable. Make sure to also remove both focussing lens tubes (L1 and L2) from their mounts.
- Remove collimation lens L3 if it is existent.
- Insert the first focussing lens L1 into the mount closer towards the laser. Do not change its position along the beam path, only adjust horizontal or vertical position if necessary. The beam should exit the optical unit through the center of the “depl. F” port.
- Proceed with the second focussing lens L2 in the second mount. Take care of the correct direction. Adjust its position if necessary.
- Now observe the laser beam transmitted through the “depl. F” exit port on a target about 1 meter behind the optical unit.
- Change the distance of L1 and L2 by carefully rotating the micrometer screw of L1 so that the diameter of the beam on the target is minimized.
- **Attention: Increasing the distance more will result in too high intensity at the position of the nonlinear crystal and its damage.**
- Now insert the doubling crystal and compensator and proceed as described in section 3.2.

3.4 HarmoniXX THG Routine Operation

There are three possibilities to set up the **HarmoniXX** for easy and efficient conversion of the fundamental. These are:

- User Wavelength Adjust
- User Actuator Adjust
- Remote Wavelength Adjust

Remote wavelength adjust depends on use of the GUI software and connection an external Ocean Optics CCD spectrometer. The other two modes are accessible from both the controller and from the GUI software.

3.4.1 User Wavelength Adjust

This mode of operation requires the user to simply enter the desired wavelength via the controller, or via the supplied GUI software.

- Note the fundamental wavelength from the Chameleon laser, e.g. 790 nm.
- Select the GoToWL (Go To Wavelength) menu on the controller using the rotary MENU button to scroll and then press to select.
- Select the desired fundamental wavelength using the rotary TUNING button. Note that pressing the TUNING button repeatedly scrolls between small, medium, and large step sizes (1, 10, 100) ▫ visible in the bottom right corner of the screen.
- The **HarmoniXX THG** actuators will move to preset positions per the fundamental wavelength selected. Second harmonic light should be visible.

3.4.2 User Actuator Adjust

It is also possible for the user to define the precise positions of each individual actuator. This option can be useful, for example, to fine-tune the harmonic output power after setting the fundamental wavelength via the GoToWL function (see previous section).

This is achieved via the MANUAL menu on the controller, or via the supplied GUI software.

Press the MENU button to toggle between GoToWL and MANUAL.

- Select the MANUAL menu on the controller.

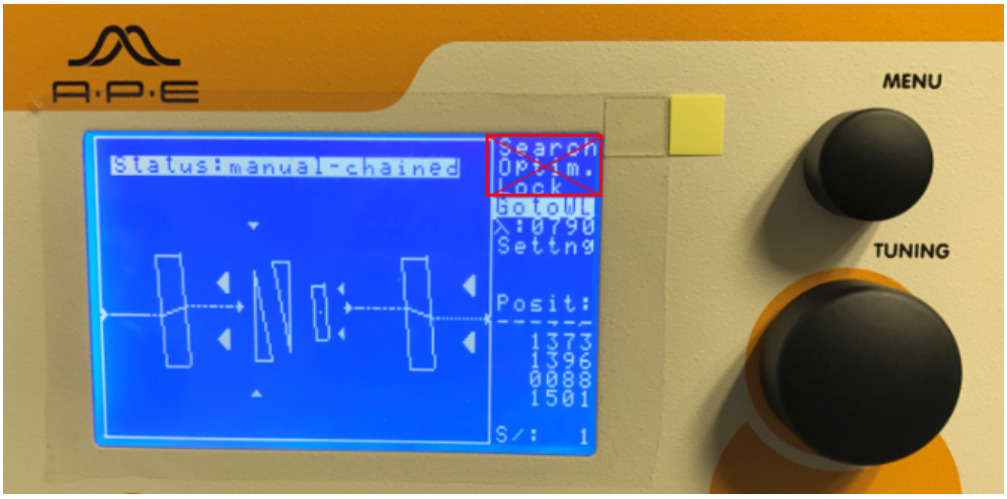


Figure 3.2: Goto WL menu

- Scroll using the MENU button to highlight the desired actuator, then adjust the desired position of that actuator using the TUNING button. Note that pressing the TUNING button repeatedly scrolls between small, medium, and large step sizes (1, 10, 100) ▫ visible in the bottom right corner of the screen.
- Repeat as necessary for each actuator.

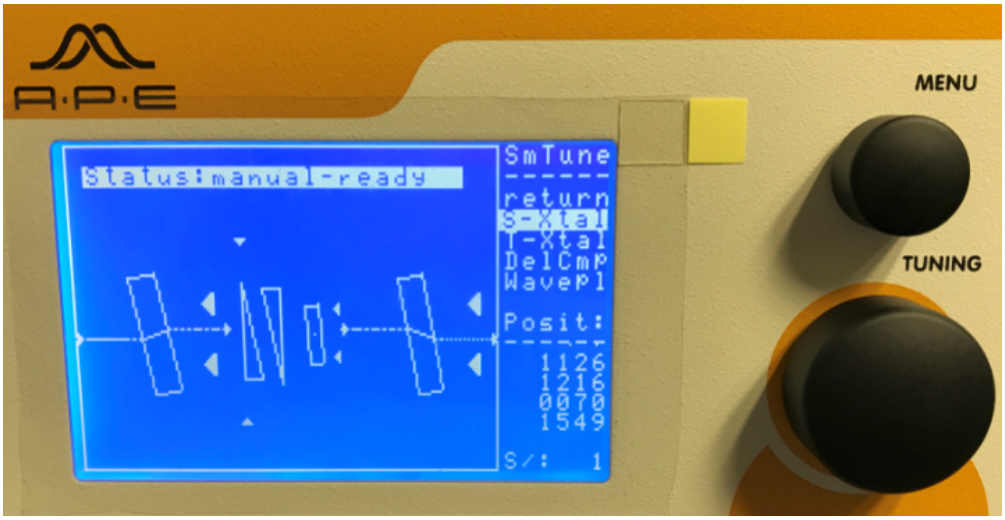


Figure 3.3: Manual actuator adjust.

3.5 GUI-software

The **GUI** software provides the same function as the controller unit, only conveniently available on a standard Windows© PC. After installation and connecting the **HarmoniXX** to a COM Port, the **GUI** should automatically detect the available unit. In case an Ocean Optics CCD Spectrometer is connected, it will be automatically detected as well.

Figure 3.4: User Actuator Adjust using GUI.

3.6 Routine Operation

- Check beam alignment (including output window when using **AT-Option**).
- Install the appropriate crystal and compensator for fs or ps operation, respectively.
- Optimize phase matching angle and L1 focus (maximize SHG output power).
- Proceed with the THG angle and focussing as well.
- When changing the laser wavelength tune crystal angle.

4 TCP/IP interface

4.1 Standardized Software Interface via TCP

The **HarmoniXX THG GUI** control software (see Section 3.5) includes a TCP interface that allows the user to remote control the software with a fixed set of commands. It can be used by starting the TCP server in the **Config** tab of the software. All commands follow the SCPI99 standard, but the standard is not completely implemented nor completely supported! The commands follow the general scheme shown in figure 4.1.

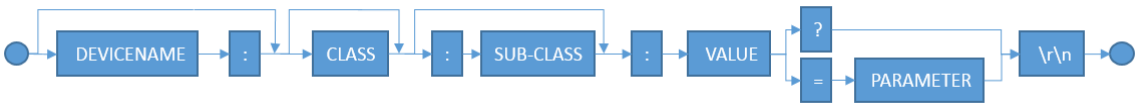


Figure 4.1: General scheme of the commands to control the **HarmoniXX THG** using TCP connection.

For example a valid set-command looks like this:

```
hxx:wavelength=800\r\n
```

but it is also allowed to shorten this command to:

```
:wavelength=800\r\n
```

All available TCPIP commands can be found at the end of this Section. All communication is text based and the commands do not use binary data as parameters.

Please note, that the **commands are executed sequentially**. This means, the software must finish the first command before the next one is executed. As example if two tuning-commands are sent directly after one another with two different wavelengths, the **HarmoniXX THG** will first tune to the wavelength given in the first command. Once the tuning has finished, the device will then directly start another tuning procedure to tune to the second wavelength. **Interruption of a previous sent command with a newly sent one is impossible.**

*IDN?

Get Device Identification
<manufacturer> string
Manufacturer Name
<model> string
Modelnumber/-name
<software> string
Software Version
<firmware> string
Firmware Revison

Example:

```
*IDN?
```

*RST

Execute device reset

Example:

```
*RST
```

*STB?

Get Device Status Byte
<parameter> integer
SCPI Device Status Byte

Example:

```
*STB?
```

*ESR?

Get event status register
<esr> integer
SCPI Event Status Register

Example:

```
*ESR?
```

*OPER?

Get operation status register
<oper> integer
SCPI Operation Status Register

Example:

```
*OPER?
```

LIST_MODULES?
MDLS?

Get list of all loaded modules (name, type, version)

<modules> string
List of all loaded modules, Format = [MODULE_NAME] (T: [MODULE_TYPE], R: [FIRMARE/SVN_REVISION])

Example:

```
list_modules?
```

INTERFACE_XML?
IXML?

Get APE Interface Description in XML Format

<xml_file> array of bytes in block data format
SCPI-Block-Data; XML-File-Content is passed as ASCII Values in Block-Data-Segment

Example:

```
interface_xml?
```

SHG<shg>

Set SHG xtal angle position

<shg> integer, range: 10 ... 3096
SHG angle position in steps

Example:

```
SHG=1000
```

SHG?

Get SHG xtal angle position

<shg> integer, range: 10 ... 3096
SHG angle position in steps

Example:

```
SHG?
```

THG<thg>

Set THG xtal angle position
<thg> integer, range: 32 ... 3106
THG angle position in steps

Example:

```
THG=1000
```

THG?

Get THG xtal angle position
<thg> integer, range: 32 ... 3106
THG angle position in steps

Example:

```
THG?
```

DC<dc>

Set Delay Compensator position
<dc> integer, range: 4 ... 138
Delay Compensator position in steps

Example:

```
DC=1000
```

DC?

Get Delay Compensator position
<dc> integer, range: 4 ... 138
Delay Compensator position in steps

Example:

```
DC?
```

WP<waveplate>

Set Waveplate position
<waveplate> integer, range: 204 ... 4190
Waveplate position in steps

Example:

```
WP=1000
```

WP?

Get Waveplate position
<waveplate> integer, range: 204 ... 4190
Waveplate position in steps

Example:

```
WP?
```

WAVELENGTH<wavelength>
WL<wavelength>

Set wavelength
<wavelength> integer, range: 1000 ... 700
set wavelength in nm

Example:

```
wavelength=800
```

WAVELENGTH?
WL?

Get wavelength
<wavelength> integer, range: 1000 ... 700
set wavelength in nm

Example:

```
wavelength?
```

MODE<mode>

Set Mode
<mode> string
(manual; search; optimize; wavelength; lock)

Example:

```
mode=manual
```

MODE?

Get Mode
<mode> string
(manual; search; optimize; wavelength; lock)

Example:

```
mode?
```

DEMO_WL<wavelength>

Set Wavelength
<wavelength> integer
(Set Wavelength for Demo-Mode)

Example:

```
demo_wl=800.5
```

HXX<command>

Write to hxx controler
<command> string
(send command directly to hxx controller)

Example:

```
hxx=MMN,
```

SPECTRUM?

Get the measured opo spectrum
<spec> string
Measured spectrum data as SCPI Block data. Data is formatted as double values and stored as interleaved array [X0,Y0,X1,Y1,...,Xn,Yn]

Example:

```
spectrum?
```

PEAK?

Get Peak Wavekength
<bw> double
Measured peak wavelength

Example:

```
peak?
```

SENSORS?

Get Sensor Data
<sensor> string
shg_pos; shg_int; thg_pos; thg_int; shg_gain; thg_gain

Example:

```
sensor?
```

ACTORS?

Get Actuator Data
<sensor> string
shg_pos; thg_pos; dc_pos; wp_pos

Example:

```
actors?
```

5 Demo Code of HarmoniXX THG Control using SCPI Commands

Demo scripts for different high-level languages are available on the APE website. You can either use the direct link:

`http://www.ape-berlin.de/en/page/standardized-software-interface/`

or you can browse via “tools” → “Standardized Software Interface” to see the list of supported languages which contains:

- C++
- C#
- LabVIEW™
- Python
- Matlab
- Ruby

6 RS-232 command list

If the GUI software is not desired, the **HarmoniXX THG** is able to connect to a PC by a serial RS-232 connection. The following settings are needed to establish a connection:

Baud rate	38400
Data bits	8
Parity	None
Stop bits	1
Handshaking	None
End character	None

Here is a complete command list for the control of the **HarmoniXX THG** :

Command	Description	Response	Format
GST,	Get Status	BST + 3 Byte	HEX
GID,	Get Identity	BKN + 20Byte	ASCII
BRK,	Break (stop all actuators)	BST+3Byte	HEX
SRS	Search	BST + 3 Byte	HEX
SRO	Search+Optimize	BST + 3 Byte	HEX
OPT,	Optimize	BST+3Byte	HEX
MMN,	Manual mode	BST+3Byte	HEX
NWLxxxx,	GotoWL	BST+3Byte	HEX
NWOxxxx,	GotoWL+Optimize	BST+3Byte	HEX

For example, the command to tune the **HarmoniXX SHG** to the conversion of 800 nm would be **NWL0800,**.

7 Maintenance and Troubleshooting

The crystals are slightly hygroscopic. Therefore the instrument is to be kept from humidity and the crystals are to be kept in a dry box when not in use.

Problem: No or very weak THG Signal
Possible reasons:

- No pulse generation of the laser.
- Crystal length not according to the pulse width.
- Crystal and compensator mounted at the wrong positions.
- Focusing strongly detuned.
- wrong wave plate and delay compensator position

Problem: SHG Signal generated, but low THG power
Possible reasons:

- Wrong THG crystal, wave plate or delay compensator position
- alignment of delay compensator tilt (refer to Figure 2.5)
- unlikely: alignment of delay compensator first prism rotation. Open 2.5 mm allen screw in front of delay prism 1 and use handle to adjust angle (refer to Figure 2.5)

7.1 Technical Support

For technical questions or problems within Germany, please contact:

APE Angewandte Physik & Elektronik GmbH
Plauener Stra▫e 163 - 165, Haus N
D - 13053 Berlin
tel +49 30 98601130
fax +49 30 986011333
service@ape-berlin.de
http://www.ape-berlin.com

To contact our international distributors, please have a look at our website:

http://www.ape-berlin.com
For technical support in all other countries, please contact your local **HarmoniXX** vendor.

Declaration of Conformity to EU RoHS

Products listed below that are manufactured by APE Angewandte Physik & Elektronik GmbH are in compliance with EU Directive 2015/863 of the European Parliament and of the Council of July 22, 2019 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (also known as **RoHS Recast**). In addition, this declaration of conformity is issued under the sole responsibility of APE Angewandte Physik & Elektronik GmbH. Specifically, products manufactured do not contain the substances listed in the table below in concentrations greater than the listed maximum value.

Substance	Limit (ppm)
Cadmium (Cd)	< 100
Lead (Pb)	< 1000
Mercury (Hg)	< 1000
Hexavalent Chromium (Cr VI)	< 1000
Poly Brominated Biphenyls (PBB)	< 1000
Poly Brominated Diphenyl ethers (PBDE)	< 1000
Bis(2-Ethylhexyl) phthalate (DEHP)	< 1000
Benzyl butyl phthalate (BBP)	< 1000
Dibutyl phthalate (DBP)	< 1000
Diisobutyl phthalate (DIBP)	< 1000

Signature:

Name (printed): Dr. Konrad von Volkmann
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