THORLABS

Piezoelectric Deformable Mirror

DMP40
Operation Manual



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Warning

Sections marked by this symbol explain dangers that might result in personal injury or death. Always read the associated information carefully, before performing the indicated procedure.

Attention

Paragraphs preceded by this symbol explain hazards that could damage the instrument and the connected equipment or may cause loss of data.

Note

This manual also contains "NOTES" and "HINTS" written in this form.

Please read this advice carefully!

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1 General Information

The Thorlabs' Piezoelectric Deformable Mirror DMP40 is used to correct distorted wavefronts that result from common sources of wavefront aberrations, such as astigmatism and coma.

The Thorlabs DMP40 Deformable Mirror consists of a piezoelectric disk with a segmented back electrode glued to a glass substrate carrying the continuous reflective surface. The segmented back electrode controls a number of independent mirror segments. Each segment area can be forced to perform a local concave or convex bending, depending on the applied voltage. Thereby the mirror can assume any desired shape to compensate for distorted wavefronts.

Besides individual or grouped segment control, the DMP40 software provides pre-defined voltage patterns for generation of Zernike function shapes. An adaptive control algorithm based on these Zernike coefficients allows closed loop operation in conjunction with a feedback signal from our Shack-Hartmann wavefront sensors.

Each DMP40 deformable mirror has a Ø10 mm pupil and is available with one of two optical coatings: UV-Enhanced Aluminum for 250 to 450 nm or Protected Silver for 450 nm to 20 µm.

Attention

Please find all safety information and warnings concerning this product in the chapter Safety 76 in the Appendix.

1.1 Ordering Codes and Accessories

Ordering Code	Short Description
DMP40-F01	Piezoelectric Deformable Mirror, UV Enhanced Aluminum, 10 mm Pupil Diameter, Imperial
DMP40/M-F01	Piezoelectric Deformable Mirror, UV Enhanced Aluminum, 10 mm Pupil Diameter, Metric
DMP40-P01	Piezoelectric Deformable Mirror, Protected Silver, 10 mm Pupil Diameter, Imperial
DMP40/M-P01	Piezoelectric Deformable Mirror, Protected Silver, 10 mm Pupil Diameter, Metric

Recommended Accessories:

For Closed Loop Control setups, we recommend Thorlabs Wavefront Sensors (WFS) and Microlens Arrays (MLA) that are offered in combination.

Wavefront Sensor (WFS Item# Prefix)	Short description
WFS20	High-Speed Shack-Hartmann Wavefront Sensor
WFS30	General Purpose Shack-Hartmann Wavefront Sensor
WFS40	Large Area Shack-Hartmann Wavefront Sensor

Microlens Arrays:

Microlens Arrays (WFS Item# Suffix)	Short description
-5C	based on Thorlabs MLA150-5C
-7AR	based on Thorlabs MLA150-7AR
-14AR	based on Thorlabs MLA300-14AR

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1.2 Requirements

These are the requirements for the PC intended to be used for remote operation of the DMP40.

1.2.1 Software Requirements

The DMP40 software is compatible with the following operating systems:

- Windows® 7 SP1 and later (32-bit, 64-bit)
- Windows® 8.1 (32-bit, 64-bit)
- Windows® 10 (32-bit, 64-bit)

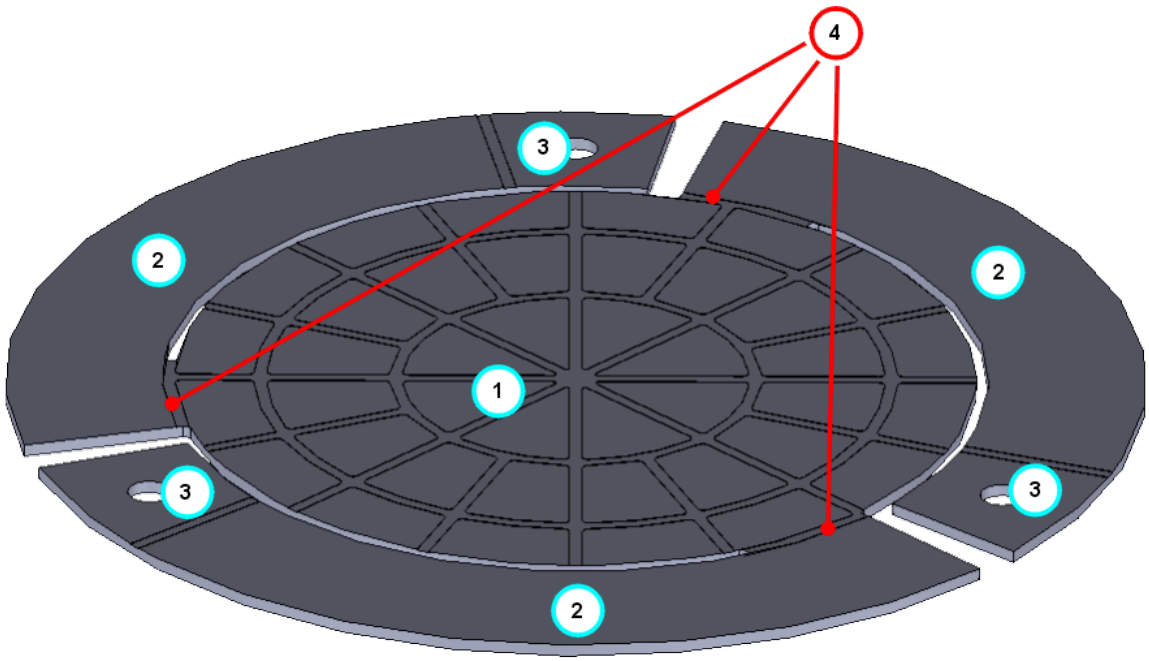
For operation of the DMP40, Microsoft® .Net Framework version 4.6.2 or higher must also be installed. This software comes with the Thorlabs DMP40 installation package, available for download on the software tab of the Piezoelectric Deformable Mirror website.

For the Control Loop 38 operation a Thorlabs Wavefront Sensor with a software version of 4.6 and later is required. For optimal performance, please use the latest software version available online.

1.2.2 Hardware Requirements

CPU:	2 GHz or higher
RAM:	4 GB
Graphic card	256 MB memory (shared)
Graphic resolution	min.: 1024 x 768; recommended: 1280 x 800
Hard disk	1.2 GB (32 bit) / 2.6 GB (64 bit) free storage space
Interface	USB 2.0 port, USB cable according the USB 2.0 specification

2 Operating Principle



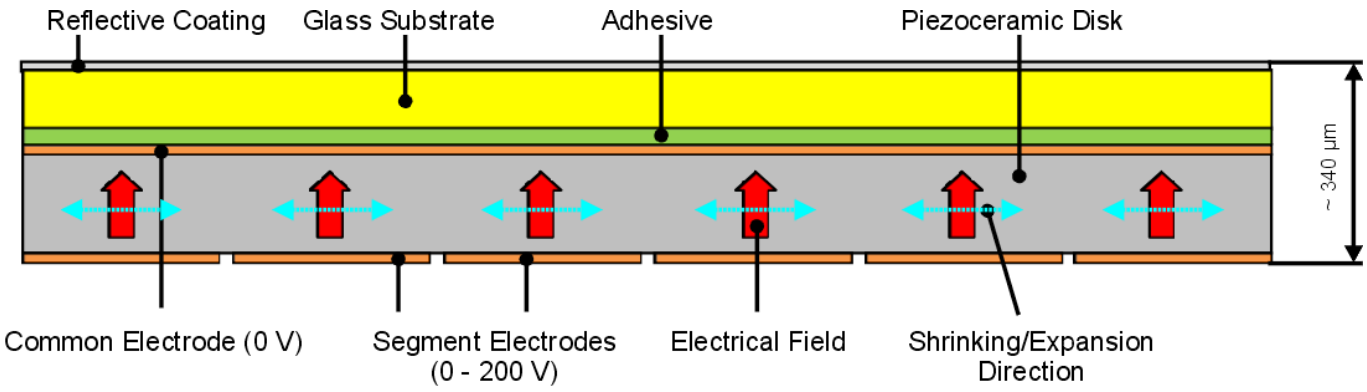
DMP40 structure - rear view

1 Inner Mirror (40 segments)
2 Bending arms for tip-tilt control
3 Fixing points (mirror to supporter)
4 Connections between inner mirror and tip-tilt arms

The heart of the Thorlabs DMP40 is a deformable mirror (1). It is comprised of a glass substrate with a reflective coating that has a thin piezo ceramic disk with segmented electrodes glued to the back side.

The inner mirror has 3 connection (4) to the bending arms 6 (2), which in turn are fixed to the mirror supports in the cabinet.

2.1 Inner Mirror

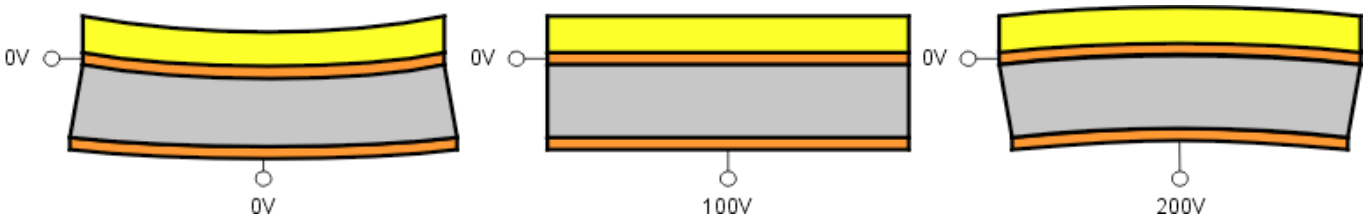


Cross section of the DMP40 inner mirror

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The above sketch shows a simplified cross section of the inner mirror. The common electrode for all segments is connected to ground (0 V), while the back side electrode is divided into 40 single segments that can be controlled individually by a DC voltage in the range 0 – 200 V each.

During the gluing process, a control voltage of 100 V is applied to all segment electrodes. For this reason, a flat mirror surface will appear at a control voltage level of 100 V, applied to all segments. At voltages <100 V, the piezo material above the corresponding electrode will expand, leading to a local concave shape, while a voltage >100 V shrinks the piezo and leads to a local convex shape:



Applying a voltage to a piezo segment

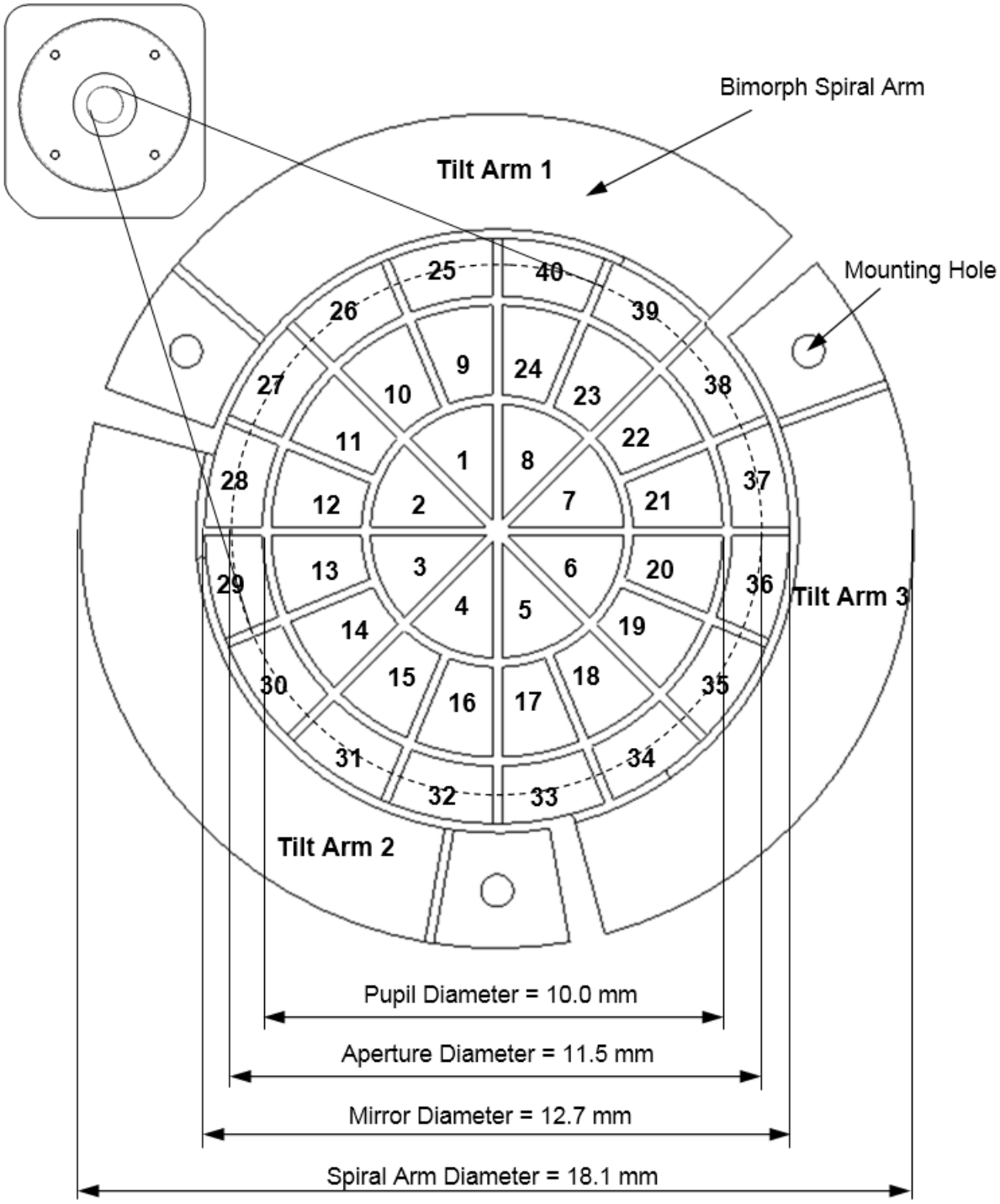
Applying the same voltage higher or lower than 100 V to all 40 electrodes results in a pure spherical mirror shape. An arbitrary surface shape can be generated by applying a defined voltage pattern.

Note

The mirror will be nearly flattened after connecting it to the power supply and to a PC with the installed DMP40 software! The reason is that the software will initialize the hardware only after PC connection is made.

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2.2 Segment Structure



View onto the mirror surface

Electrode numbering is shown for a mirror with the reflective surface facing the viewer and with the mounting hole facing down.

Note

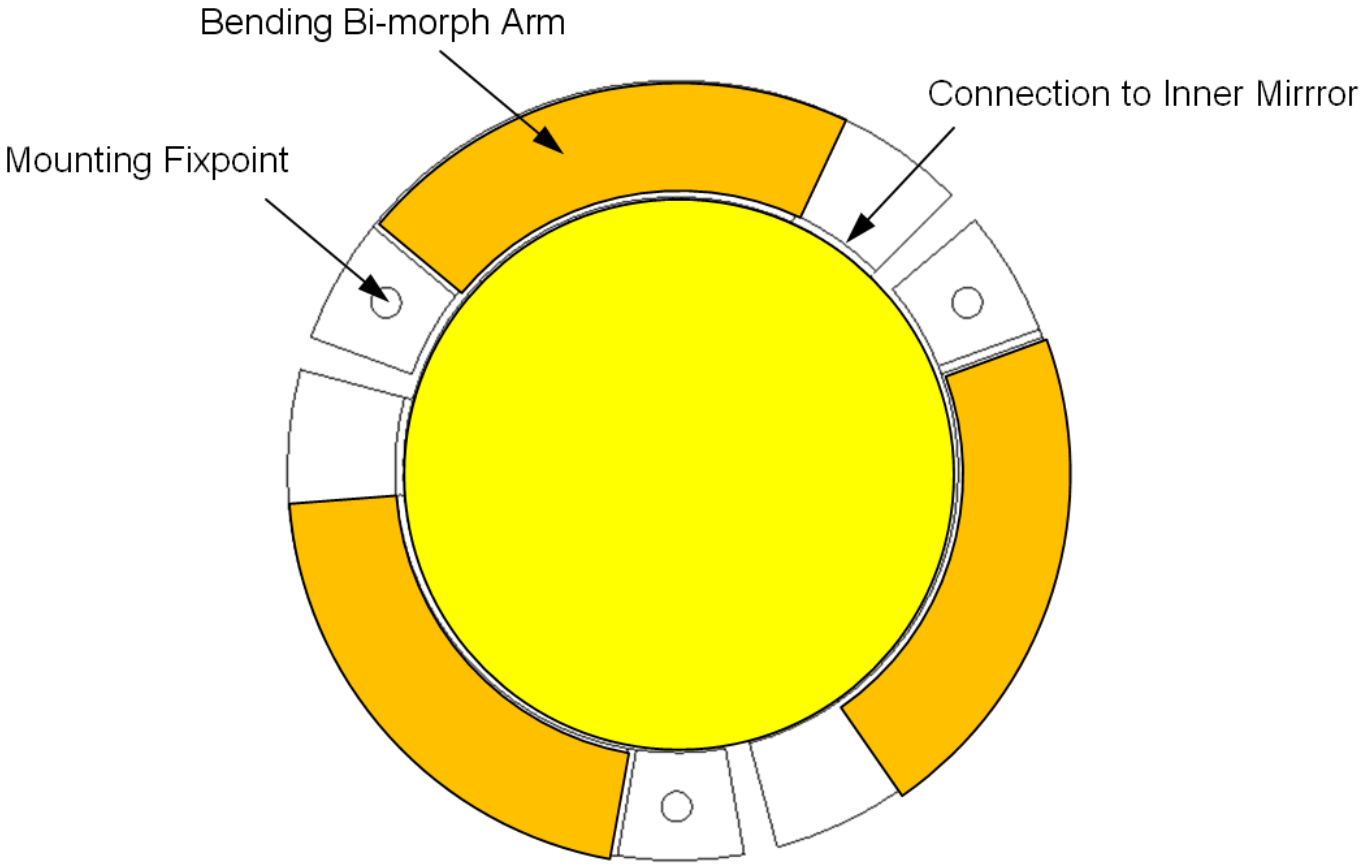
The instrument driver software accepts zero-based segment indices in the range 0 – 39 and tip/tilt elements in the range 0 – 2, while the user interface refers to the numbering as shown in the above diagram.

The segments 25 to 40, surrounding the mirror pupil, are used to get defined curvatures even at the pupil's rim. This improves the quality and amplitude of the Zernike terms generation.

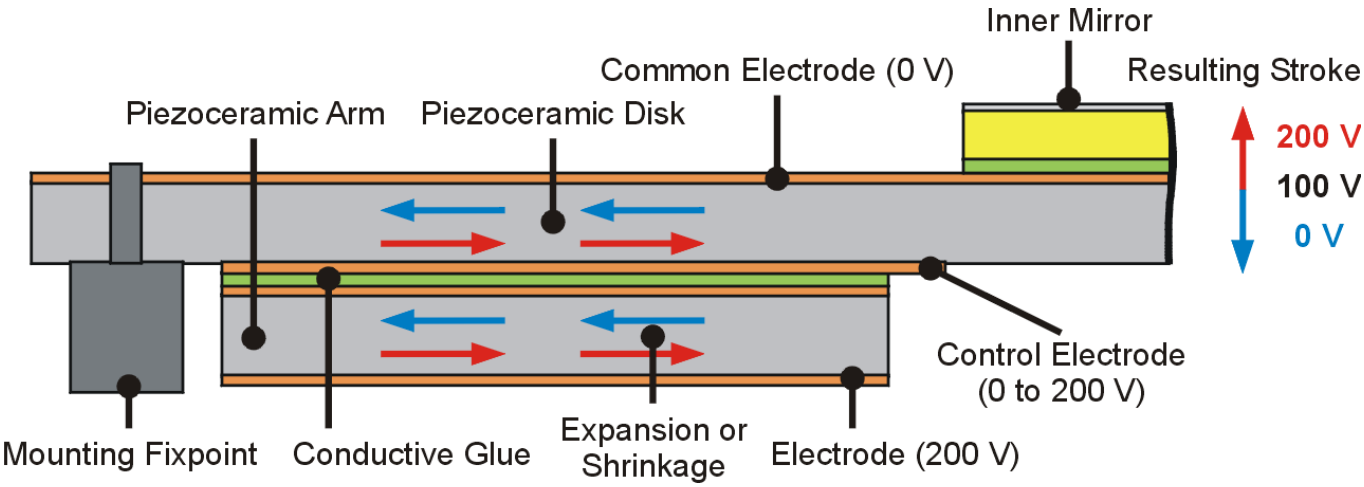
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2.3 Tip-Tilt Arms

The inner mirror is surrounded by 3 arms that are used for mounting and tilting the inner mirror. Each arm is fixed to a support at one end and holds the inner mirror at the other end.



These arms have a bi-morph design in order to increase bending, which increases the tilt amplitudes. Two piezo-ceramic layers are glued to each other and controlled by opposite inner electrical field strengths. While one layer is expanding the other is shrinking.



Cross section of a bimorph arm

As shown in the figure, a bending arm (upper part) and the additional spiral arm (lower part) are connected in series between the common electrode (0 V) and an electrode connected to a fixed voltage of 200 V. The control electrode is located between the disk and the arm. The control voltage (0 to 200 V) leads to simultaneous shrinkage and expansion of the upper piezo disk and the lower piezo arm, respectively, this way doubling the achievable stroke of the arm.

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The resulting stroke of each bi-morph arm changes the height of the inner mirror at its connection point to the arm. Since the inner mirror is held by 3 identical arms it can be tilted in any direction.

Phase Modulation:

Applying the same voltage to all three arms, the mirror will move parallel to its surface while its tilt remains constant. This feature can be used for optical phase modulation.

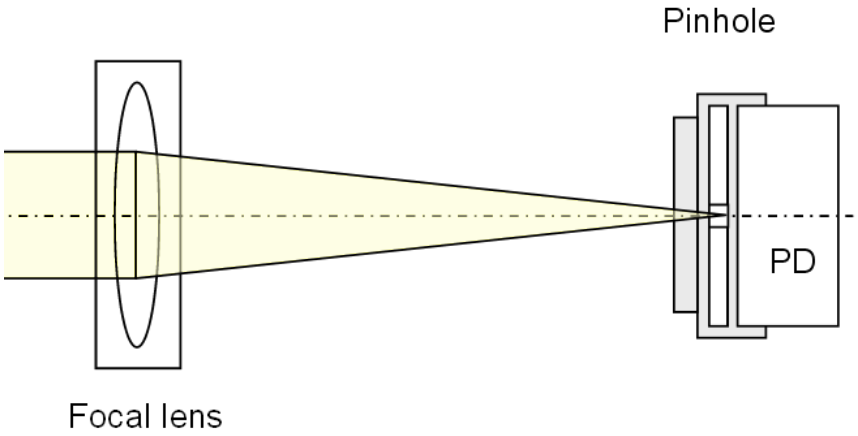
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2.4 Closed Loop Control

The DMP40 software allows closed loop control of a sensor and the DMP40 to be set up in order to achieve flat, spherical or other wavefront shapes. Basically, there are two methods to build closed loop feedback: either by using a photo detector with the analog feedback input 15 of the DMP40 or by using a wavefront sensor with the respective software solution.

Analog Feedback Loop

A part of the manipulated beam, derived from a polarization independent beam splitter, is directed via a focusing lens and a pin hole onto a photo detector PD. The output signal of the photo detector is connected to an Analog Feedback Connector 59 (not included). This Analog Feedback Connector can then be plugged into the DMP40 analog feedback input jack 15. The feedback values can be used to optimize the adaptively adjusted wavefront. A simple max search algorithm can be programmed (not included in the GUI or driver) to optimize the wavefront without a Wavefront Sensor.



This feedback method works for 2 cases:

1. Flat Wavefront

If the beam focus is located exactly in the plane of the pinhole, the optical power incident on the photo detector will be at a maximum in the case of an ideally flat wavefront.

2. Spherical Wavefront

If the focal point is located in front of or behind the pinhole, the optical power into the photo detector will be maximized when the wavefront is spherical.

The analog feedback input (1) 15 (2.5 mm stereo jack) of the DMP40 provides two separate inputs dedicated to voltage and current feedback signals. The current input can be connected directly to a photodiode.

Note

There is no internal calibration for the current and voltage values. These are just feedback values that are suited for maximum search algorithms but not for exact measurements!

Wavefront Sensor Feedback Loop

Using the measurement results of a Thorlabs Wavefront Sensor, the DMP40 software can control the wavefront reflected from the DMP40 according to the settings. This way it is possible to generate a flat wavefront.

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The DMP40 software uses the wavefront sensor measurement data provided via the WFS DataSocket interface (included with the wavefront sensor software).

In the section Closed Loop Control 38 of this manual, this control loop method is described and illustrated.

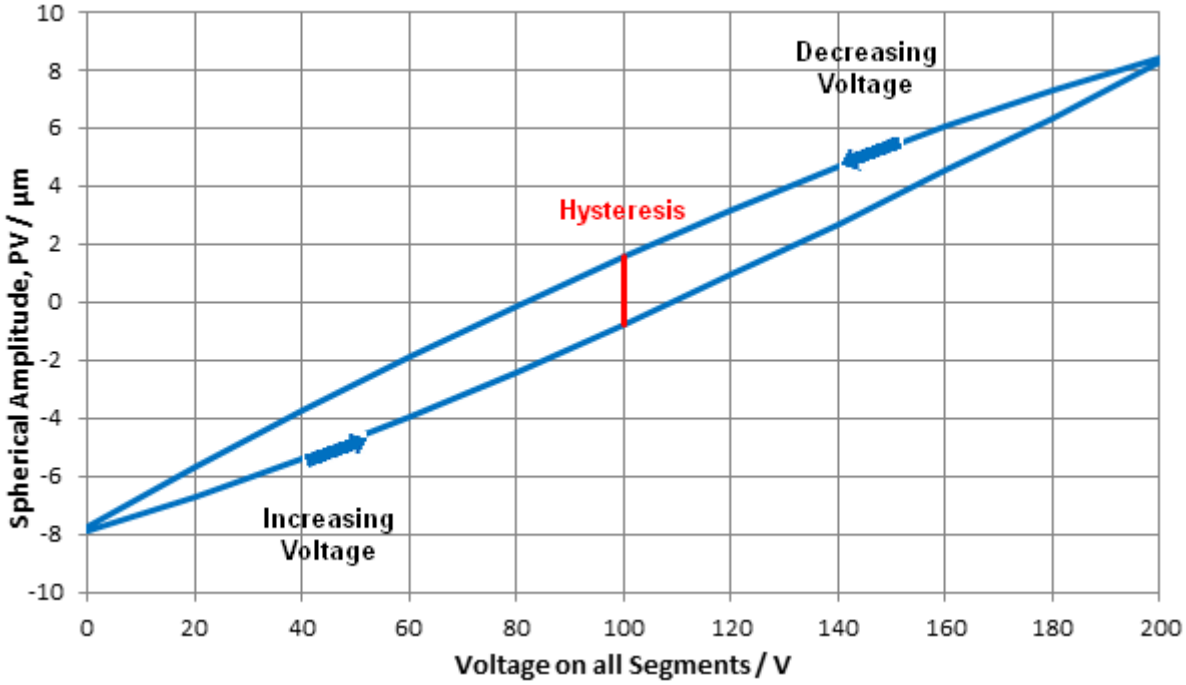
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2.5 Hysteresis of Piezoelectric Materials

Hysteresis is a well known effect in ferromagnetic and ferroelectric materials.

Due to the hysteresis of the PZT (lead zirconate titanate) material, that is used for the Deformable Mirror, the mirror stroke depends not only on the actual applied control voltages, but also on the "history" of recent changes. This "memory effect" is caused by internal states of the material that differ for increasing and decreasing voltages.

Due to the hysteresis effect, the mirror stroke does not follow the same track each time the control voltage is increased or decreased. The diagram below shows a typical hysteresis curve of the spherical deformation at a voltage oscillation between 0 V and 200 V (i.e., the same voltage change is applied to all 40 mirror segments).



DMP40 Hysteresis Curve

The hysteresis is expressed as the maximum difference divided by the maximum stroke between the two tracks. For this particular sample the hysteresis is 2.3 µm or - related to the total stroke range of 16.3 µm - 14%. The max. hysteresis of the used material for the DMP40 is 20%.

For this reason, a control voltage of 100 V (half of the maximum control voltage) will not always produce a flat mirror (zero spherical deformation); the previous control voltage needs to be taken into account. For instance, a flat shape is achieved when the voltage is increased from 0V towards 114V and the same shape is achieved when decreasing the voltage from 200V down to 82V.

Note

The maximum concave and the maximum convex stroke may differ slightly as well!

Hysteresis Compensation

The DMP40 software incorporates a hysteresis compensation. The driver software monitors all consecutive voltage changes for each segment and the three spiral arms individually and applies a corrected voltage, calculated based on a mathematical algorithm, to the mirror segments.

Consequently, when controlling the DMP40 via the DMP40 software, the mirror behaves almost like a mirror without a hysteresis effect. Both tracks of the hysteresis curve will collapse to a straight line.

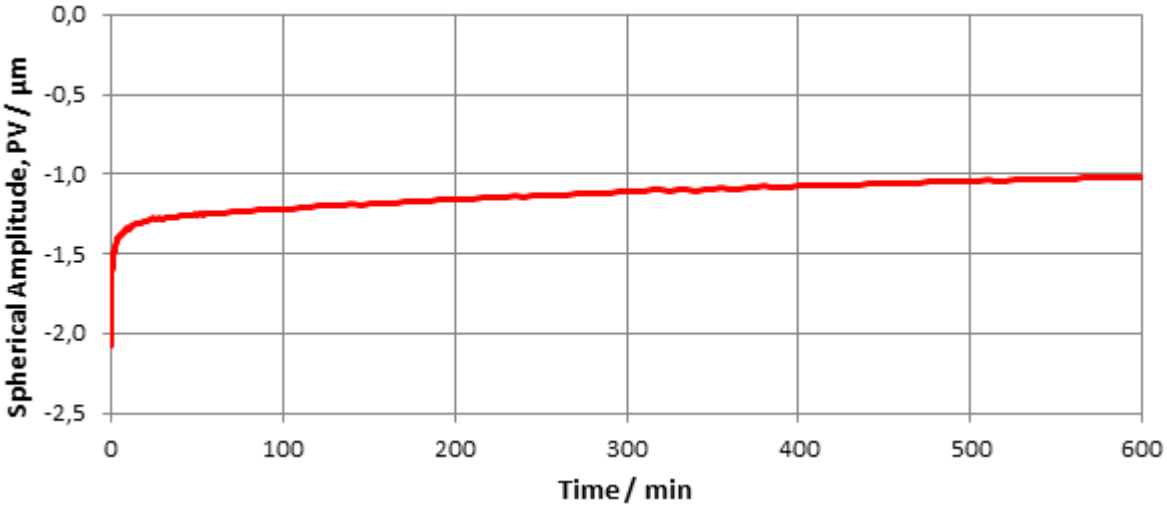
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2.6 Creep of Piezoelectric Materials

The creep effect is known in material science as a slow movement or deformation of a material under the influence of an external stress.

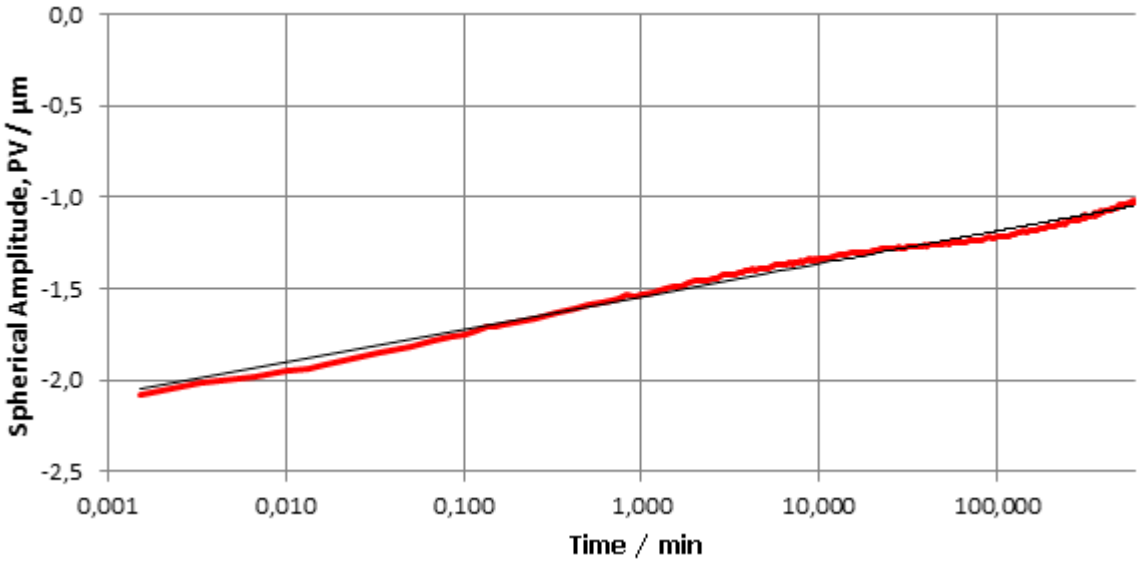
In piezoelectric materials, a creep effect is considered the continuing material expansion or shrinking after a voltage change was applied. The creep effect lets the piezoelectric material continue its mechanical change in the same direction as was induced by the last voltage step. The resulting stroke change is logarithmically dependent on time, which means that the creep speed decreases over the time, but never actually ceases.

After power-on, all DMP40 control voltages are set to 100V in order to get a nearly flat shape. Since the piezo material was at zero voltage for a long time before, the voltage step from 0 to 100V causes an immediate jump, followed by a long-term drift.



Drift after Power-On (Linear Time Scale)

The majority of the creep is observed within half an hour but it goes on over many hours. In logarithmic scale the drift appears as a nearly straight line:



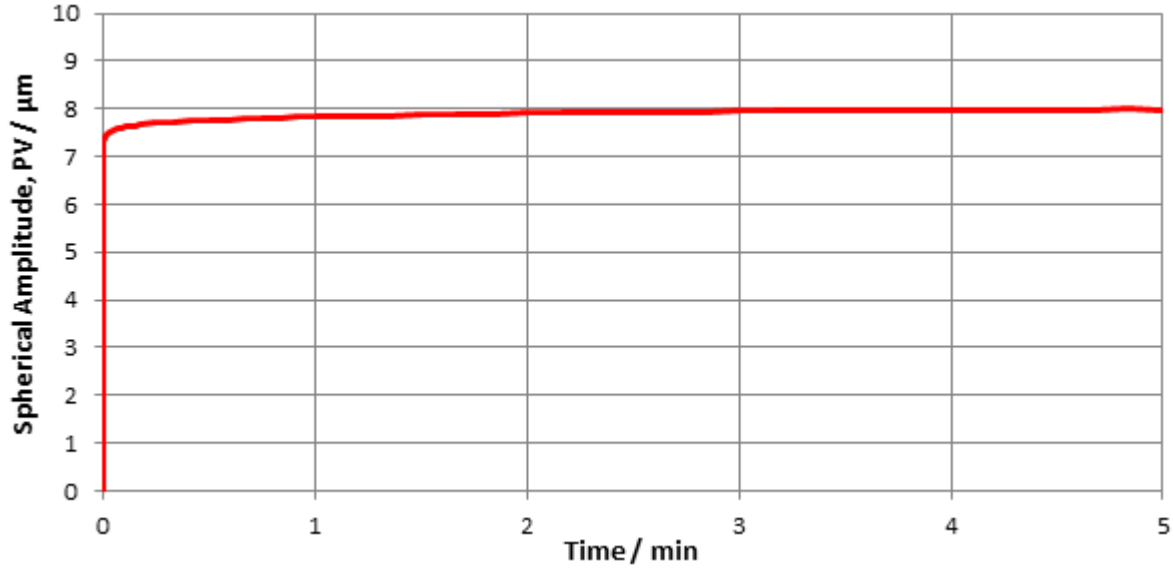
Drift after Power-On (Logarithmic Time Scale)

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Relaxing the Creep

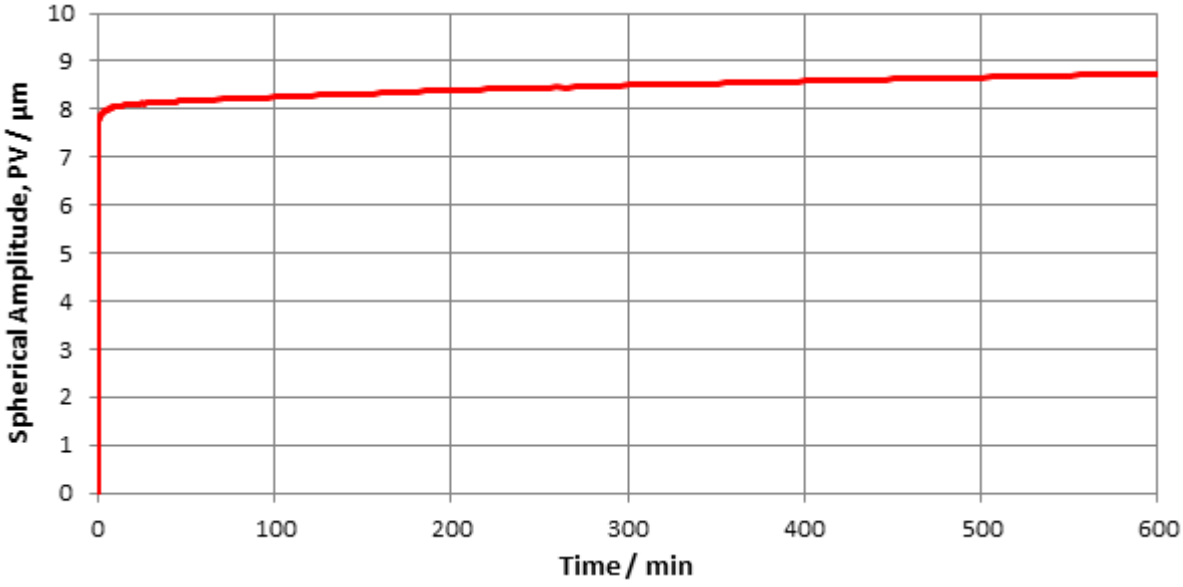
The DMP40 software offers a Relax 14 function. Pressing the appropriate button, the control voltages of all segments are increased and decreased sequentially, starting at the full range (0 to 200 V) with subsequent decreasing amplitude, reaching at the end the mean voltage of 100 V. This way the time required to come to a stable and nearly flat mirror shape is shortened drastically.

Drift effects occur whenever the mirror's control voltage is changed. For instance, a step from 100V to 200V on all segments causes a step from zero to about 7.5 µm spherical amplitude.



Drift after 100 V -> 200 V Step (Short Term)

Although this 7.5 µm deflection seems to be stable after a few minutes, there is a long-term drift towards 8.8 µm after 10 hours:



Drift after 100 V -> 200 V Step (Long Term)

Creep Consequences

Consider the creep effect particularly when performing adaptive correction using a feedback loop control: As long as the control loop is closed, slow drift effects of the DMP40 are corrected automatically.

As soon as the loop control is stopped, the last voltage pattern remains applied to the mirror segments, but the physical mirror shape will start a slow, continuous creep which leads to a wavefront drift.

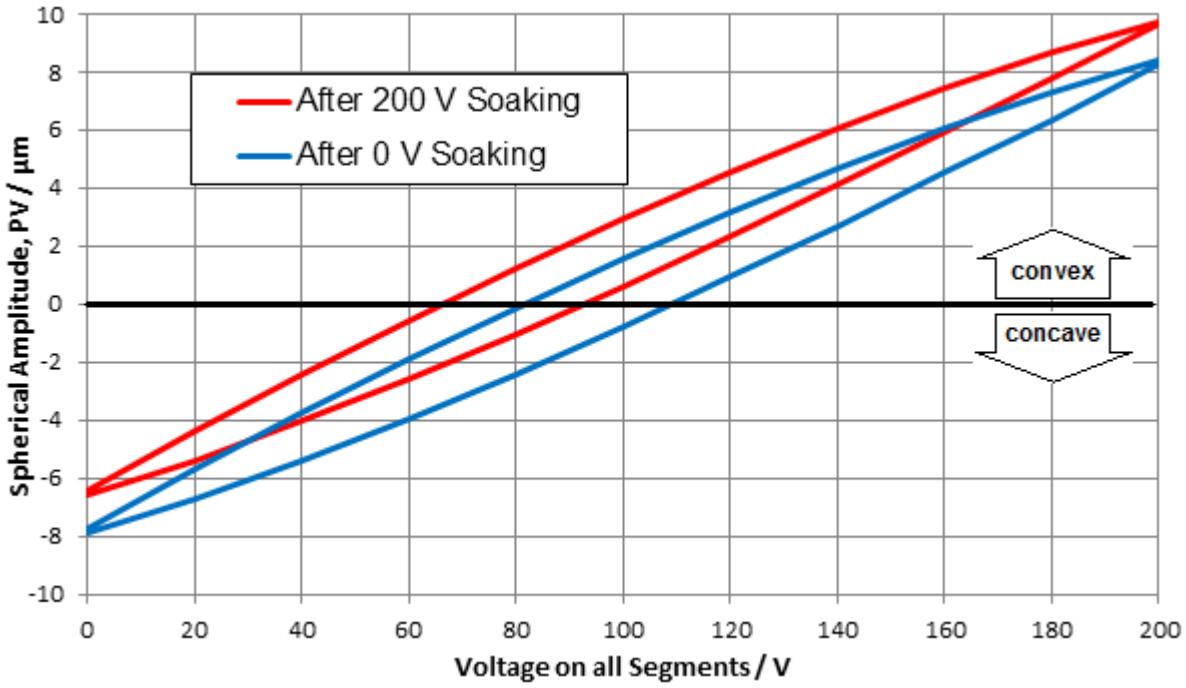
Note

Even if a voltage pattern that produced a defined wavefront is reproduced exactly, the original defined wavefront will not be reproduced exactly.

The DMP40 software is not able to compensate for the creep effect. Creeping can be eliminated only within a closed loop control system. In other words, piezoelectric deformable mirrors cannot be used to exactly set a deterministic wavefront distortion.

Shift of Hysteresis Curve

Finally, the creep overlays the hysteresis, so that the hysteresis curve will be shifted, depending on the voltage applied to all segments before measuring the hysteresis curve. The diagram below illustrates that.



Shift of Hysteresis Curve

The creep effect is present regardless of whether the DMP40 is switched on or off. After the DMP40 was switched-off for a long period, the hysteresis was measured. The creep let the mirror's concave shape at 0 V increase, which leads to a shift of the hysteresis curve downwards (blue curve).

Then a segment voltage of 200 V was applied for several hours. The hysteresis (red curve) is shifted by about 1.4 µm towards convex direction, equivalent to about 8% of the spherical range.

However, both hysteresis amplitudes are equal, they are just shifted.

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2.7 Relaxing the Mirror

In the previous chapters some essential properties of piezoelectric materials - hysteresis and creep (drift) - were described in detail. These properties have a non-negligible impact on the control of the mirror surface by applying voltages. The resulting surface shape depends not only on the present voltage pattern, but also on the "history" of previous changes.

Example: Assume a starting condition where the mirror was flat at 100 V

1. The segment voltage has been changed from 100 V to 200 V (maximum convexity), and then back to 100 V.
   In this case, the hysteresis' impact 10 is that after applying 100 V the mirror remains somewhat convex. The creep effect, on the other hand, makes the surface continue to move in the direction of the last adjustment: the mirror surface becomes more and more flat. If we wait long enough, it will become concave.
2. The segment voltage has been changed from 100V to 0V (maximum concavity) and then back to 100V.
   This is the opposite case: The mirror remains slightly concave due to hysteresis, and continues to flatten over time due to creep.

The effects described above are more significant, the larger the change in the applied voltage.

The DMP40 software provides a Relax feature to eliminate or at least to minimize the above impacts. It will carry out 3 steps:

1. Remember the actual voltage pattern
2. Damped oscillation of the applied voltage symmetrically with respect to the original voltage. This means that to a segment with an initial voltage of 100V a "sequence" of 200 V - 0 V - 190 V - 10 V -... 110 V - 90 V - 100V will be applied during relax. This maximum relax amplitude will be the less the closer the initial segment voltage was to the limit (0 V or 200 V).
3. Restore the voltage pattern that was present prior to Relax

This way, the mirror is moved in both directions with decreasing amplitude so that hysteresis and creep (drift) effects will be minimized.

When should the **Relax** be done?

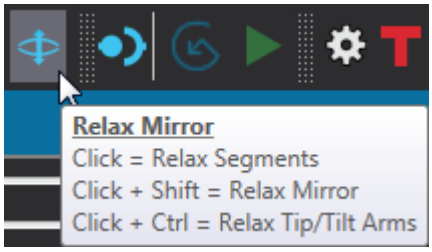
Relax is recommended to prevent recently-made large voltage changes from impacting the next experiment, e.g.:

- after starting up the software
- after applying voltage patterns and their subsequent restoration
- prior to a new experiment
- prior to starting closed loop control using a wave front sensor

Relax segments, tip/tilt arms and the entire mirror

There are 3 relax options:

- Relax the inner mirror segments only: Just click the 'Relax' button
- Relax the tip/tilt arms only: Press 'Control' key and click the 'Relax' button
- Relax the entire mirror: Press 'Shift' key and click the 'Relax' button.



An appropriate tool tip appears when hovering the mouse over the the the 'Relax' button.

3 Getting Started

Inspect the shipping container for damage.

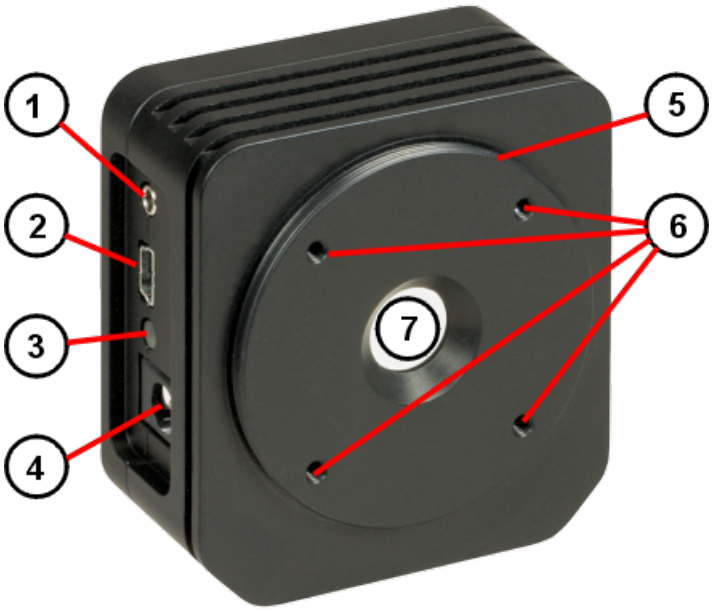
If the shipping container seems to be damaged, keep it until you have inspected the contents and you have inspected the DMP40 mechanically and electrically.

Verify that you have received the following items within the package:

3.1 Parts List

1. DMP40-x01 Deformable Mirror
2. USB 2.0 cable A to Mini B, length 1.5 m
3. Power supply 100 to 240 V AC to 12 V / 1.5A DC
4. Power Cord
5. Quick Start

3.2 Operating Elements



1 Analog feedback inputs

2 USB connector

3 Status LED:
Red: USB connected, DC power failure (no DC input recognized)
Green: Ready

4 Power supply input

5 SM2 outer thread

6 4-40 inner threads, 5 mm depth (for mounting to Thorlabs cage system)

7 Optical aperture

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3.3 Installing Software

Note

Do not connect the DMP40 to the PC prior to software installation!

Attention

Exit all running applications on your PC as the installer may require a reboot of your PC during installation!

Software download

Please download the software package from the software tab of the product website. The most recent version of the software will always be available online.

Click the Software button to download the DMP40 Software ZIP archive, unpack it and open the installation folder. Double click the application setup.exe.

Note

Depending on your Windows® Security and User Account Control settings, warnings may appear several times during the installation process, asking to allow software installation. Please confirm that when appropriate in order to proceed with a proper software installation.

The installer checks if Microsoft® .NET Framework 4.6.2 is installed already and requires the installation of eventually missing components. An appropriate status message appears - click "Install".

Usually, the Microsoft® .NET Framework is already installed and updated during the Windows® Update process. After finishing the .Net Framework installation, the installer may require a reboot of the computer. Please do so.

After the reboot, the installer continues with installing the DMP40 software.

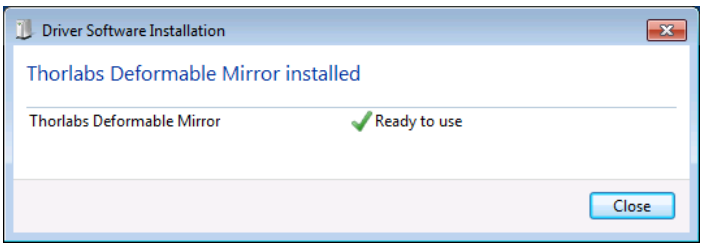
A Readme screen comes up with important information about the installed software.

Click **Next >** and in the next screen **Finish** to finalize installation process.

3.4 First Steps

After installing the DMP40 software and mounting the DMP40 to the optical setup, proceed with the following steps:

1. Connect the power supply to the mains outlet using the provided power cord.
2. Connect the DC output of the power supply to the DC input (4) 15 and make sure the status LED (3) lights up, first red and finally green.
3. Connect the USB cable to the DMP40 and to the PC.
4. The operating system recognizes the connected DMP40 and installs necessary software components (device driver).



5. Start the DMP40 software from the desktop icon.
6. The application starts and automatically connects to the DMP40.

Note

Pressing the keyboard button **F1** calls up the context sensitive online help to the DMP40 software.

3.5 Out-of-the-Box Test

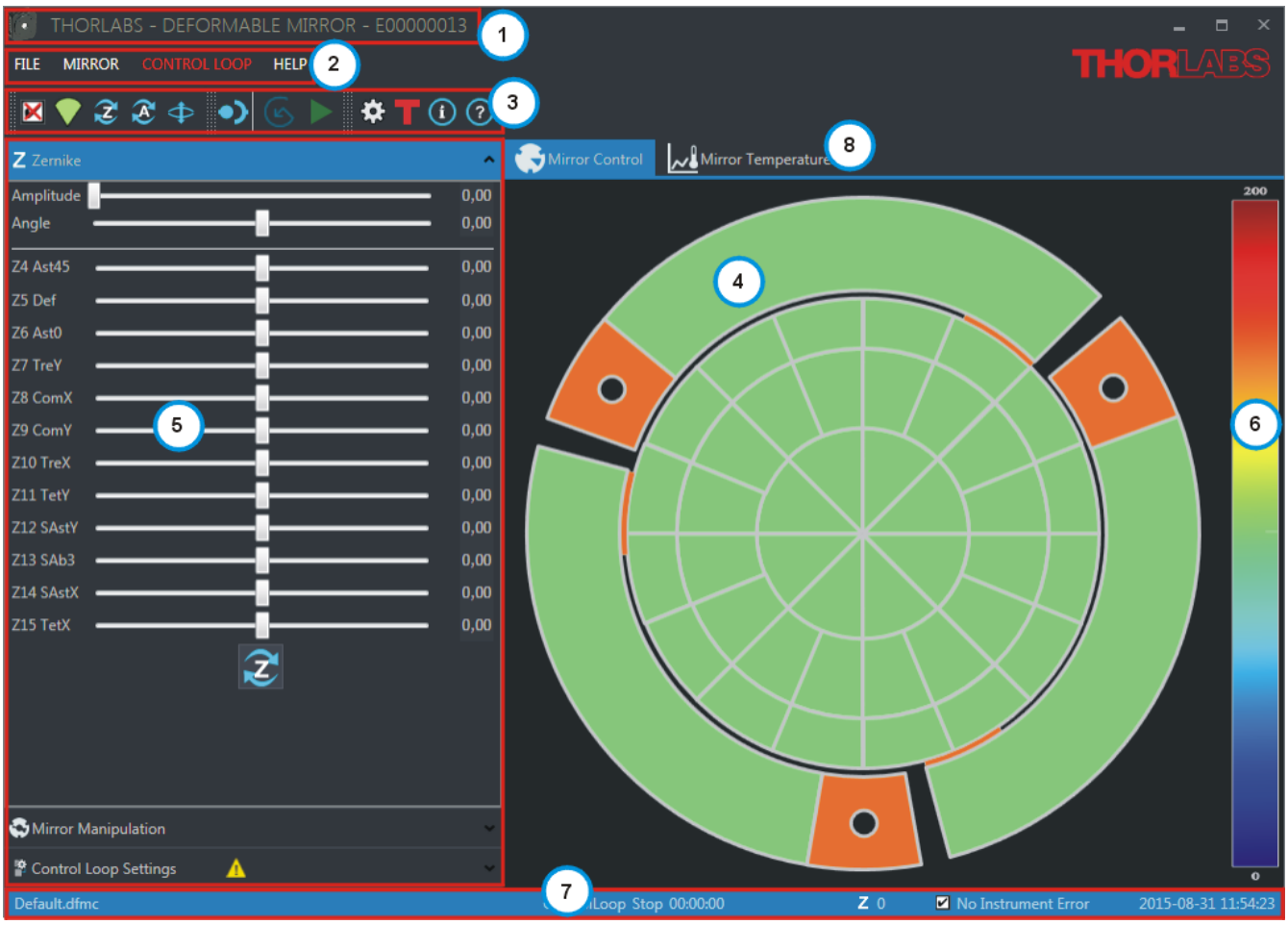
It is simple to test the DMP40 "out of the box". You do not need even a light source or other optical equipment - just your eyes:

- Connect the DMP40 to the power supply and to the PC with installed software.
- Start the Deformable Mirror software. The DMP40 is initialized.
- Look onto the mirror surface and change the position until you can see your eye's pupil.
- Press the "Relax" button in the toolbar and observe the diameter of your pupil. The Relax function changes the mirror segment voltages in such way that the mirror surface alternates between concave and convex, changing the diameter of the reflected pupil of your eyes.

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4 Operation

After connecting the DMP40 and starting the software, the default GUI window opens:



1 GUI Header 18
2 Menu Bar 19
3 Tool Bar 22
4 Mirror Control Panel 24
5 Control Panel 27
6 Color Bar (Mirror voltages) 33
7 Status Bar 34
8 Mirror Temperature Display 35

4.1 GUI Header

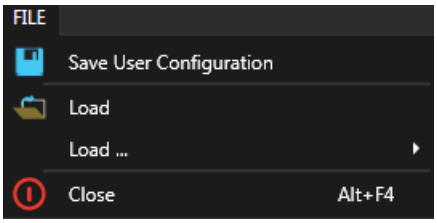
The header of the graphical user interface indicates the recognized product and its serial number by default. If the device status changes (e.g., the DMP40 is disconnected or the DMP40 power supply fails), the color turns to red and the present status is given.

For details, please refer to section Troubleshooting 52.

4.2 Menu Bar



The FILE menu allows you to save or load deformable mirror data.

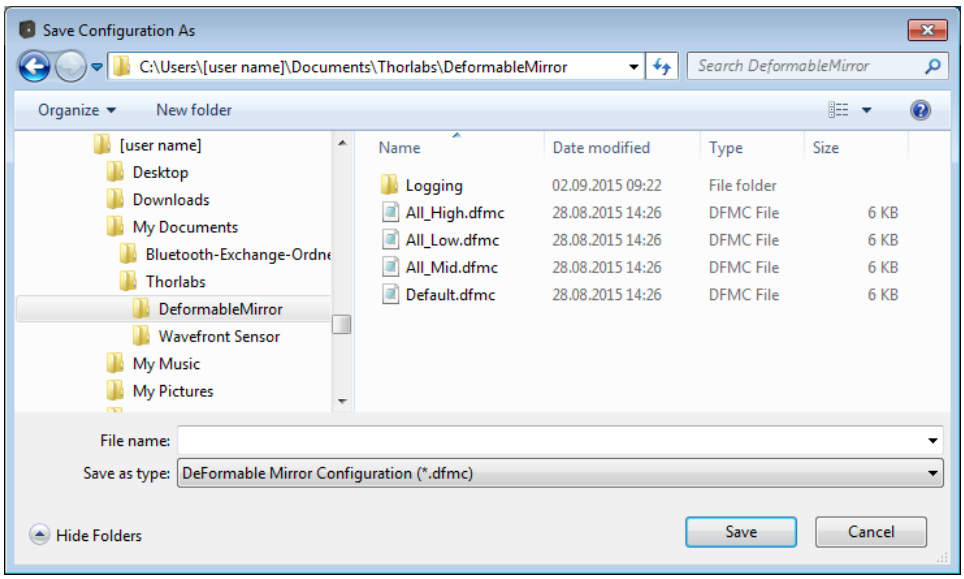


The file format is ***.dfmc** (Deformable Mirror Configuration). A configuration file is comprised of three main parts:

- General information: Information about software version, driver version and the recognized instrument
- Application settings
  - Size and position of the GUI
  - Active Control Panel 27
  - Color style 33
  - ID overlay status 20
  - Zernike pattern orientation 23
  - Control Loop settings 21 (delay, selected Zernikes)
- Data
  - Status of hysteresis compensation
  - Voltage pattern that is applied to tip tilt arms and inner mirror segments
  - Zernike slider positions

Save User Configuration

You can save (and restore via the **Load** function) your present configuration at any time:



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Indicate a file name and click the **Save** button. This way, a configuration can be used, for example, to duplicate a setup or to save a configuration for future use.

Load

This menu item allows any user configuration file to be loaded. With this option, all application settings and DMP40 data (Zernike slider positions and segment voltages) can be restored easily.

Note

With updating the DPM40 software from older versions, the file structure of the configuration files may have changed form .dmfd to .dmfc. The .dmfd files will not readily be recognized by the new software version. Please follow the steps described in the section troubleshooting 55, loading .dmfd files.

Load ... Data (Zernike and Voltages) Only

Using this option, only data 37 are loaded, while application settings remain unchanged. In this case, only the Zernike and voltage data is retrieved from the selected .dfmc file.

Note Loading data from a *.dfmc file just reproduces and applies the saved voltage pattern and Zernike positions. Due to the piezoelectric properties (see Hysteresis of Piezoelectric Materials 10 and Creep of Piezoelectric Materials 11), the surface shape generated by the DMP40 will not exactly reproduce the original surface shape from the previous application of these parameters!

Note Data reconstruction will be correct only if the settings for Flip and Rotate are the same as at the moment the data were saved.

Load ... Settings Only

In contrast to the previous function, here only application settings 37 are retrieved from the selected *.dfmc file. Segment voltages and Zernike slider positions remain unchanged.

Close

The application will be closed.

Note

When closing the application, all settings and data will be saved automatically.

The MIRROR Control Menu



Cancel Segment Selection deselects the selected segments, see section Segment Control 26.

Enable Index Overlay is a toggle button to enable/disable the numbering of the mirror segments.

Home Zernike resets all Zernike sliders to the home position. Please note that manipulating Zernikes applies a voltage shift to all of the mirror segments related to this Zernike coefficient. In other words, this is a voltage offset, not an absolute voltage!

Resetting Zernike sliders to home position means that the appropriate Zernike coefficients are set to zero. The voltage pattern on the mirror segments is generated accordingly.

Any segment voltages that were generated by direct mirror segment manipulation 31, will remain unchanged after homing Zernikes.

Restore resets all Zernike sliders to the home position and the voltage of all mirror segments and arms to 100 V.

Relax is a function that removes mechanical tensions in the mirror. For details, please see section Relaxing the Mirror 14. There are 3 relax options: Relax the inner mirror segments only (just click the Relax function), relax the tip/tilt arms only (press 'Control' key and click) or relax the entire mirror (press 'Shift' key and click).

Hysteresis Compensation



The last topic in the **Mirror** control menu can be expanded in order to enable/disable the hysteresis compensation 10 for the mirror segments / arms.

By default, the hysteresis compensation is enabled. However, if it is desirable to analyze hysteresis effects on the mirror shape, the hysteresis compensation can be disabled by unchecking the appropriate box(es).

The CONTROL LOOP Settings Menu

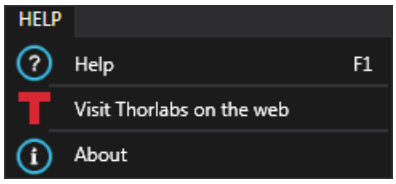


This is a short menu to enable / disable the Zernike coefficients used for closed loop control. A red colored menu topic indicates that no Zernikes are selected.

Select the desired Zernike coefficients that you want to maintain ZERO during closed loop control.

In the Control Panel, tab Control Loop Settings 32, this selection can be made as well.

The HELP Menu



The keyboard button **F1** brings up the online help - either the entire help document or context sensitive.

Note

Context sensitive help means that the online help opens at the point that describes the selected functionality.

Example: A Zernike slider was moved. Pressing F1 brings up the Zernike Control section of the help file.

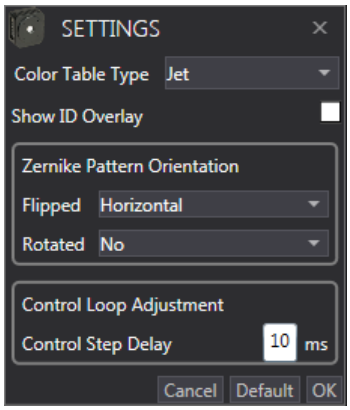
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4.3 Toolbar



- Cancel Segment Selection: Manually selected single segments 25 or groups of segments 26 are being deselected.
- Toggle button to enable/disable the numbering of the mirror segments.
- Home Zernike 27: Sets all Zernike coefficients to zero. Voltage patterns on the segments resulting from manual direct mirror manipulation, will remain.
- Restore: Sets all Zernike coefficients to zero and all segment and arm voltages to 100 V.
- Relax 14 the mirror: There are 3 relax options: Relax the inner mirror segments only (just click the Relax function), relax the tip/tilt arms only (press 'Control' key and click) or relax the entire mirror (press 'Shift' key and click).
- DataSocket Server Connection (toggle icon and status return)
- Closed Loop Parameter Determination 41
- Enable / disable the loop control 43
- Opens the Common Settings 23 dialog (see below)
- Resets the application completely to the initial state 37 after installation.
- Opens the link to the Thorlabs web site
- Opens the About 51 box
- Opens the online Help

4.4 Common Settings



Color Table: There are 7 different color styles to choose from. See Color Bar 33.

Show ID Overlay: Check the box to display the segment indices.

Zernike Pattern Orientation

The DMP40 software calculations for closed loop control depend on the optical setup, particularly how optical elements in the optical path between the DMP40 surface and the wave front sensor influence the image orientation, or in other words the Zernike pattern orientation. Mirrors and beam splitters flip the image. Also, there may be a rotation between the XY axes of the DMP40 and the WFS. All this can be compensated manually in this menu. The pattern can be flipped horizontally, vertically, or by a rotation angle of 0°, 45°, 90° or 135°. Besides the manual correction, the DMP40 software is able to analyze the Zernike pattern orientation automatically - please see section Control Loop Determination 41.

Note

Any changes that are made manually to **Zernike Pattern Orientation** in this panel will overcome the results of the Control Loop Determination results! In other words, if you change **Flip** and/or **Rotate** after an automatic adjustment was carried out, the control loop will not work correctly.

Control Loop Adjustment

Control Step Delay is the delay time in milliseconds between setting a Zernike pattern for loop control and retrieving the next data from the WFS via DataSocket.

Click **Default** to apply default settings:

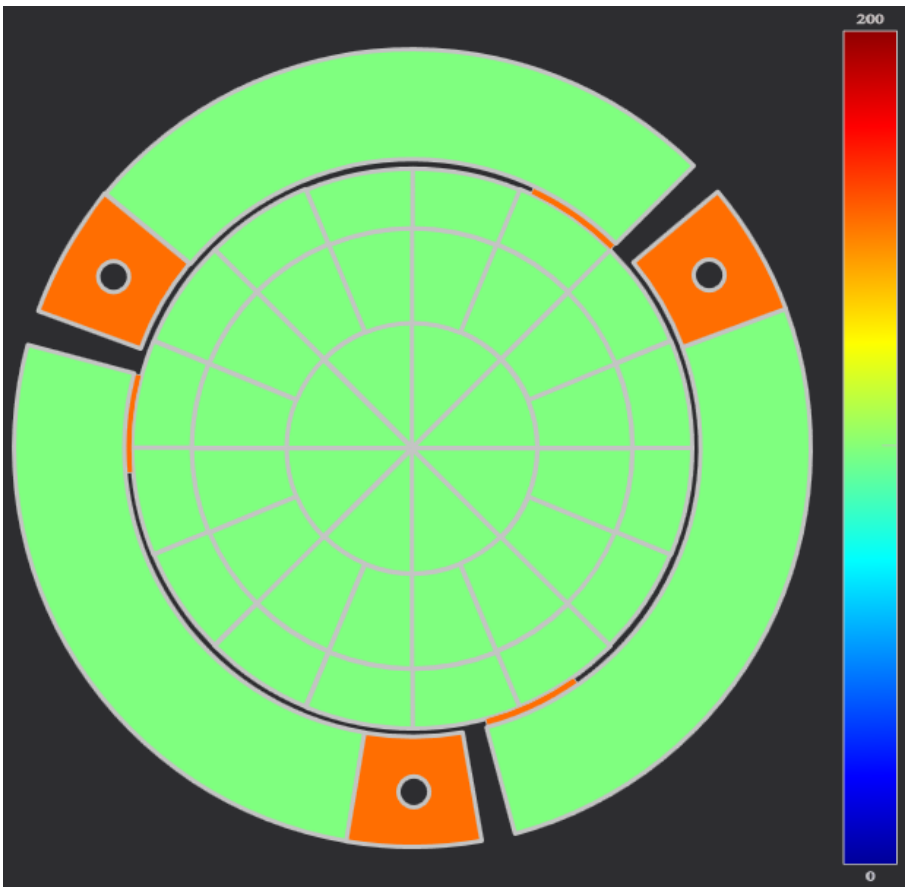
- Color Table = Jet
- Show ID Overlay = disabled
- Zernike Pattern Orientation: Flip = horizontal, Rotate = none
- Control Step Delay = 10 ms

Click **OK** to apply changes or **Cancel** to discard them.

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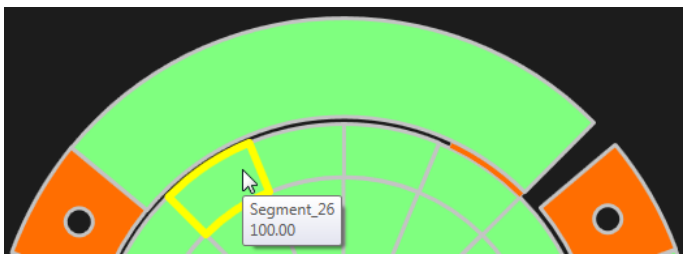
4.5 Display Mirror Control

The default start screen of the DMP40 software shows the mirror segments and the voltages applied to the segments and spiral arms.



The color of the mirror segments represents the applied voltage according to the color scheme displayed in the color bar to the left. The color scheme can be changed in the Settings 23 menu.

Hovering the mouse over a mirror segment causes a window to appear where the segment number and the applied voltage are displayed:

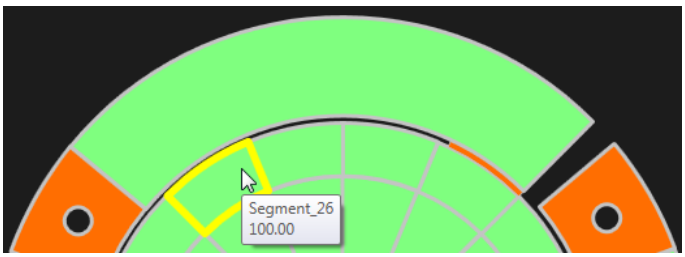


4.5.1 Individual Segment Control

Single Segment Control

The individual segment voltages can be changed:

1. Move the mouse over the segment. When the segment voltage is displayed, turn the mouse wheel. The segment color changes in accordance with the voltage:



2. Hover the mouse over the segment, then click right mouse button. A dialog opens.



Shifting the slider results in a coarse voltage change (see displayed numeric value and segment color). Alternatively, you can input the desired voltage numerically. Finally, using the mouse scroll wheel (or cursor buttons), the segment voltage can be changed with the following increments:

			Increment
Ctrl +	Mouse Wheel	(←↑↓→)	0.2 V
	Mouse Wheel	(←↑↓→)	1.0 V
Shift+	Mouse Wheel	(←↑↓→)	10.0 V

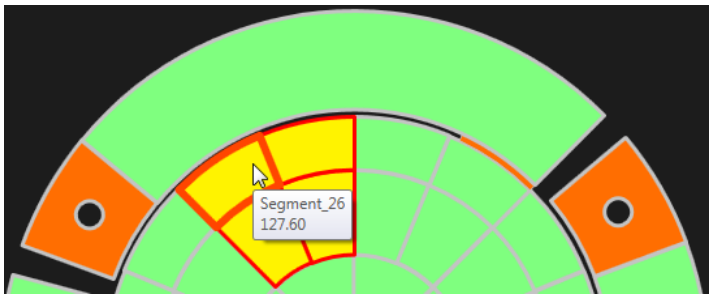
Note

"Restore (Ctrl+A)" resets the voltage of ***all segments and arms*** to 100 V. Additionally, all Zernike sliders are set to zero.

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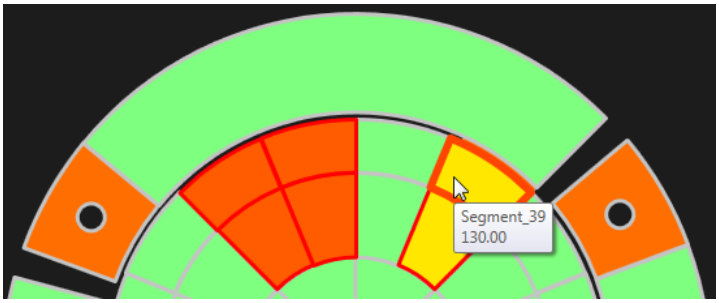
4.5.2 Control in Arbitrary Groups of Segments

Left click on a segment / spiral arm to select it. Selected parts appear with a red rim. Place the mouse pointer over a selected segment / spiral arm and turn the mouse wheel. The voltages of all selected elements will change with the same increment:



Notes

- If the elements were set previously to a selection of different voltages, the change will apply as an offset to all segments:



- By right clicking on a selected element, the slider in the pop up window allows you to change only the individual segment voltage.
- Press the  button to cancel selection of segments.

4.6 Control Panel

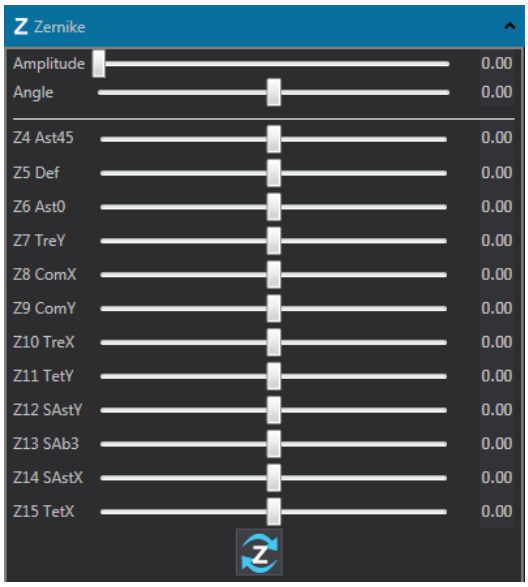
The control panel on the left side is designed in an "outlook bar" style, where only the active tab is expanded and highlighted. Three panels are available:

- Zernike Control 27
- Mirror Manipulation 31
- Control Loop Settings 32

Click to the desired panel header to expand it.

4.6.1 Zernike Control

The **Zernike** manipulation panel allows a predefined voltage pattern to be applied on all segments in order to introduce deterministic distortions to the reflected wavefront or to compensate for distortions of the incident wavefront.



The button (Zernike Home) ***resets all*** Zernike sliders to their home position. Double click the Zernike name (e.g. "Z5 Def") to ***reset the appropriate*** Zernike to its home position.

Note

Resetting Zernike sliders to home position means that the appropriate Zernike coefficients are set to zero. The voltage pattern on the mirror segments is generated accordingly.

Any segment voltages that were generated by direct mirror segment manipulation 31, will remain unchanged after homing Zernikes.

4.6.1.1 Tip / Tilt Control



When changing the voltages on the spiral arms, the entire mirror surface is tipped and tilted. As the DMP40 uses 3 arms, the direct control of Tip X (Z2) and Tilt Y (Z3) is not possible. However, Tip X and Tilt Y do not introduce wavefront distortions - they just change the pointing

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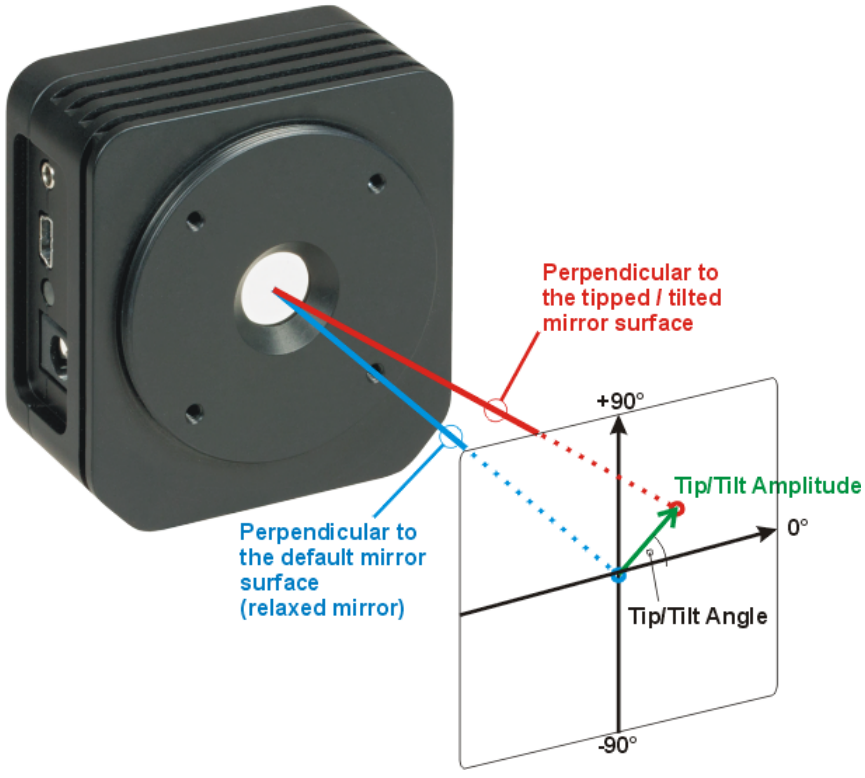
direction of the entire mirror surface (segments). For this reason, the DMP40 software supports the manipulation of the tip/tilt angle and amplitude.

The tip/tilt angle and amplitude are defined relative to a plane that is parallel to the surface of the mirror in the relaxed position, as shown in the drawing below. Consider an XY coordinate system in this plane, with the X-axis parallel to the base of the mirror's housing.

The **tip/tilt angle** is the angle between the x-axis and a projection of the normal to the mirror's surface onto the plane parallel to the mirror's relaxed position, as shown in the drawing below. It can be set to a value from -180 to +180 degree.

The **tip/tilt amplitude** describes, how much the mirror is tipped/tilted. It scales with the magnitude of the projection of the normal to the mirror's surface onto the XY plan parallel to the home position. For the purposes of the mirror software, it has been normalized and can be scaled from 0 to +1.

The following figure below illustrates that by a projection of the perpendicular to the mirror surface onto a screen, that is located in front of the mirror. You can imagine this as the deviation of a light beam, that is reflected from the mirror surface.



Tip/Tilt Manipulation: Amplitude and Angle



The upper part of this panel has two sliders, named "Amplitude" and "Angle".

The amplitude can be changed

- numerically: enter a value between 0.00 and 1.00
- coarse: by dragging the slider
- fine with 3 different increments (see the following table):

			Increment
Ctrl +	Mouse Wheel	(←↑↓→)	0.01
	Mouse Wheel	(←↑↓→)	0.05
Shift+	Mouse Wheel	(←↑↓→)	0.1

The angle can be changed

- numerically: enter a value between -180° and +180°
- coarse: by dragging the slider
- fine with 3 different increments:

			Increment
Ctrl +	Mouse Wheel	(←↑↓→)	0.2
	Mouse Wheel	(←↑↓→)	1.0
Shift+	Mouse Wheel	(←↑↓→)	10.0

Note

The color of the tip-tilt arms represents the setpoint value of the voltage that is calculated for the desired tilt. With hysteresis compensation 10 enabled, the physical voltage applied to the piezoelectric arms is different but not shown.

Double click the wording **Amplitude** or **Angle** to ***reset this*** to its home position.

Press the  (Zernike Home) button to ***reset all*** Zernike sliders, including the Amplitude and Angle sliders, to their home position.

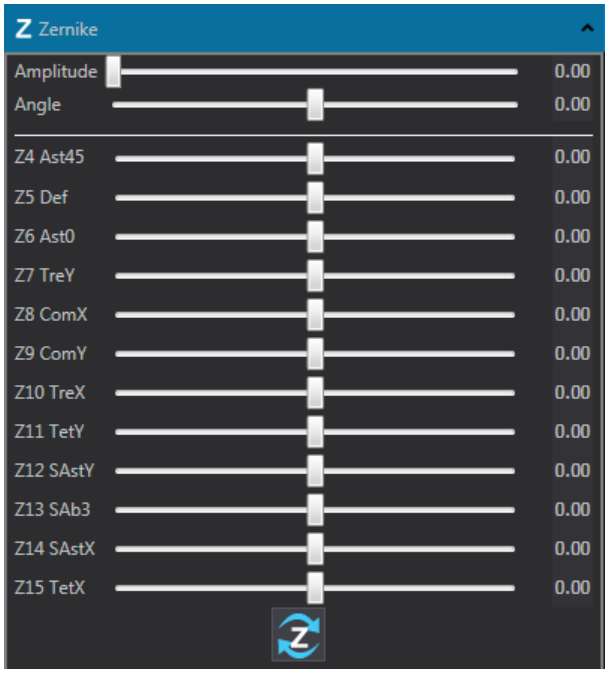
Note

Resetting Zernike sliders to home position means that the appropriate Zernike coefficients are set to zero. The voltage pattern on the mirror segments is generated accordingly.

Any segment voltages that were generated by direct mirror segment manipulation 31, will remain unchanged after homing Zernikes.

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4.6.1.2 Zernike Control of Higher Order



The sliders for control of Zernike Z4 to Z15 are located below the sliders for "Amplitude" and "Angle".

These controls allow a predefined segment voltage pattern to be set up that introduces a wavefront distortion described by the selected Zernike coefficient. The sliders allow you to change Zernikes within a control range that is limited by the stroke of individual segments. Due to the dependency on the optical setup, materials used in the beam propagation path, and specific piezoelectric effects, the control range cannot be calibrated in absolute values.

Control sliders and numerical inputs allow each Zernike to be set within a relative range between -1 and +1.

In the closed loop control mode, the sliders show the correction of the mirror surface that is necessary to maintain a given wavefront.

Shifting the slider results in a coarse Zernike change. Alternatively, you can input the desired value numerically. Finally, using the mouse scroll wheel (or cursor buttons), the slider value can be changed with the following increments:

			Increment
Ctrl +	Mouse Wheel	(←↑↓→)	0.01
	Mouse Wheel	(←↑↓→)	0.05
Shift+	Mouse Wheel	(←↑↓→)	0.1

Double click the Zernike name (e.g. "Z5 Def") to ***reset the appropriate*** Zernike to its home position.

Press the (Zernike Home) button to ***reset all*** Zernike sliders, including the Amplitude and Angle sliders, to their home position.

Note

Resetting Zernike sliders to home position means that the appropriate Zernike coefficients are set to zero. The voltage pattern on the mirror segments is generated accordingly.

Any segment voltages that were generated by direct mirror segment manipulation 31, will remain unchanged after homing Zernikes.

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4.6.2 Mirror Manipulation

In the tab **Mirror Manipulation**, segment rings and/or sectors (eighths of the mirror surface) can be selected to be manipulated simultaneously.



Ring Selection

No.	Ring	Segments
1	inner	1 to 8
2	middle	9 to 24
3	outer	25 to 40

Eighths Selection

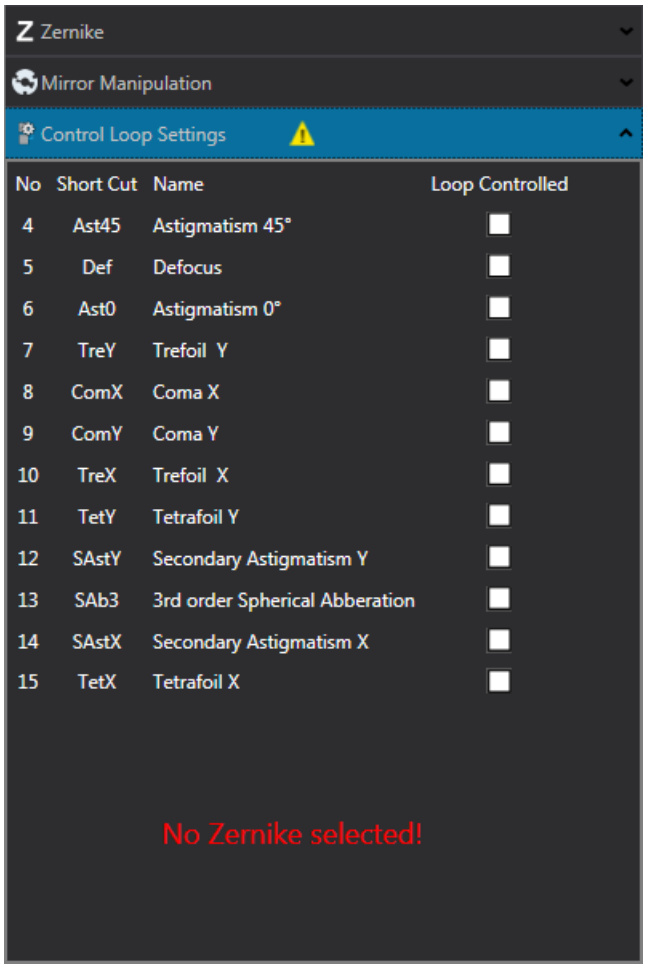
No.	Segments
4	1, 9, 10, 25, 26
5	2, 11,12, 27, 28
6	3, 13, 14, 29, 30
7	4, 15, 16, 31, 32
8	5, 17, 18, 33, 34
9	6, 19, 20, 35, 36
10	7, 21, 22, 37, 38
11	8, 23, 24, 39, 40

The made selection can be canceled by either pressing the same icon again, or via the toolbar icon 22 'Cancel Segment Selection' ( ).

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4.6.3 Control Loop Settings

In the Control Loop Settings menu, the user can select Zernikes to maintain at 0.



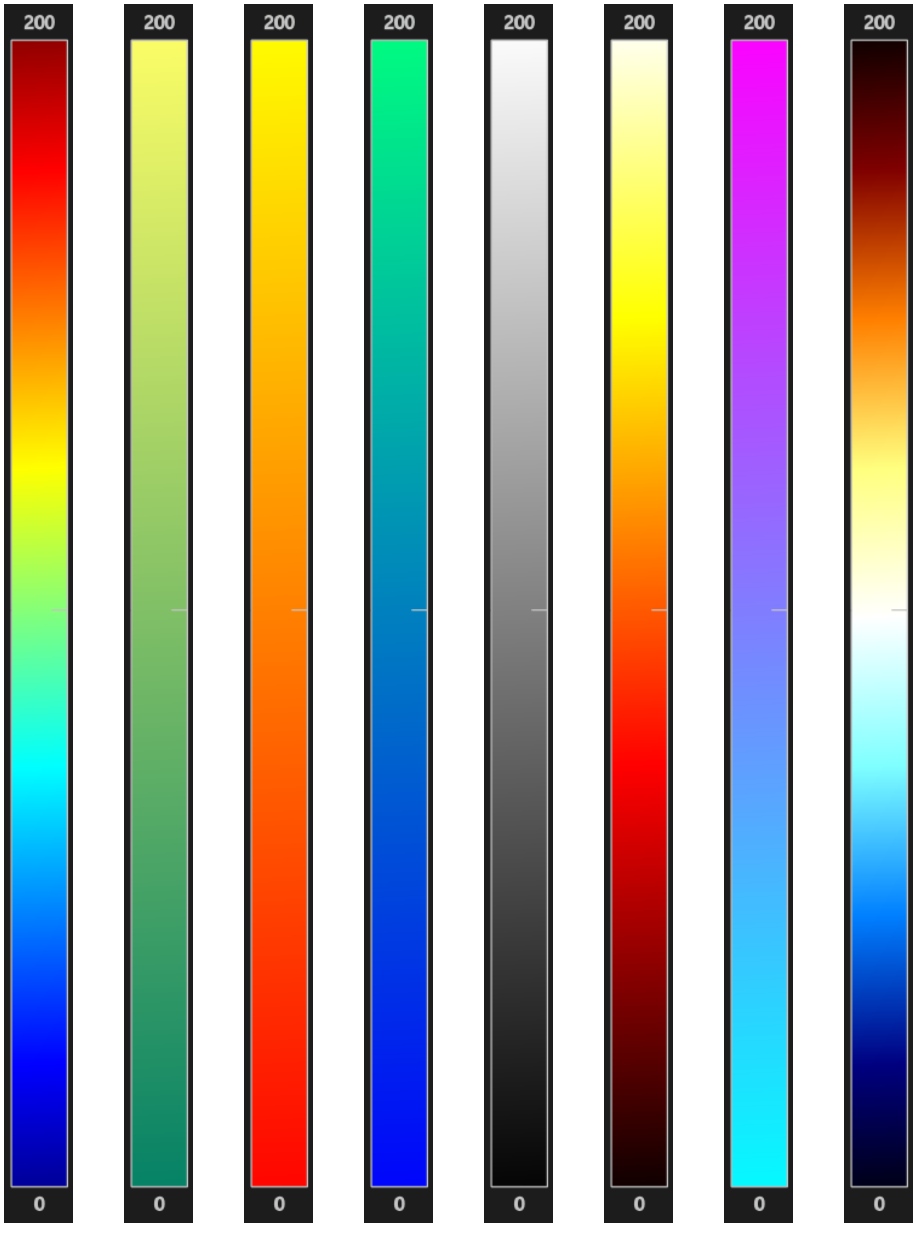
Selected Zernikes are indicated by a check mark.

If no Zernikes are selected, a warning icon will be displayed in the header bar and the menu topic CONTROL LOOP 21 is colored in red. The Control Loop menu from the menu bar offers the same settings in short form:



4.7 Color Bar

The color bar represents the voltage that is applied to a segment / spiral arm, in a certain color. There are several color tables available that can be selected in the Settings 23 menu.



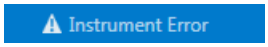
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4.8 Status Bar

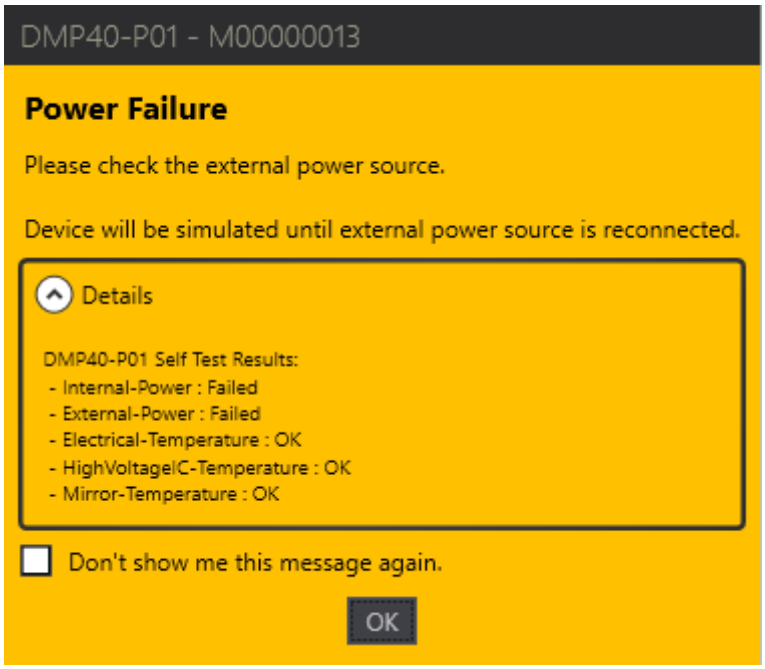


The status bar displays (from left to the right):

- status and duration of control loop;
- number of Zernikes that is used for closed loop control 32;
- instrument status and
- current date and time.

If an error was detected, the message 

appears and a separate window pops up that describes the detected error in detail, e.g.:



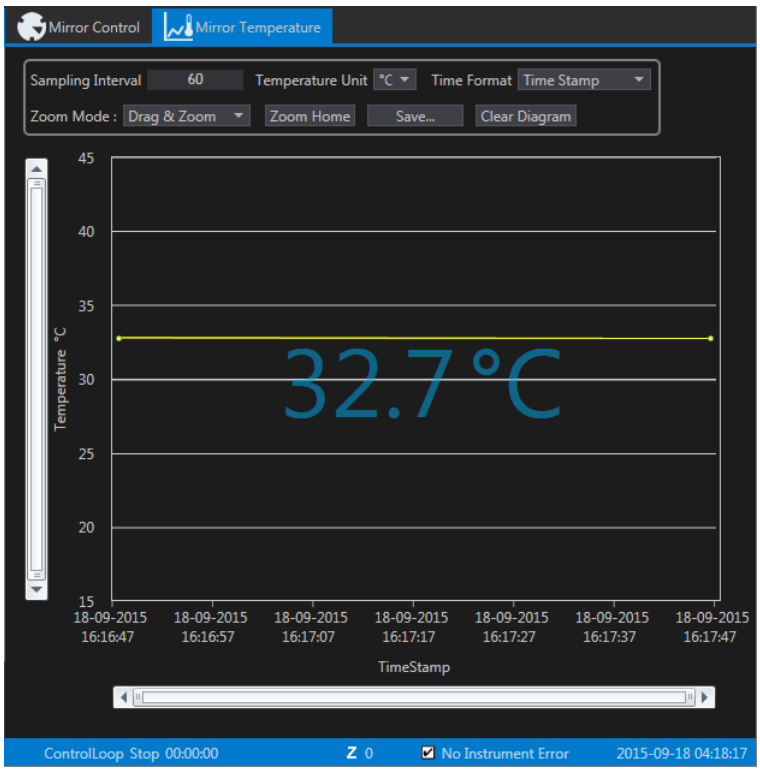
By checking the button "Don't show me this message again", you can omit further display of error messages.

Please see section Troubleshooting 52 for detailed description of possible error messages.

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4.9 Display Mirror Temperature

The mirror temperature chart is displayed in a separate tab next to the mirror control display:



The temperature at the rear side of the mirror is recorded and starts automatically with application start.

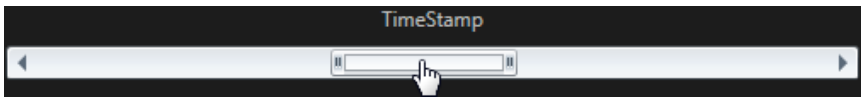
Parameters	Selection	Factory Default
Sampling Interval	1 to 3600 sec	60 sec
Temperature Unit	°C, °F, K	°C
Time Format	Time Stamp (date and time) Elapsed time (hh:mm:ss)	Time Stamp
Zoom Mode	Drag & Zoom; Panning Panning only	Drag and Zoom
Save	Save as *.csv Save as image (JPG, PNG, BMP)	-

Panning

Move the mouse cursor over the time or temperature bar, until the cursor changes to ⇦⇨:



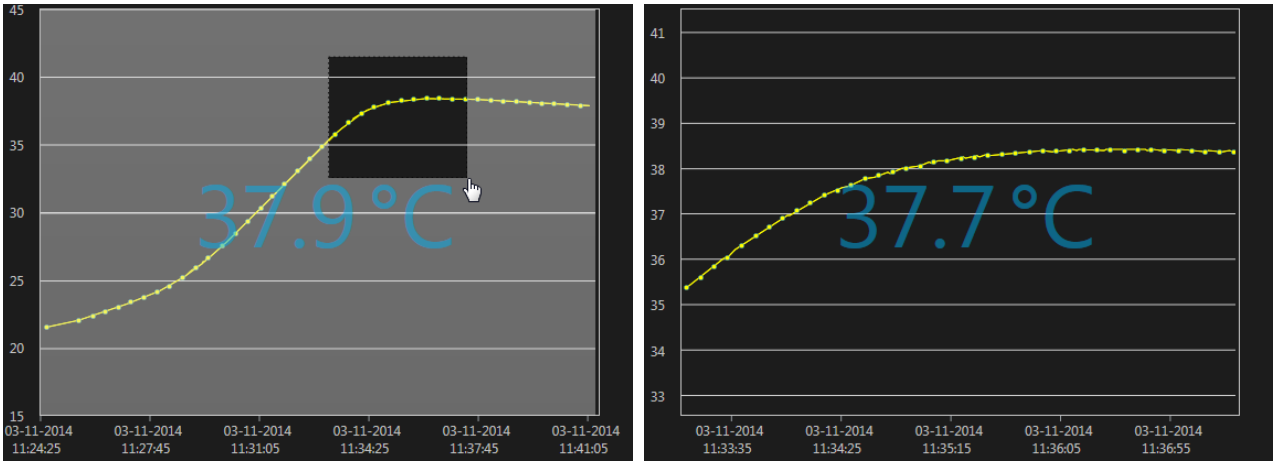
Click and move the mouse until you get the desired zoom factor. If necessary, repeat for the other end of the bar. Then release the mouse and move its cursor over the bar so that it changes to . Click and hold to pan the diagram:



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Drag & Zoom

Press and hold the left mouse button, the draw an rectangle around the area of interest. By releasing the mouse button, the display zooms in the marked area.



Press **Zoom Home** to reset the diagram - all recorded values are restored.

Press **Save** to save the accumulated temperature values to either a *.CSV file or an image. Saving as an image is possible in BMP, JPG or as a transparent PNG.

Press **Clear Diagram** to delete the temperature record and restart the temperature logging.

All settings made to the DMP40 software are saved when terminating the program, and are restored with the next software session.

4.10 The Configuration File

The configuration file comprises of three main parts:

- General information: Information about software version, driver version and the recognized instrument
- Application settings
  - Size and position of the GUI
  - Active Control Panel 27
  - Color Style 33
  - ID Overlay Status 22
  - Zernike Pattern Orientation 23
  - Control Loop Settings 21 (delay, selected Zernikes)
- Data
  - Status of hysteresis compensation
  - Voltage pattern that is applied to tip tilt arms and inner mirror segments
  - Zernike amplitudes (for information only)
  - Zernike slider positions

At the first start of the DMP40 application, a default configuration is loaded. The table below shows the details of this configuration:

Default Configuration

Parameter	Value
Application Settings	
GUI Window Position	X=0; Y=0 (left upper corner of the display)
GUI Window Size	width = 1024, height = 730
Active Control Panel	Zernike
Color Table Type	Jet
ID Overlay (Segment Numbering)	hidden
Manual Setting of Zernike Orientation	Flip = horizontal Rotate = none
Control Loop Settings	DataSocket address: dstp://localhost/WFS_WavefrontSensor Control step delay = 10 ms Selected for control loop Zernikes: none
Info Dialogs	Enabled. Error messages will be displayed.
Application Settings	
Status of Hysteresis Compensation	enabled
Voltages on Inner Mirror Segments	100 V
Voltages on Tip / Tilt Arms	100V
Zernike Sliders	0
Tip/tilt Amplitude Slider	0
Tip/tilt Angle Slider	0

This default configuration can be restored at any time by clicking to the Reset Application Settings  button in the tool bar.

When closing the application, all settings and data will be saved automatically. These most recent settings are being loaded when starting the application again so that the last configuration will be restored.

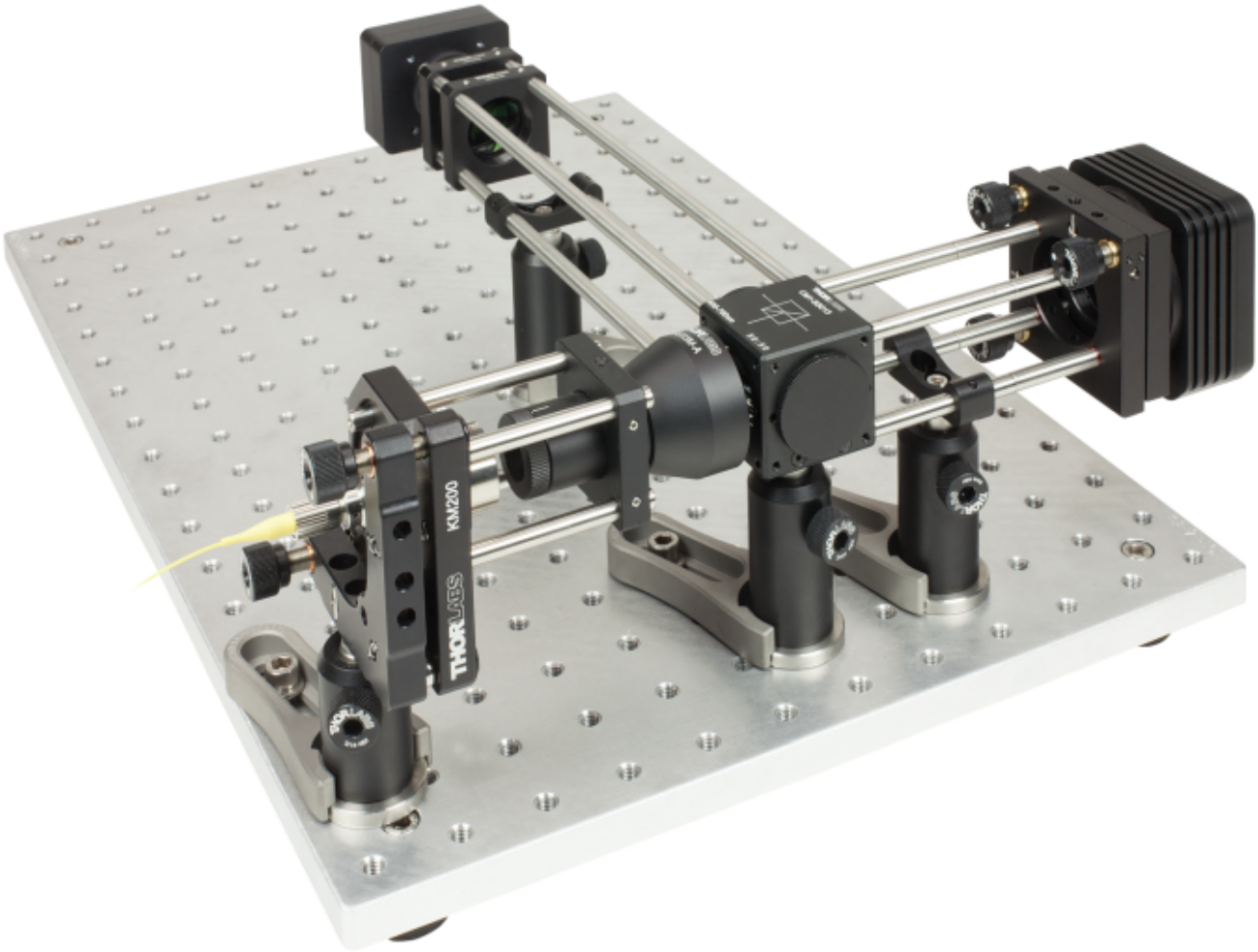
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4.11 Closed Loop Control

This section describes the closed loop control using a Thorlabs wavefront sensor. With the control loop switched on, the software tries to maintain a plane wavefront, i.e., it tries to zero the Zernike coefficients that are enabled for loop control 32. For this purpose, the wavefront data that are measured by the WFS software and transferred to the DMP40 software via the WFS DataSocket interface are used.

Requirements

1. Hardware: A Thorlabs wavefront sensor WFS20, WFS30 or WFS40.
   A suitable optical setup, for example:



Note

All descriptions in this manual related to Zernike coefficients and loop control are based on the setup shown above and its geometry. Changing the beam propagation and / or the orientation of the DMP40 and / or the Wavefront Sensor will impact on Zernike definitions.

2. Software: The Thorlabs Wavefront Sensor Software must be installed to the computer.

Note

For correct loop operation, the **WFS software V4.6 or later** is required.

4.11.1 Preparation

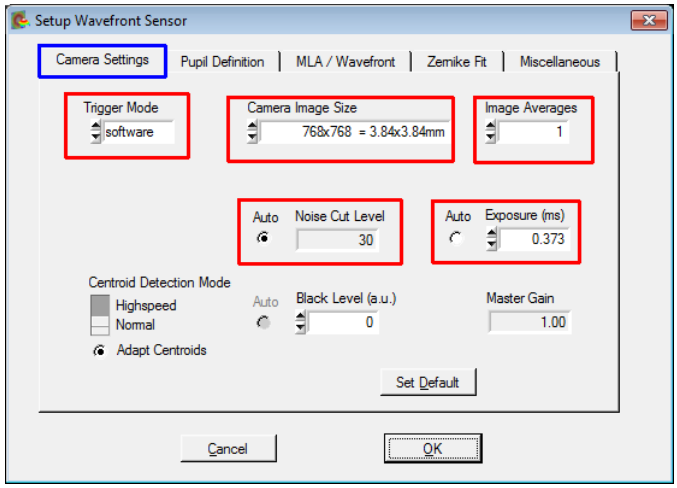
The setup must be aligned as described in section Alignment of the Reference Setup 67.

1. Make sure the DMP40 is connected and the software is running (see First Steps 17).

Note This is important because the mirror is initialized and the surface is brought to an almost flat shape only after starting the software! Without being connected to a power supply and initialization, the mirror has a concave shape.

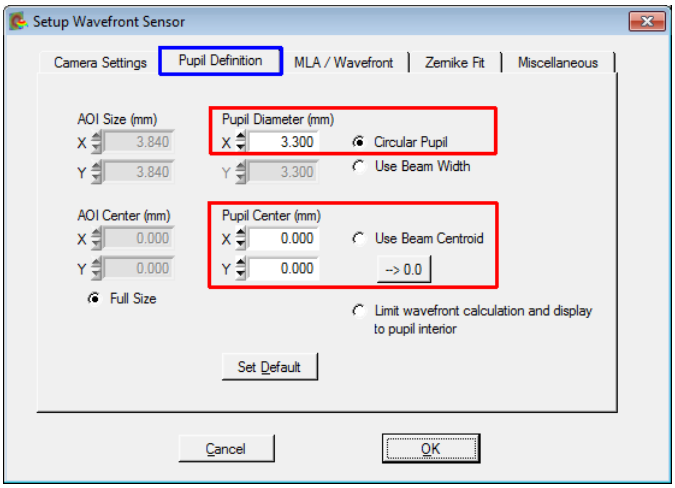
2. Relax the DMP40.
3. Make sure the Wavefront Sensor is connected to the computer and the WFS software is running. Check the recommended settings of the wavefront sensor by right-clicking on the diagram area or select from the menu bar "Setup" - "Wavefront Sensor...":

- **Camera Settings** Tab:



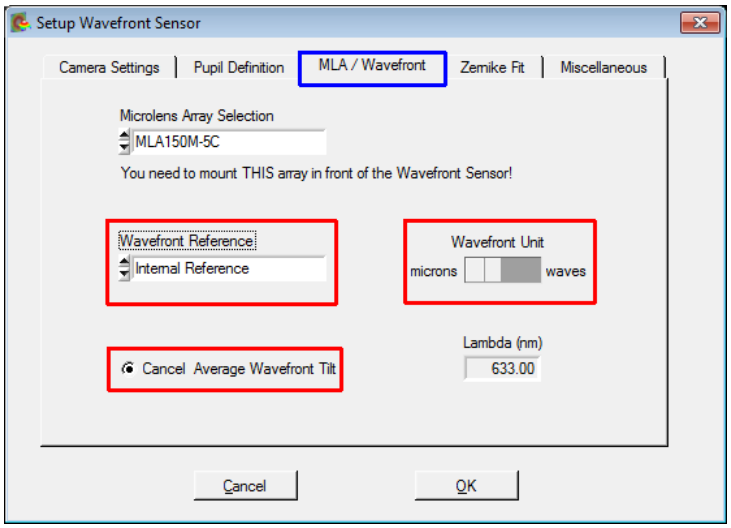
- Set **Trigger Mode** to *software*. This is important in order to get the wavefront data via DataSocket at the correct moment.
  Note If you can't find the *software* trigger mode in the drop-down list, your WFS software version is certainly not 4.6 (or later). Please visit the Thorlabs web site and download the most recent WFS software.
- **Exposure** control: Set the exposure first to *Auto*, and after the camera got adjusted to optimum exposure time, keep this value by unchecking the *Auto* box.
- To achieve faster operation, the **Centroid Detection Mode** can be set to **Highspeed**.

- **Pupil Definition** Tab:



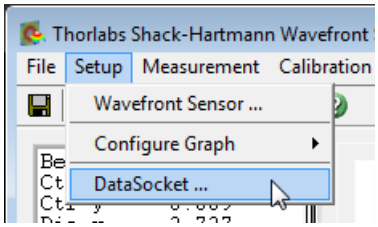
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- Tab **MLA / Wavefront**:

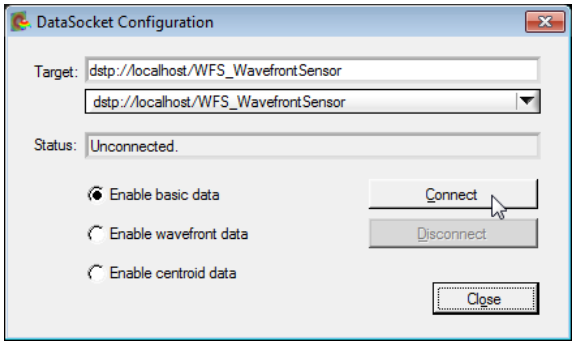


- Set **Wavefront Unit** to *microns*. This is important in order to get the correct Zernike amplitude values during control loop parameter determination. Further, the wavefront data then are independent of the wavelength setting in the WFS software.
- **Cancel Average Wavefront Tilt**: Select this option for closed loop control. However, for alignment of the optical setup it might be useful to have calculated and displayed the wavefront tilt as well.

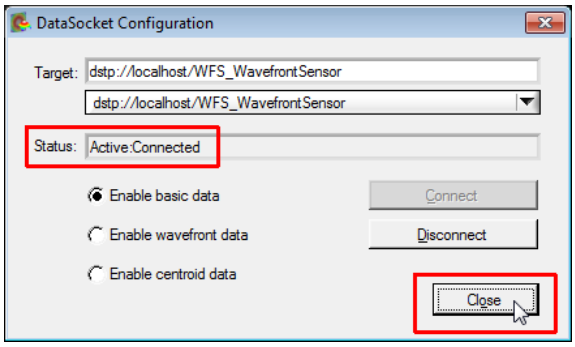
4. Open the menu Setup -> DataSocket...



5. Select "Enable basic data", then Click "Connect":



6. Make sure, the Status changes to "Active connected", then click "Close":



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4.11.2 Control Loop Parameter Determination

The components used in the optical setup may cause the image to be rotated or flipped (beam splitter). For closed loop control, it is essential to know the orientation of the image along the optical path from the DMP40 mirror surface to the input of the wavefront sensor. Further, it is necessary to know the maximum amplitude of each individual Zernike coefficient that can be achieved by mirror manipulation.

The DMP40 software has a unique feature that allows the above information to be determined with a single mouse click - the Control Loop Determination Wizard .

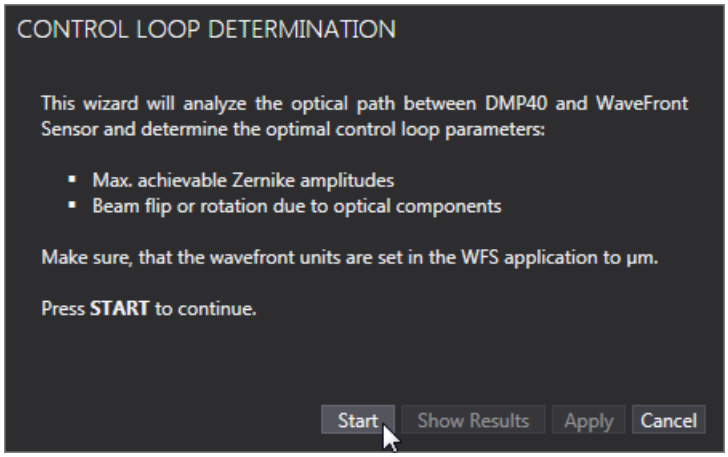
First of all, the WFS software must be configured as described in the previous section Preparation 39. Make sure that the wavefront units 40 are set to µm, that the DataSocket 40 of the WFS is connected and that the WFS operates in Software trigger mode 39.

Click the DataSocket Connection icon ( ). The DMP40 software establishes a connection to the DataSocket server of the WFS and the icon will change to Connected ( ).

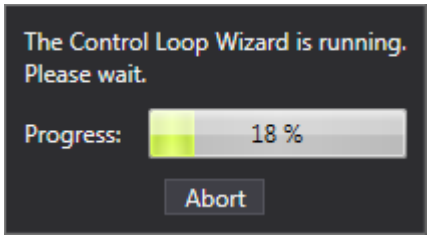
Note

If the DataSocket was not enabled in the WFS software, an error message 54 comes up and the icon changes back to Disconnected ( ).

Click the **Control Loop Determination** icon . The following panel comes up:

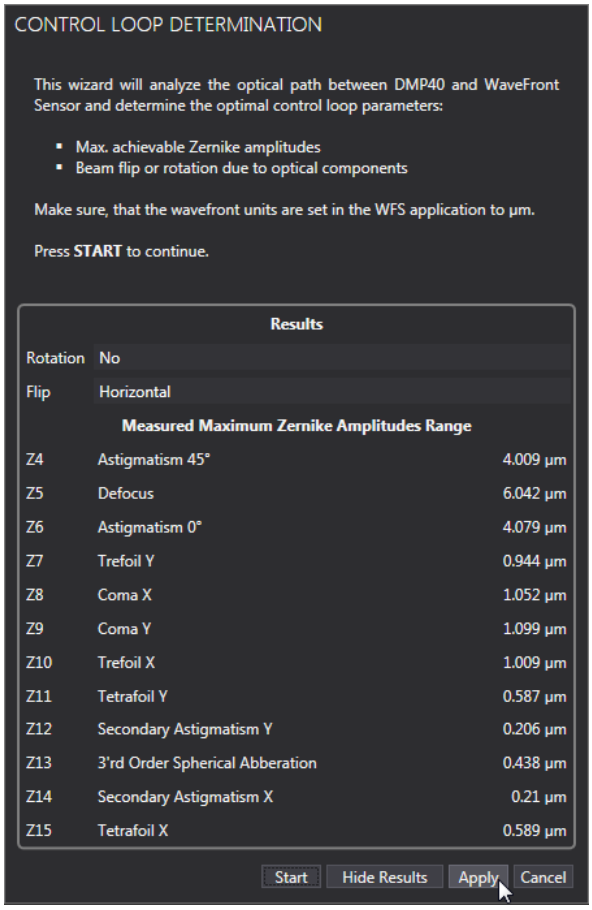


Click **Start** to begin the control loop determination.



When finished, the results will be be displayed:

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Apply releases the results for control loop and the ▶ button will be enabled in order to start the control loop.

Cancel will discard the results and close the window. The control loop cannot be started.

Start restarts the loop parameter determination.

4.11.3 Enabling the Control Loop

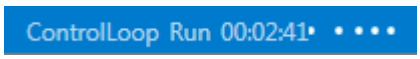
After a successful determination of the control loop parameters (see previous section), the control loop can be activated. Click to the ▶ toggle button in the menu bar.

Note

If no Zernikes are selected for loop control, the Control Loop Settings 32 dialog window comes up. Please select the desired Zernike coefficients that should be used for maintaining a flat wavefront.

The ▶ button will change to ■ this way indicating that the next click will disable the loop.

The status bar changes to



The loop function can be tested by observing the Zernike slider reaction when dragging one of the enabled sliders to the left or to the right. Each manual slider movement is followed by a reaction of the control algorithm that forces the slider to a position where the appropriate Zernike readout of the wavefront sensor is minimized.

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5 Write Your Own Application

In order to write your own application, you need a specific instrument driver and some tools for use in different programming environments. The driver and tools are included in the installer package.

In this section the location of drivers and files, required for programming in different environments, are given for installation under Windows® 7 (32 and 64 bit)

Note

DMP40 software and drivers contains 32 bit and 64 bit applications.

In 32 bit systems, only the 32 bit components are installed to

```
C:\Program Files\...
```

In 64 bit systems the 64 bit components are being installed to

```
C:\Program Files\...
```

while 32 bit components can be found at

```
C:\Program Files (x86)\...
```

In the table below you will find a summary of what files you need for particular programming environments.

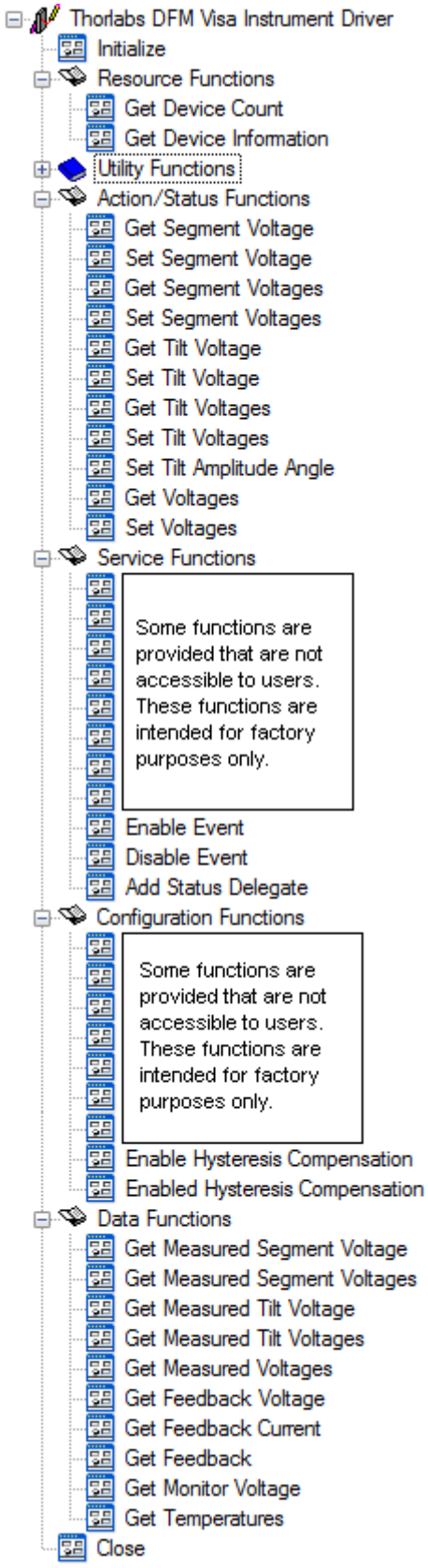
Programming environment	Necessary files
C, C++, CVI	*.fp (function panel file; required for CVI IDE only) *.h (header file) *.lib (static library) *.dll (dynamic linked library)
C#	.net wrapper dll
LabView™	*.fp (function panel) Beside that, LabVIEW™ driver vi's are provided with the *.llb container file

In the next sections the location of above files is described in detail.

Note

Two drivers are provided for the DMP40:

TLDFM driver - This is the basic driver for direct communication with the DMP40. An overview is given below:



Comments

Find connected hardware
Retrieve device information

Set / Get voltage of single segment

Set / Get voltage arrays to/from multiple segments

Manipulate tilt arms

Set / Get voltages to all arms and segments

Only 3 of the Service Functions are accessible by default. Hidden functions are not relevant for the user, because they are dedicated to manufacturing purposes only.

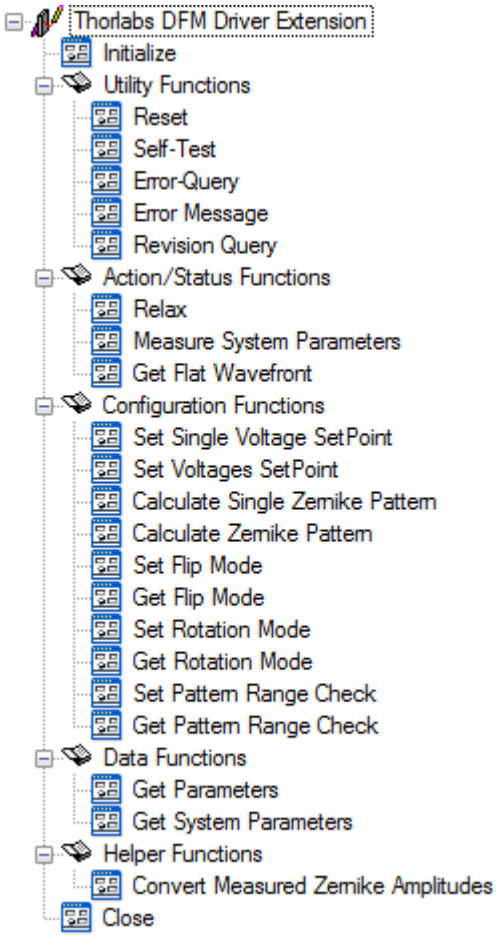
There are only two configuration functions accessible to users:
- enable hysteresis compensation
- get status of hysteresis compensation

Data functions allow voltages of single segments or arrays of segments, as well as the mirror temperatures, to be retrieved.

"Feedback" functions are for future use.

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TLDFMX driver - This is the driver extension that provides a calculation library to the programmer. For example, calling the "Calculate Zernike Pattern" function and handing over the desired amplitudes, the driver extension returns the pattern in an array of segment voltages. This returned pattern is then passed to an appropriate basic driver function in order to set this calculated voltage pattern to the DMP40. An overview is given below:



Comments

Utility functions
Used for common tasks

Action/Status functions
Used for complex operations

Configuration functions are different from configuration functions in the basic driver!

Data functions allow the following to be retrieved:
- the parameters of the extension driver
- measured parameters of the control loop

Convert Zernike results from Wavefront Sensor into DMP40 representation

5.1 Instrument driver 32bit on 32bit systems

```
C:\Program Files\IVI Foundation\VISA\WinNT\Bin\TLDFM_32.dll
C:\Program Files\IVI Foundation\VISA\WinNT\Bin\TLDFMX_32.dll
```

Note

This instrument driver is required for all development environments!

NI LabVIEW™ driver (including an example VI)

```
C:\Program Files\National Instruments\LabVIEW xxxx\Instr.lib\...
...TLDFM\TLDFM.llb
...TLDFMX\TLDFMX.llb
```

(LabVIEW™ container file with driver vi's - "LabVIEW™ xxxx" stands for actual LabVIEW™ installation folder.)

Header file

```
C:\Program Files\IVI Foundation\VISA\WinNT\include\TLDFM.h
C:\Program Files\IVI Foundation\VISA\WinNT\include\TLDFM_def.h
C:\Program Files\IVI Foundation\VISA\WinNT\include\TLDFMX.h
C:\Program Files\IVI Foundation\VISA\WinNT\include\TLDFMX_def.h
```

Static Library

```
C:\Program Files\IVI Foundation\VISA\WinNT\lib\msc\TLDFM_32.lib
C:\Program Files\IVI Foundation\VISA\WinNT\lib\msc\TLDFMX_32.lib
```

Function Panel

```
C:\Program Files\IVI Foundation\VISA\WinNT\TLDFM\TLDFM.fp
C:\Program Files\IVI Foundation\VISA\WinNT\TLDFMX\TLDFMX.fp
```

.net wrapper dll

```
C:\Program Files\Microsoft.NET\Primary Interop Assemblies\...
...Thorlabs.TLDFM_32.interop.dll
...Thorlabs.TLDFMX_32.interop.dll
```

Example for C

```
C:\Program Files\IVI Foundation\VISA\WinNT\TLDFM\Examples\Csample
```
`sample.c` - C program how to communicate with a DMP40
`...\bin\TLDFM_Sample_x86.exe` - same, but executable
```
C:\Program Files\IVI Foundation\VISA\WinNT\TLDFMX\Examples\Csample
```
`sample.c` - C program how to use the extended driver functions
`...\bin\TLDFMX_Sample_x86.exe` - same, but executable

Example for C#

Project file

```
C:\Program Files\IVI Foundation\VISA\WinNT\TLDFM\...
...Examples\DotNet\Sample.csproj-
C:\Program Files\IVI Foundation\VISA\WinNT\TLDFMX\...
...Examples\DotNet\Thorlabs.TLDFMX_32.Interop.Sample.csproj-
```

Example for LabView™

Included in driver llb container

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5.2 Instrument driver 32bit on 64bit systems

```
C:\Program Files (x86)\IVI Foundation\VISA\WinNT\Bin\TLDFM_32.dll
C:\Program Files (x86)\IVI Foundation\VISA\WinNT\Bin\TLDFMX_32.dll
```

Note

This instrument driver is required for all development environments!

NI LabVIEW™ driver (including an example VI)

```
C:\Program Files (x86)\National Instruments\LabVIEW xxxx\...
...Instr.lib\TLDFM\TLDFM.llb
...Instr.lib\TLDFMX\TLDFMX.llb
```

(LabVIEW™ container file with driver vi's - "LabVIEW xxxx" stands for actual LabVIEW™ installation folder.)

Header file

```
C:\Program Files (x86)\IVI Foundation\VISA\WinNT\include\TLDFM.h
C:\Program Files (x86)\IVI Foundation\VISA\WinNT\include...
...\TLDFM_def.h

C:\Program Files (x86)\IVI Foundation\VISA\WinNT\include\TLDFMX.h
C:\Program Files (x86)\IVI Foundation\VISA\WinNT\include...
...\TLDFMX_def.h
```

Static Library

```
C:\Program Files (x86)\IVI Foundation\VISA\WinNT\lib\msc...
...\TLDFM_32.lib

C:\Program Files (x86)\IVI Foundation\VISA\WinNT\lib\msc...
...\TLDFMX_32.lib
```

Function Panel

```
C:\Program Files (x86)\IVI Foundation\VISA\WinNT\TLDFM\TLDFM.fp
C:\Program Files (x86)\IVI Foundation\VISA\WinNT\TLDFMX\TLDFMX.fp
```

.net wrapper dll

```
C:\Program Files (x86)\Microsoft.NET\Primary Interop Assemblies...
...\Thorlabs.TLDFM_32.interop.dll
...\Thorlabs.TLDFMX_32.interop.dll
```

Example for C

```
C:\Program Files (x86)\IVI Foundation\VISA\WinNT\TLDFM\...
...Examples\CSample
```

`sample.c` - C program how to communicate with a DMP40

`...\bin\TLDFM_Sample_x86.exe` - same, but executable

```
C:\Program Files (x86)\IVI Foundation\VISA\WinNT\TLDFMX\...
...Examples\CSample
```

`sample.c` - C program how to use the extended driver functions

`...\bin\TLDFMX_C_Sample_x86.exe` - same, but executable

Example for C#
Project file
```
C:\Program Files (x86)\IVI Foundation\VISA\WinNT\TLDFM\...
...Examples\DotNet\Sample.csproj

C:\Program Files (x86)\IVI Foundation\VISA\WinNT\TLDFMX\...
...Examples\DotNet\Thorlabs.TLDFMX_32.Interop.Sample.csproj
```

Example for LabVIEW™
Included in driver llb container

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5.3 Instrument driver 64bit on 64bit systems

```
C:\Program Files\IVI Foundation\VISA\Win64\Bin\TLDFM_64.dll
C:\Program Files\IVI Foundation\VISA\Win64\Bin\TLDFMX_64.dll
```

Note

This instrument driver is required for all development environments!

NI LabVIEW™ driver (including an example VI)

```
C:\Program Files\National Instruments\LabVIEW xxxx\...
...Instr.lib\TLDFM\TLDFM.llb
...Instr.lib\TLDFMX\TLDFMX.llb
```

(LabVIEW™ container file with driver vi's - "LabVIEW xxxx" stands for actual LabVIEW™ installation folder.)

Header file

```
C:\Program Files (x86)\IVI Foundation\VISA\WinNT\include\TLDFM.h
C:\Program Files (x86)\IVI Foundation\VISA\WinNT\include...
...\TLDFM_def.h

C:\Program Files (x86)\IVI Foundation\VISA\WinNT\include\TLDFMX.h
C:\Program Files (x86)\IVI Foundation\VISA\WinNT\include...
...\TLDFMX_def.h
```

Static Library

```
C:\Program Files\IVI Foundation\VISA\Win64\Lib_x64\...
...msc\TLDFM_64.lib
...msc\TLDFMX_64.lib
```

Function Panel

```
C:\Program Files (x86)\IVI Foundation\VISA\WinNT\...
...TLDFM\TLDFM.fp
...TLDFMX\TLDFMX.fp
```

.net wrapper dll

```
C:\Program Files (x86)\Microsoft.NET\Primary Interop Assemblies...
...\Thorlabs.TLDFM_32.interop.dll
...\Thorlabs.TLDFMX_32.interop.dll
```

Example for C

Source code file is the same as 32bit on 64bit systems 48.

Example for C#

Project file (same as 32bit on 64bit systems 49)

Example for LabVIEW™

Included in driver llb container.

6 Maintenance and Service

Protect the DMP40 from adverse weather conditions. The DMP40 is not water resistant.

Attention

To avoid damage to the instrument, do not expose it to spray, liquids or solvents!

The unit does not need regular maintenance by the user. It does not contain any modules and/or components that could be repaired by the user himself.

Do not open the housing!

Since the optical mirror of the DMP40 is very thin and mounted on a flexible surface, it is extremely vulnerable!

Attention

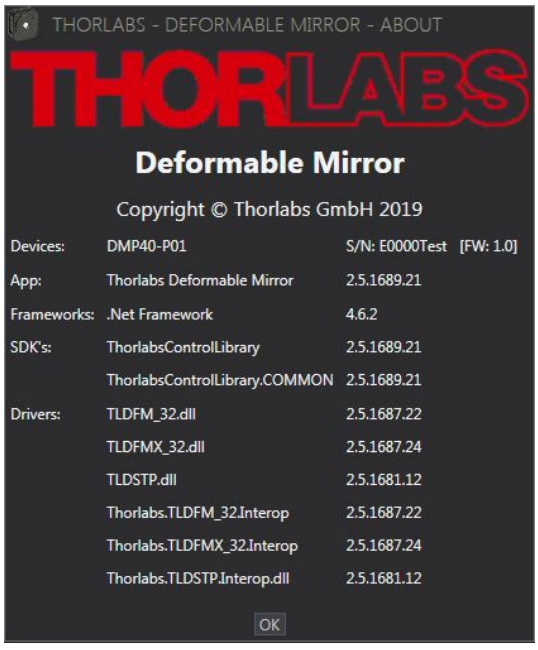
The DMP40 must not be cleaned from dust using ethanol, cleaning tissue, cotton tipped applicators or any other mechanical tools! Using these chemical and / or mechanical tools voids warranty!

Remove dust using only oil- and water-free compressed gas, such as Thorlabs Duster CA3 (Tetrafluoroetane). Keep the gas nozzle at least at a distance of 4 inches (10 cm) from the mirror surface, otherwise liquid gas drops may hit the surface and leave visible traces on the mirror surface; moreover the air pressure might damage the mirror.

In case of malfunction of the DMP40, please contact Thorlabs 80 for return instructions.

6.1 Version Information

Select the icon from the **HELP** menu or in the toolbar for detailed information about the software and the recognized DMP40:



The keyboard button **F1** brings up the online help - either the entire help document or context sensitive.

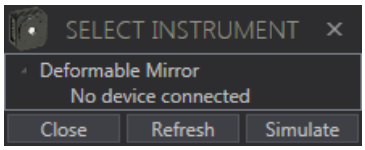
Note

Context sensitive help means that the online help opens at the point that describes the selected functionality. **Example**: A Zernike slider was moved. Pressing F1 brings up the section Zernike Control of the help file.

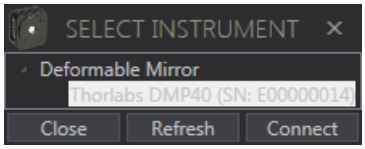
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6.2 Troubleshooting

- **When starting the DMP40 software, a SELECT INSTRUMENT error message appears:**



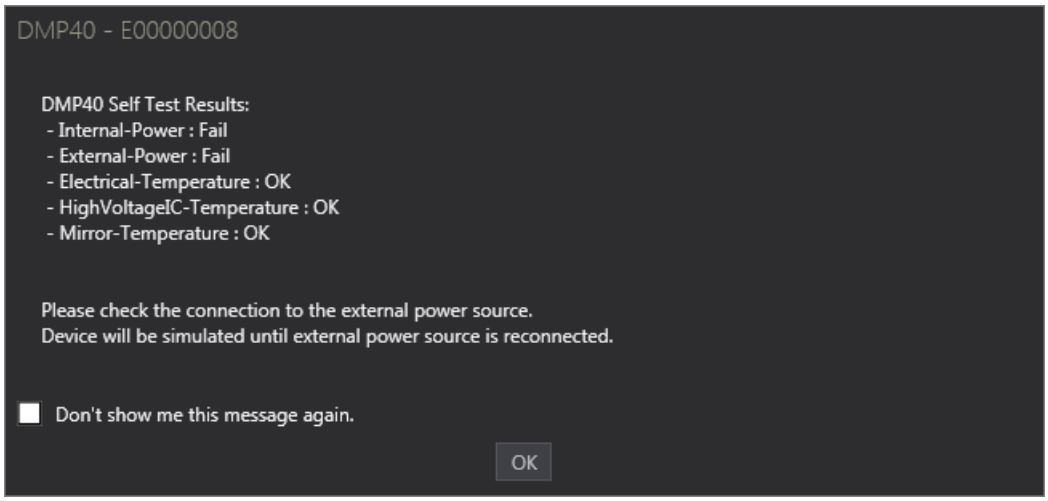
  - ➢ A DMP40 was not recognized to be connected to the PC.
  - ➢ Verify your USB connection to the DMP40, and make sure that it is also connected to the supplied AC power adapter. Then click refresh. If a DMP40 is recognized now, its type and serial number will be displayed - then click the connect button.



  - ➢ Alternatively, you can select **Simulate** - the DMP40 GUI will open in simulation mode, the header will appear accordingly:

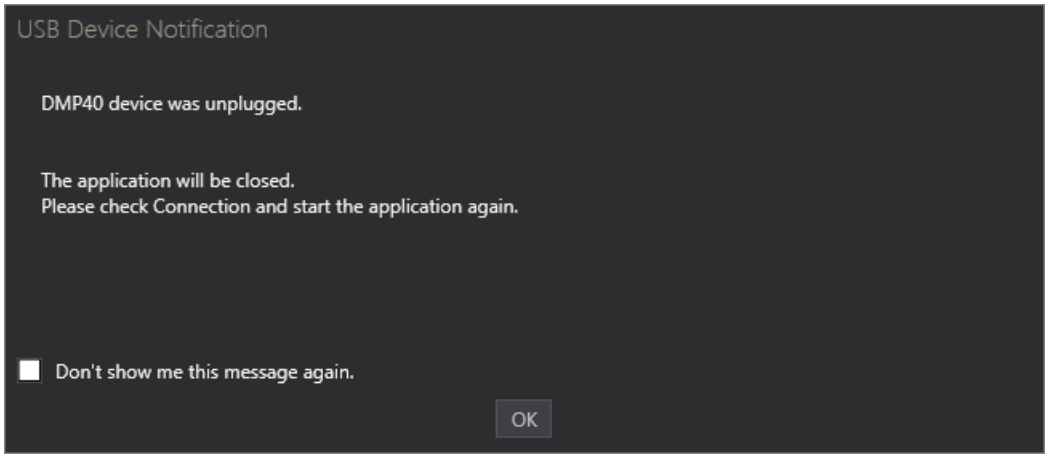


- **When starting the DMP40 software, a DMP40 Self Test Results message appears:**



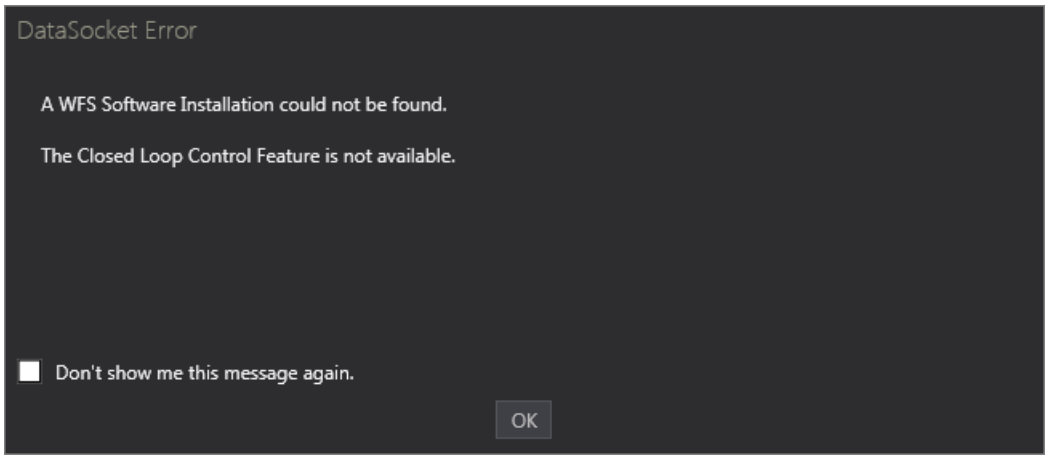
  - ➢ A DMP40 was recognized, but its DC power supply is missing (not connected or power failure). The DMP40 status LED 15 lights up red.
  - ➢ If closing the error message, the GUI opens with disabled DMP40 control. Check the external DMP40 power supply and make sure, the status LED changes to a green light. Then the GUI will be operable as intended.
  - ➢ By checking the button "Don't show me this message again", you can omit further display of this error.

- **During the DMP40 software operation, a USB DEVICE NOTIFICATION error message appears:**



  - ➢ The USB connection to the DMP40 was lost.
  - ➢ Close the dialog - the GUI will be terminated. Re-establish the connection to the DMP40, verify that the status LED lights up green and start the application again.
  - ➢ By checking the button "Don't show me this message again", you can omit further display of this error.

- **When starting the DMP40 software, a DataSocket Error message appears:**



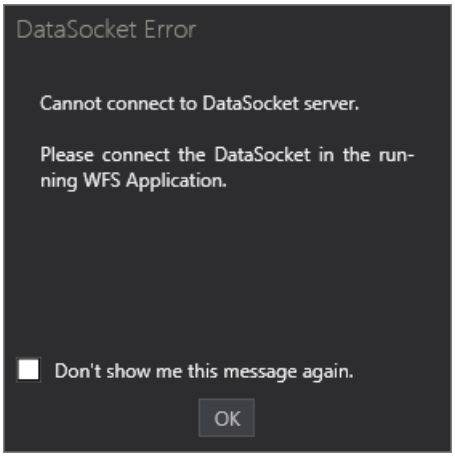
  - ➢ No installation of the WFS software could be found on the computer.
  - ➢ If you do not need the Closed Loop Control feature, just close the error message. The DMP40 GUI starts and the Loop Control features will appear grayed out and disabled:



  - ➢ If you need this feature, please install the WFS software that can be downloaded from the Thorlabs web site, and start the WFS software. If you have any difficulties in finding the software, please contact Thorlabs 80.
  - ➢ By checking the button "Don't show me this message again", you can omit further display of this error.

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- **When clicking to the DataSocket Connection icon ( ) an error message appears:**



  - ➢ The DataSocket was not connected in the WFS software. Connect the DataSocket server 40.
  - ➢ By checking the button "Don't show me this message again", you can omit further display of this error.

Important Note

Once you have checked the button "Don't show me this message again", the appropriate message will not be displayed anymore. Restore this option by resetting the application settings .

- **Loading old .dmfd configuration files:**

With updating the DPM40 software from older versions, the file structure of the configuration files may have changed form .dmfd to .dmfc. The .dmfd files will not readily be recognized by the new software version.

- There is a simple way to load old .dmfd configuration files and to convert them to the newer.dmfc format. Please follow the below steps:

1. Open ‘File’-Menu
2. Click ‘Load’
3. Switch Dialogs File-Extension-Filter to ‘|All Files|*.*‘
4. Load ‘*.dfmd‘ File
5. Save Configuration as ‘*.dfmc’ File [optional]
   a. Open ‘File’-Menu
   b. Click ‘Save User Configuration'

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7 Appendix

7.1 Technical Data

Mirror	DMP40-F01	DMP40-P01
Design	Compact housing with integrated tip / tilt stage and high-voltage drivers; USB control interface	
Mirror Principle	Unimorph piezoelectric	
Mirror Diameter	Ø 12.7 mm	
Number of Segments	40 in total 24 within the pupil, 16 - outside	
Tip / Tilt	3 Bi-morph spiral arms	
Mirror Segment Voltage Range	0 to 200 V (default: +100 V for flat mirror)	
Tip / Tilt Arm Voltage Range	0 to 200 V (default: +100 V for not tilted mirror)	
Optical Specifications		
Optical Aperture	Ø 11.5 mm	
Pupil Diameter [1])	Ø 10.0 mm	
Surface flatness	100 nm, RMS (Defocus term actively flattened)	
Coating	UV-Enhanced Aluminum	Protected Silver
Average Reflectance	>89.0% Over 250 nm to 450 nm	>97.5% Over 450 nm to 2 µm >96.0% Over 2 µm to 20 µm
Damage Threshold, CW	1 W/cm (250 – 450 nm)	4 W/cm (450 nm – 2 µm)
Damage Threshold, Pulsed Signals	0.2 J/cm² (355 nm, 10 ns, 10 Hz, Ø 0.38 mm)	1 J/cm² (1064 nm, 10 ns, 10 Hz, Ø10 mm)
Hysteresis of Piezoceramic Material [4])	15 % Typical, 25 % Max	
Physical Stroke [2])		
Tip / Tilt Range	± 2 mrad (± 20 µm related to Ø10 mm Pupil) [3])	
Z5 Defocus	± 6.5 µm	
Z4, Z6 Astigmatism	± 6.8 µm	
Z8, Z9 Coma	± 2.5 µm	
Z7, Z10 Trefoil	± 2.4 µm	
Z11, Z15 Tetrafoil	± 2.1 µm	
Z12, Z14 Secondary Astigmatism	± 1.1 µm	
Z13 3rd order Spherical Abberation	± 1.0 µm	
Dynamical Specifications		
Pattern Update Rate	4 kHz via USB 2.0 (All Voltages)	
Mirror Response Time	0.5 ms (Full Stroke)	
Tip/Tilt Response Time	5 ms (Full Stroke)	

[1]) Max. useable beam diameter relates to Zernike pupil diameter

[2]) Max. Peak-to-Valley (PV) stroke at mirror surface related to 10 mm beam diameter. The Defocus range may have an asymmetry of 30% max.

Note Wavefront amplitudes reflected from the mirror are twice as high

[3]) The mean tilt is determined for the mirror as a whole. The min. and max. tilt in each direction (360°) may differ slightly from the overall mean.

Note Wavefront amplitudes are twice as high.

[4]) The control software for these mirrors includes built-in hysteresis compensation that greatly reduces the effect on mirror performance.

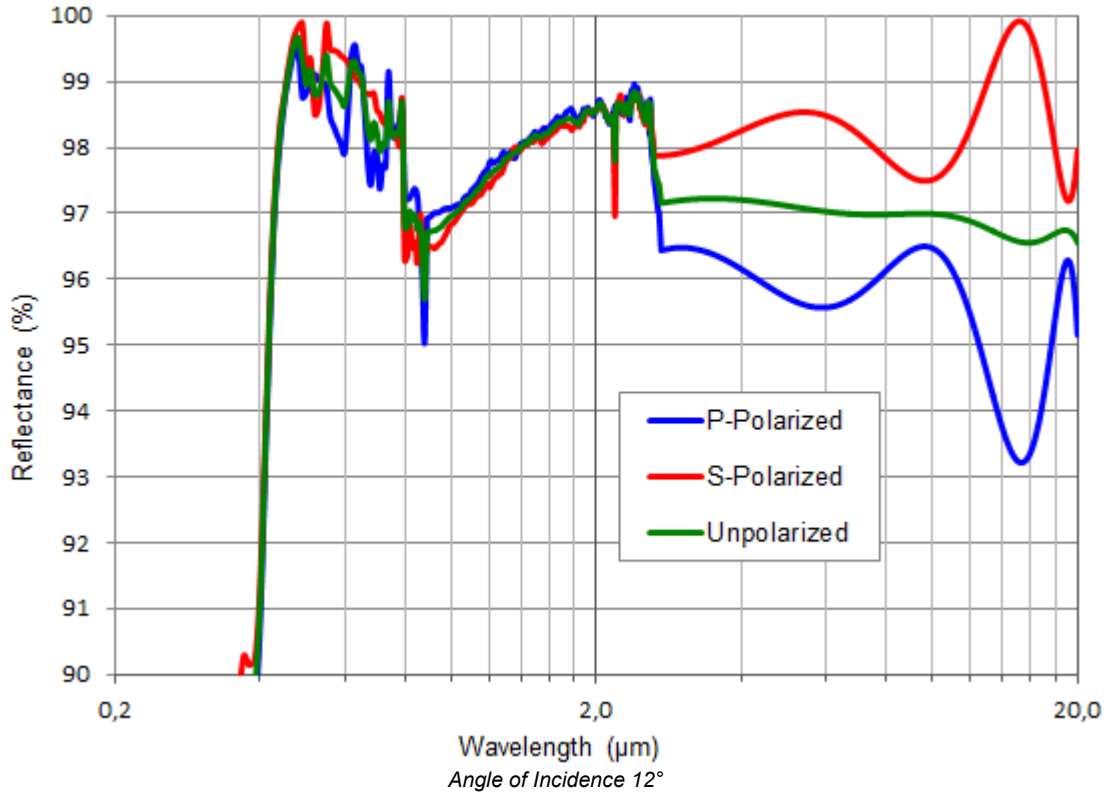
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Interface Connectors	
PC Control Interface	High Speed USB 2.0 (USB1.1 compatible) Mini USB connector
Analog Feedback Input	Current: 1 nA to 10 mA Voltage: 0 to +2.5 V (2.5 mm stereo plug, max. 3 m cable, shielded)
General Specifications	
Operating Temperature Range [4])	+5 to +35 °C
Storage Temperature Range	-20 to +70 °C
Power Supply	12 V DC / 18 VA (desktop power supply, energy level VI)
Warm-up time	not required
Operating Altitude	max. 3000 m
Dimensions (W x H x D)	64 x 60 x 31 mm (w/o dust cover)
Mounting Options	Thorlabs 30 mm cage system SM2 front thread UNC 8-32 and UNC 1/4-20 bottom thread alternatively M4 and M6 thread (metric version)
Weight	0.18 kg

[4]) non-condensing

All technical data are valid at 23 ± 5°C and 45 ± 15% rel. humidity (non condensing)

Reflectance of the Protected Silver Coating

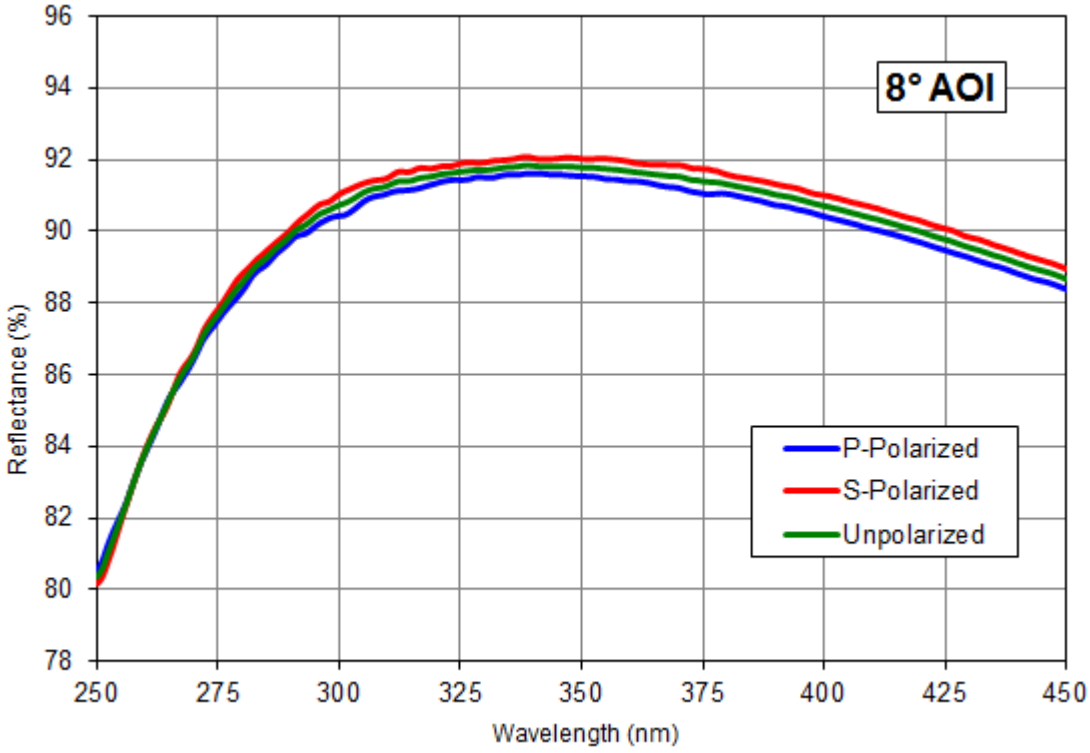


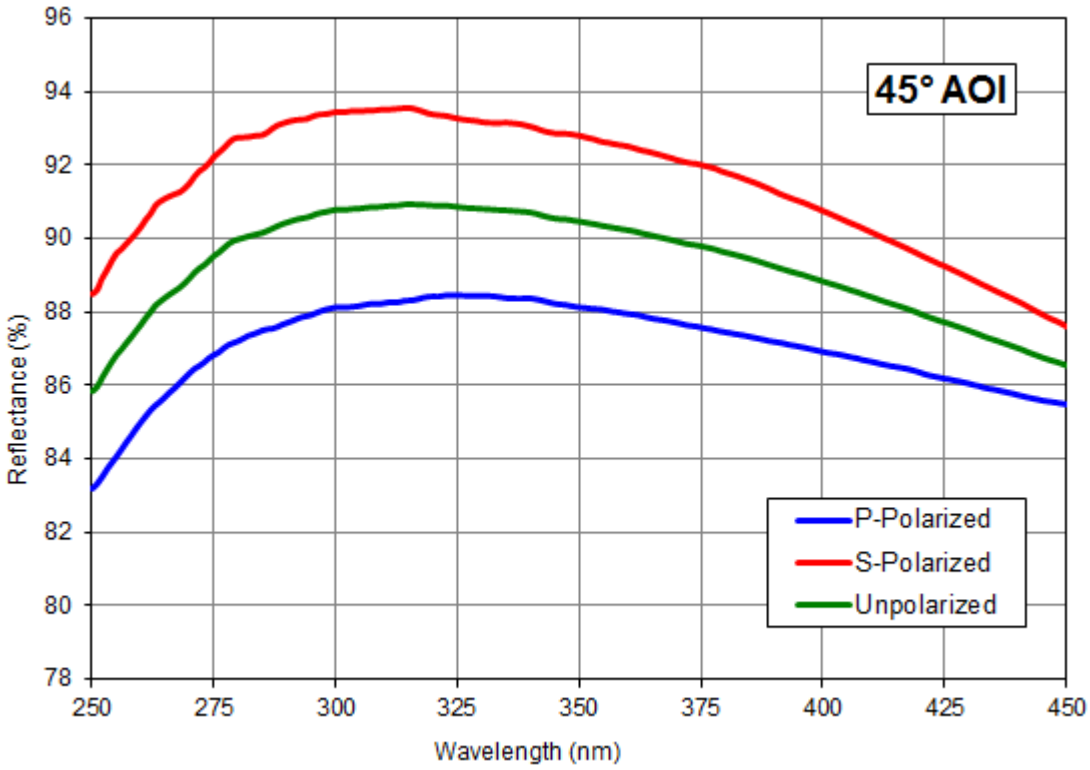
Angle of Incidence 12°

(Source:http://www.thorlabs.de/newgrouppage9.cfm?objectgroup_id=5056)

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Reflectance of the UV-Enhanced Aluminum Coating





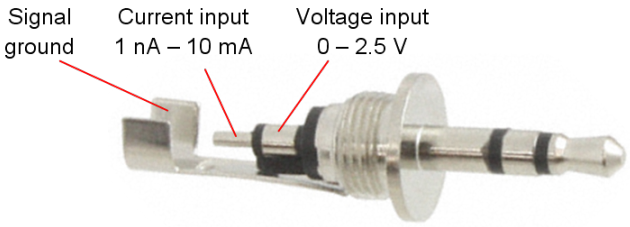
Compare: https://www.thorlabs.com/newgrouppage9.cfm?objectgroup_id=264

Note

The DMP40-F01 provides an average reflectance of > 89% only.

7.2 Analog Feedback Connector

A analog feedback connector will help to establish a closed loop control using a photo detector as described in the chapter Closed Loop Control 38. The analog feedback connector is not enclosed in the shipment but may be purchased at any supplier.



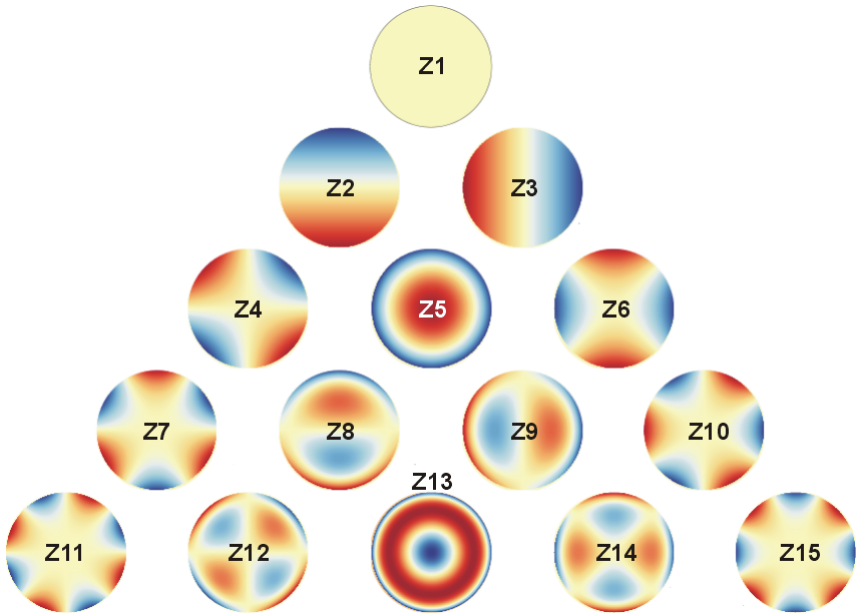
Connection of the external feedback connector (Stereo connector plug, Ø 2.5 mm)

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7.3 About Zernikes

A wavefront can be described using Zernike polynomials. These are a sequence of polynomials that are orthogonal on the unit circle. A variety of definitions exist for these Zernike functions. The Thorlabs Wavefront Sensor software and this manual follows the ANSI Standard Z80.28-210, see References [1] 79 .

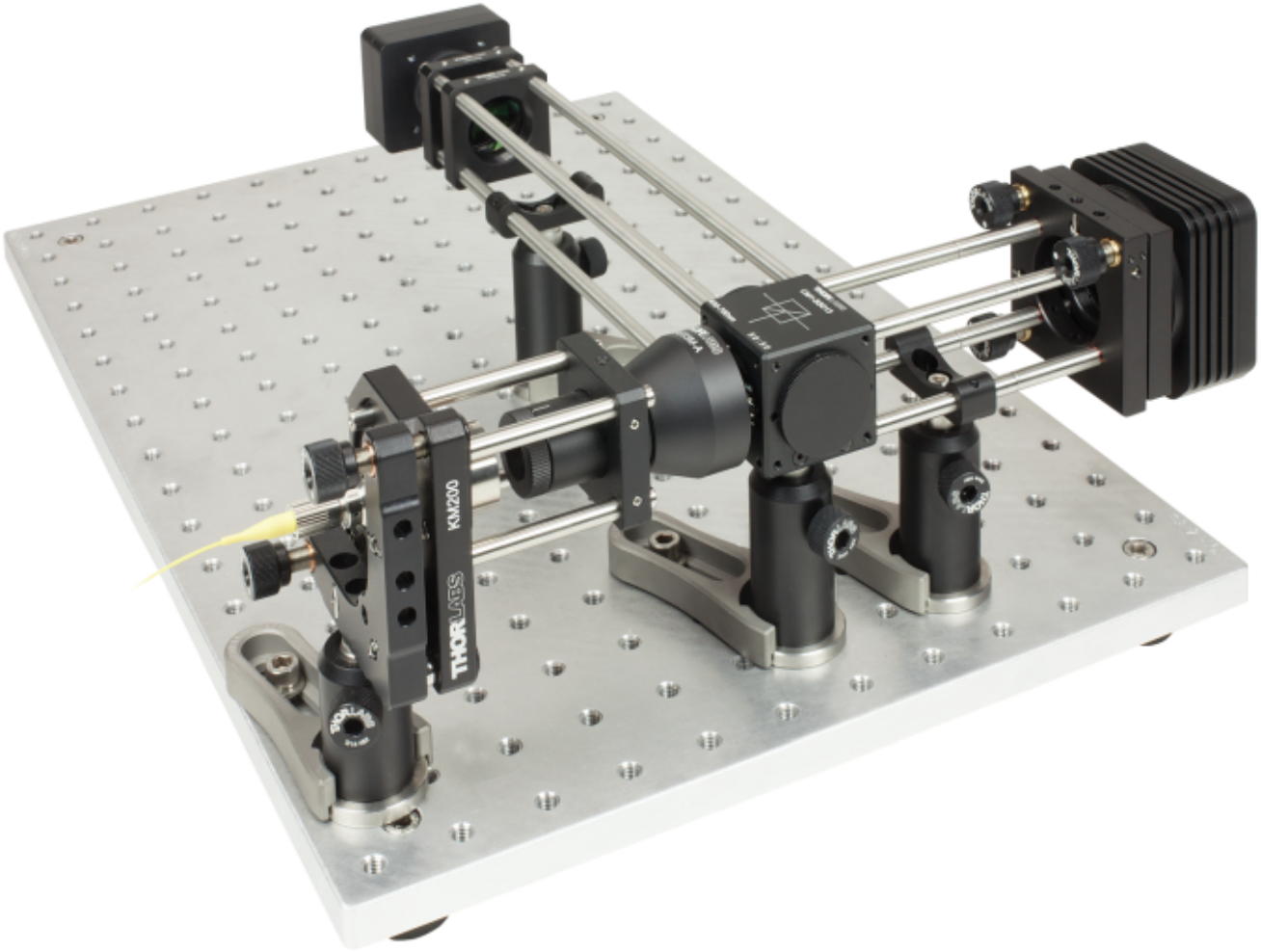
The graphic below illustrates the impact of Zernikes to the wavefront. Here, the Zernike index assignment is identical with the assignment used in DMP40 and WFS software:



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Zernike Term	Shortcut	Description
Z 1	-	Piston
Z 2	-	Tip X
Z 3	-	Tilt Y
Z4	Ast45	Astigmatism 45°
Z 5	Def	Defocus
Z 6	Ast0	Astigmatism 0°
Z 7	TreY	Trefoil Y
Z 8	ComX	Coma X
Z 9	ComY	Coma Y
Z 10	TreX	Trefoil X
Z 11	TetY	Tetrafoil Y
Z 12	SAstY	Secondary Astigmatism Y
Z 13	SAb3	3rd Order Spherical Abberation
Z 14	SAstX	Secondary Astigmatism X
Z 15	TetX	Tetrafoil X

7.4 Reference Setup



Above picture shows the reference setup that was used for the descriptions in the manual on hand.

Note

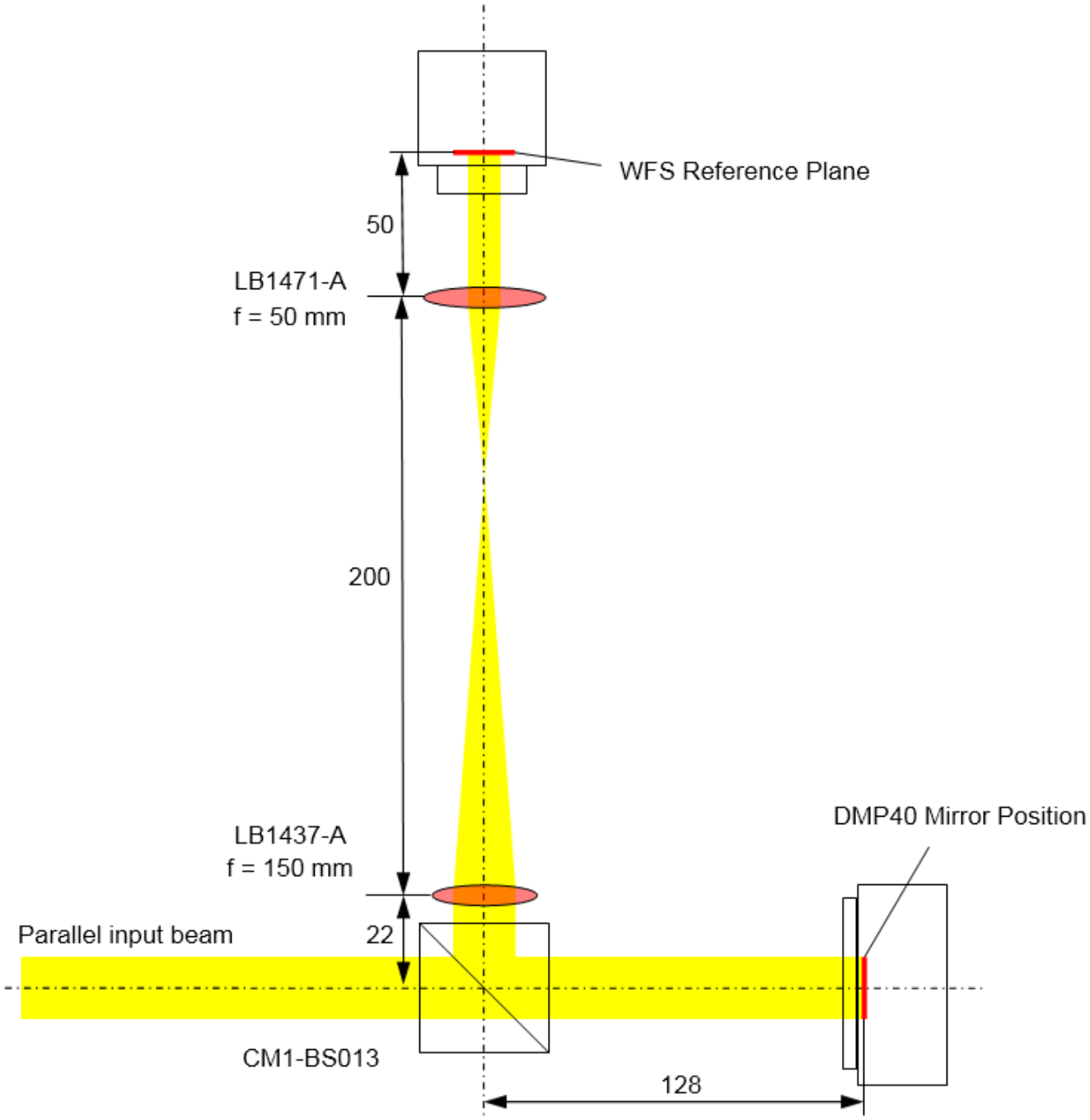
This setup was created using a DMP40-P01. Suitable AR coated components for the UV range can be found on the Thorlabs web site.

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7.4.1 Significant Distances

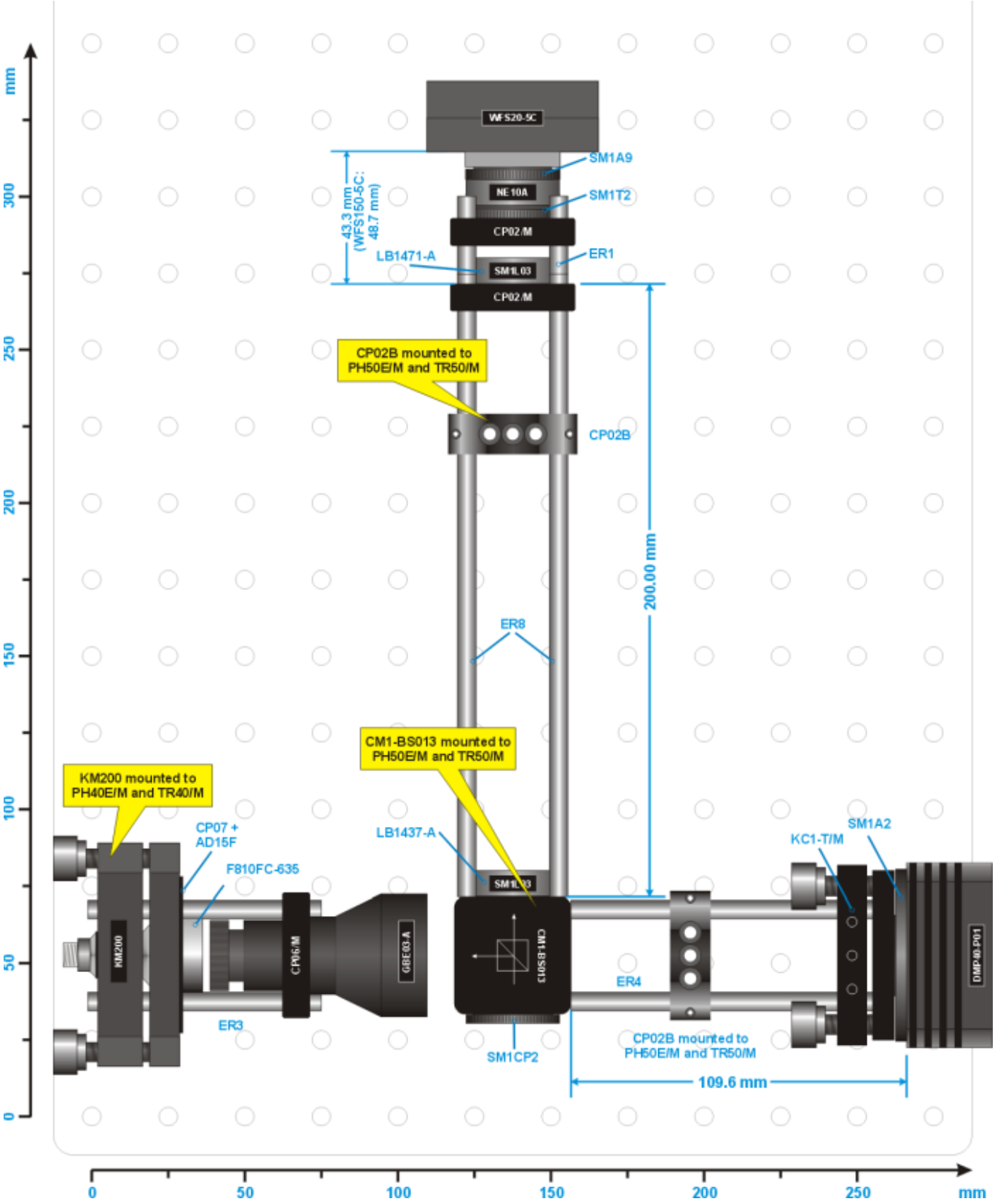
It is important to carefully reproduce this setup with respect to its geometry as well as to the location of the optical components. This is particularly important for the location of the two biconvex lenses - one of them with a focal length of 50 mm is located in front of the Wavefront Sensor, while the second with a focal length of 150 mm is located close to the beam splitter. This results in a magnification factor M = 150 mm / 50 mm = 3

The sketch below shows significant distances between the optical components with respect to recommended lenses and their focal distances:



7.4.2 Sketch and Assembly Recommendations

The setup was assembled using Thorlabs optomechanical components. A complete list of used items can be found in section List of Materials for Closed Loop Setup 72.



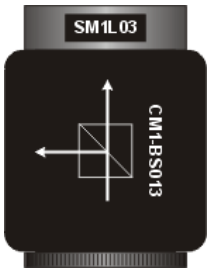
© 2021 Thorlabs

Assembling the beam forming unit

- Mount the AD15F into the CP07, secure the AD15F using the included with CP07 retaining ring (SM1RR).
- Insert the F810FC-635 collimator into the AD15F; fix it using the 2 set screws.
- Install the four ER3 rods to the CP07 and fix them.
- Insert the CP07 into the KM200 and fix it using the set screw.
- Add the CP06/M to the ER3 rods, fix it on the rods and install the beam expander. Fit the GBE03-A using the set screw.
- Fix the KM200 to the TR40/M post.

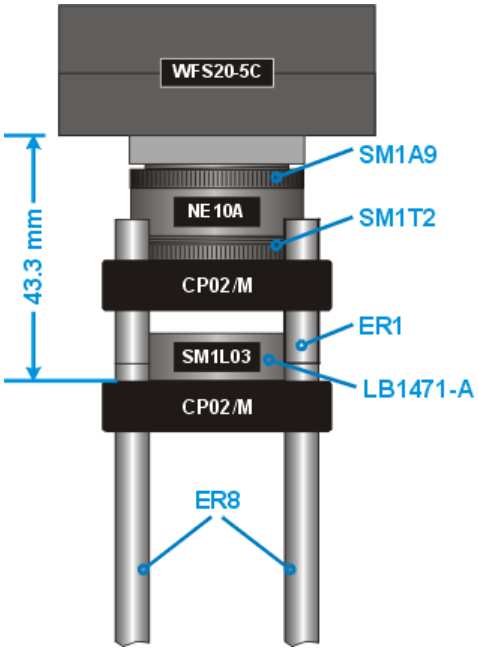
Assembling the beam splitter unit

It is important to assemble the beam splitter in the correct orientation as shown in the picture:



- Mount the LB1437-A lens (f = 150 mm) to the SM1L03, then mount it to the beam splitter as shown.
- Close the opposite aperture with the SM1CP2 cap to prevent laser emission from exiting the cube.
- Install the four ER8 rods on the beam splitter around the lens tube with the 150 mm lens and extend the rods with four additional ER1 rods.
- Move the CP02B onto the lower pair of rods, add a TR50/M post and fix all parts.
- Mount the LB1471-A lens (f = 50 mm) to the SM1L03 and mount it to the CP02/M cage plate. Slide the CP02/M on the rods as shown in the sketch.
- Adjust the distance between the face of the beam splitter, where the 150 mm lens is mounted, and the face of the cage plate that holds the 50 mm lens, to exactly 200.0 mm (see the sketch 63). Secure the CP02/M firmly. This way, the distance between the two lenses will be equal to the sum of their focal lengths.
- Mount the beam splitter to a TR50/M post.

Assembling the Wavefront Sensor unit



- Remove the protective cap from the WFS20-5C.
- Install the SM1A9 C-mount-to-SM1 adapter on the wavefront sensor.
- Screw in the NE10A neutral density filter, then add the SM1T2 lens tube adapter.
- Screw this block into the CP02/M cage plate, adjust it carefully so that the WFS cabinet bottom is parallel to the edge of the cage plate, then fix them in this position using one of the included with the SM1T2 locking rings.
- Slide this assembly onto the rods.
- Adjust the distance between the face of the cage plate that holds the 50 mm lens and the front of the WFS20-5C housing to exactly 43.3 mm. Fix the CP02/M firmly. This way, the distance between the 50 mm lens and the WFS20-5C reference plane will be equal to 50 mm.

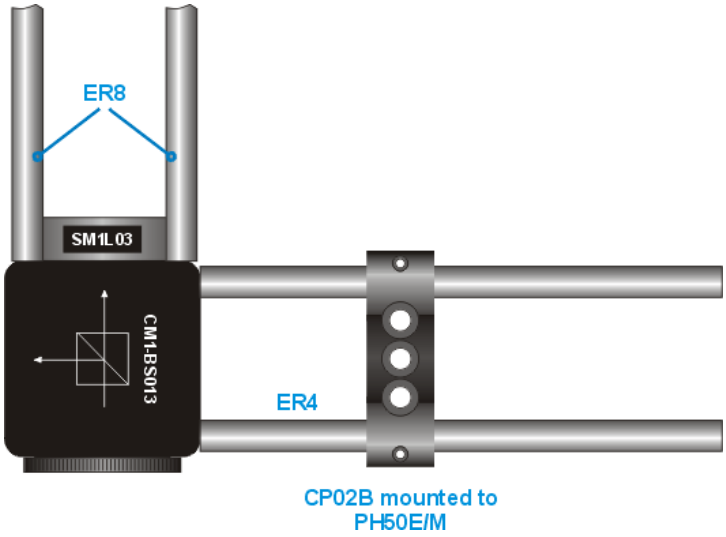
Note

If using a WFS30 or WFS40 Wavefront Sensor or a WFS20 with a different MLA (-7AR, -14AR), the above distance must be adjusted in order to achieve a distance of 50 mm between the LB1471-A lens and the reference plane of the WFS.

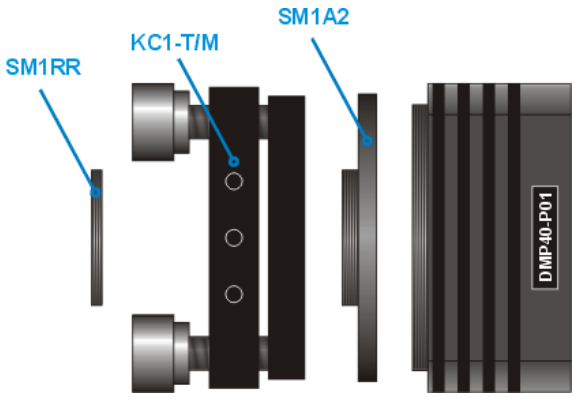
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Assembling the DMP40 unit

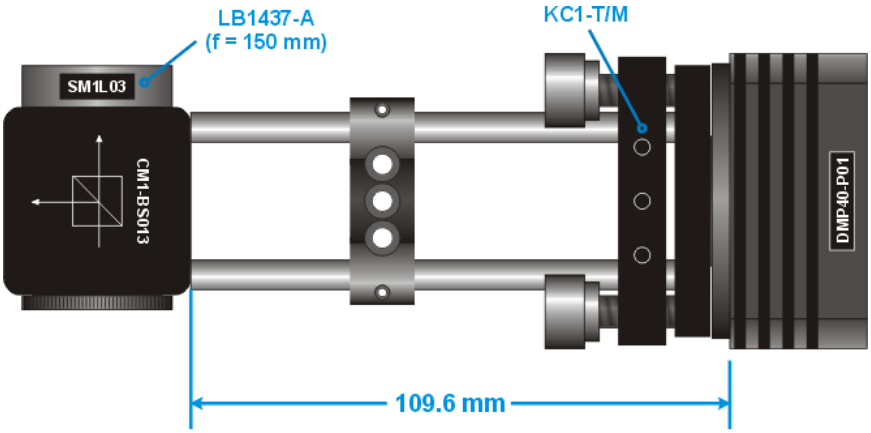
- Mount the ER4 rods to the beam splitter, as shown below. Slide on the CP02B and mount it to a TR50/M:



- Install the SM1A adapter onto the outer thread of the DMP40. Install both items in the KC1-T/M and align the upper edge of the DMP40 so that it is in parallel to the upper face of the KC1-T/M. Then fix this position using the supplied SM1RR retaining ring. The sketch below illustrates that:



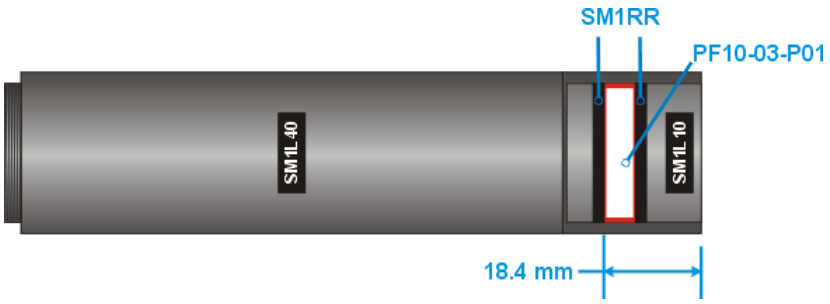
- Slide the KC1-T/1 with the DMP40 on the rods and adjust the position of the DMP40 front face relative to the beam splitter as shown in the next sketch. Doing so, the distance between the LB1437-A and the surface of the DMP40 mirror will be 150 mm and equal to the lens' focal length.



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Assembling the alignment mirror

To align the setup so that a nearly planar wavefront is incident on the wavefront sensor when the mirror is flat, the DMP40 mounted in the KC1/M can be replaced by a silver mirror with its surface located in the same plane as the DMP40 mirror surface is normally located.



The PF10-03-P01 Protected Silver Mirror is mounted to the SM1L10 1.0" lens tube. In order to achieve the correct distance to the mirror surface, install an SM1RR retaining ring (included with each lens tube) at a distance of 18.4 mm from the SM1L10 end, as shown in the above sketch. Then install the PF10-03-P01 with its reflective surface towards the retaining ring, fix it using a second SM1RR, and then stack the SM1L10 with the mounted mirror to the SM1L40 4.0" lens tube.

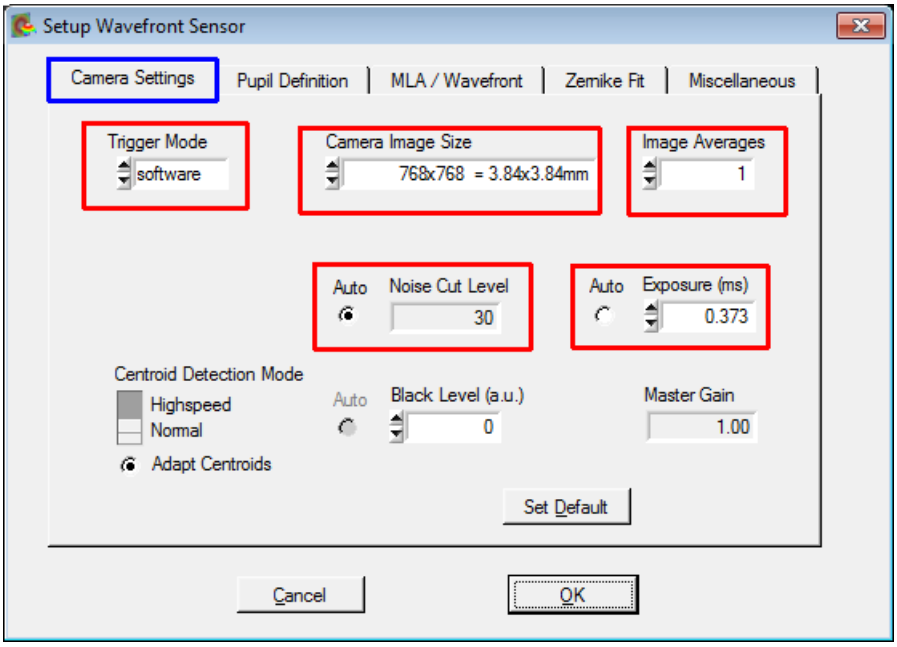
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7.4.3 Alignment of the Reference Setup

Alignment of the beam forming unit

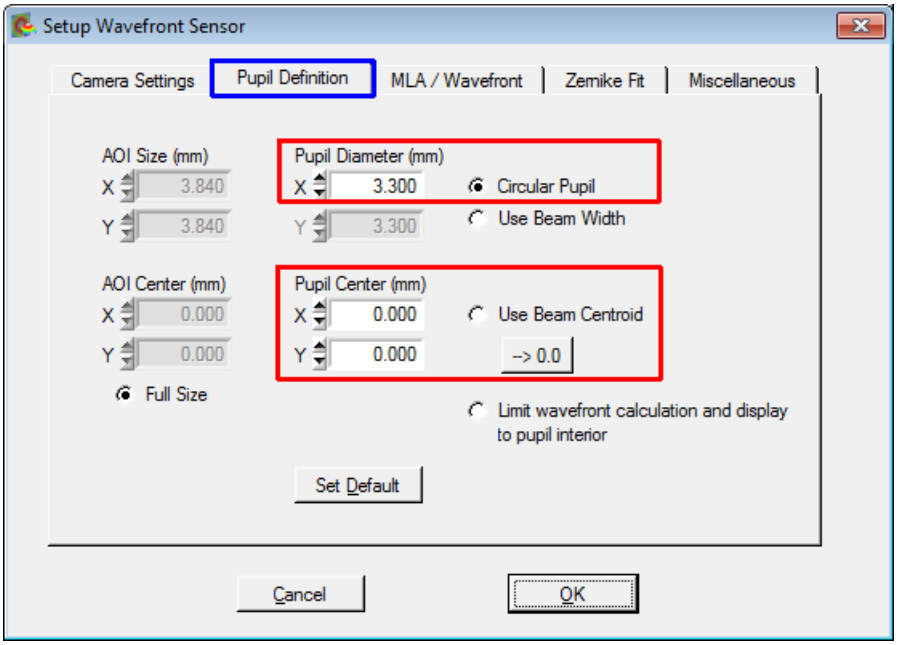
1. Connect the fiber output of the light source to the F810FC-635 collimator of the beam forming unit.
2. Connect the wavefront sensor to the PC and start the WFS software.
3. Remove the DMP40 assembly (DMP40 and KC1-T/M) from rods.
4. Install the lens tubes with the silver mirror 66 to the beam splitter port that is opposite from the beam expander.
5. Switch on the light source.
6. In the WFS software, right click on the diagram area or select from the menu bar "Setup" - "Wavefront Sensor...". Reproduce the following settings:

- **Camera Settings** Tab:
  - Select a Camera Image Size larger than the pupil diameter displayed above.
  - Set the Noise Cut Level to 30 (uncheck the **Auto** button).
  - Set the **Exposure** first to Auto so that the software defines the exposure time, then uncheck the **Auto Exposure** button. This is helpful if the beam is accidentally blocked, because in such cases the WFS camera will search for the optimal exposure time which may take some time:

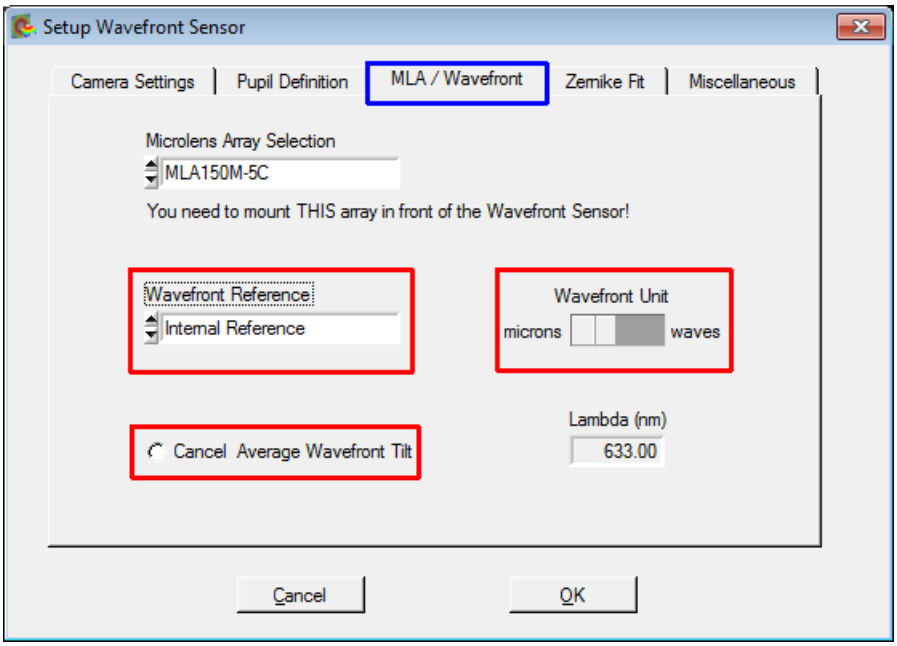


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- **Pupil Definition** Tab: It is recommended to use a pupil diameter corresponding to the DMP40 pupil diameter (10 mm) reduced by the magnification factor M of the used optics, which is 3 in the recommended setup 62.

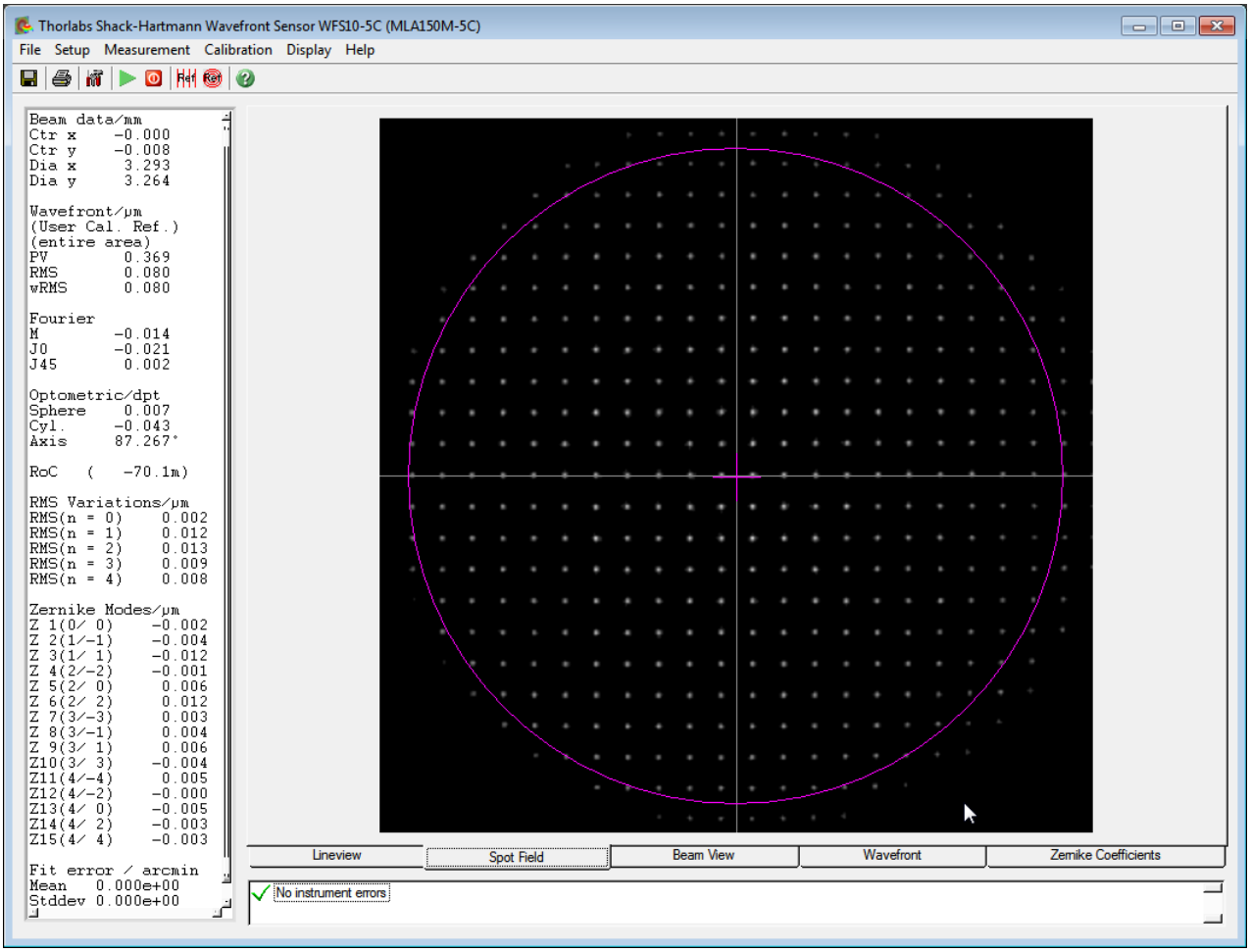


- **MLA / Wavefront** Tab: Use "Internal" wavefront reference, uncheck the box "Cancel Average Wavefront Tilt", select "Wavefront Unit" to "microns" and enter the correct wavelength according to your light source:

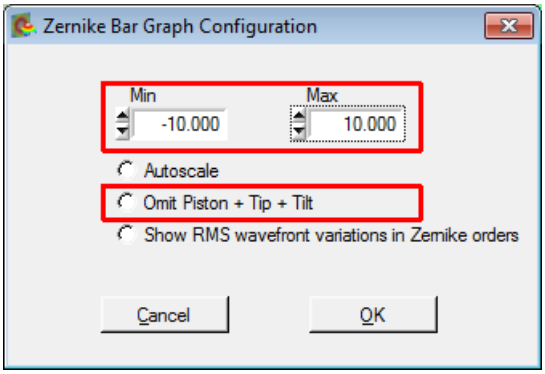


Click **OK** to close the Setup dialog.

- Select **Spot Field** graphic display and adjust the mirror so that the pupil is centered:



7. Align the setup for an almost planar wavefront by changing the beam expander's magnification - maximize the RoC (radius of curvature) or minimize Zernike Z5.
8. Now, the beam shall be adjusted in such way that the beam hits the flat reference mirror almost perpendicularly (Z1 through Z3 minimized in the **Zernike Coefficients** view) and centered to the pupil (**Spot Field** view). To make Z1 through Z3 visible, double click to the **Zernike Coefficients** diagram area, uncheck the box "Omit Piston + Tip + Tilt", uncheck "Autoscale" and set the min and max to appropriate values, for example:

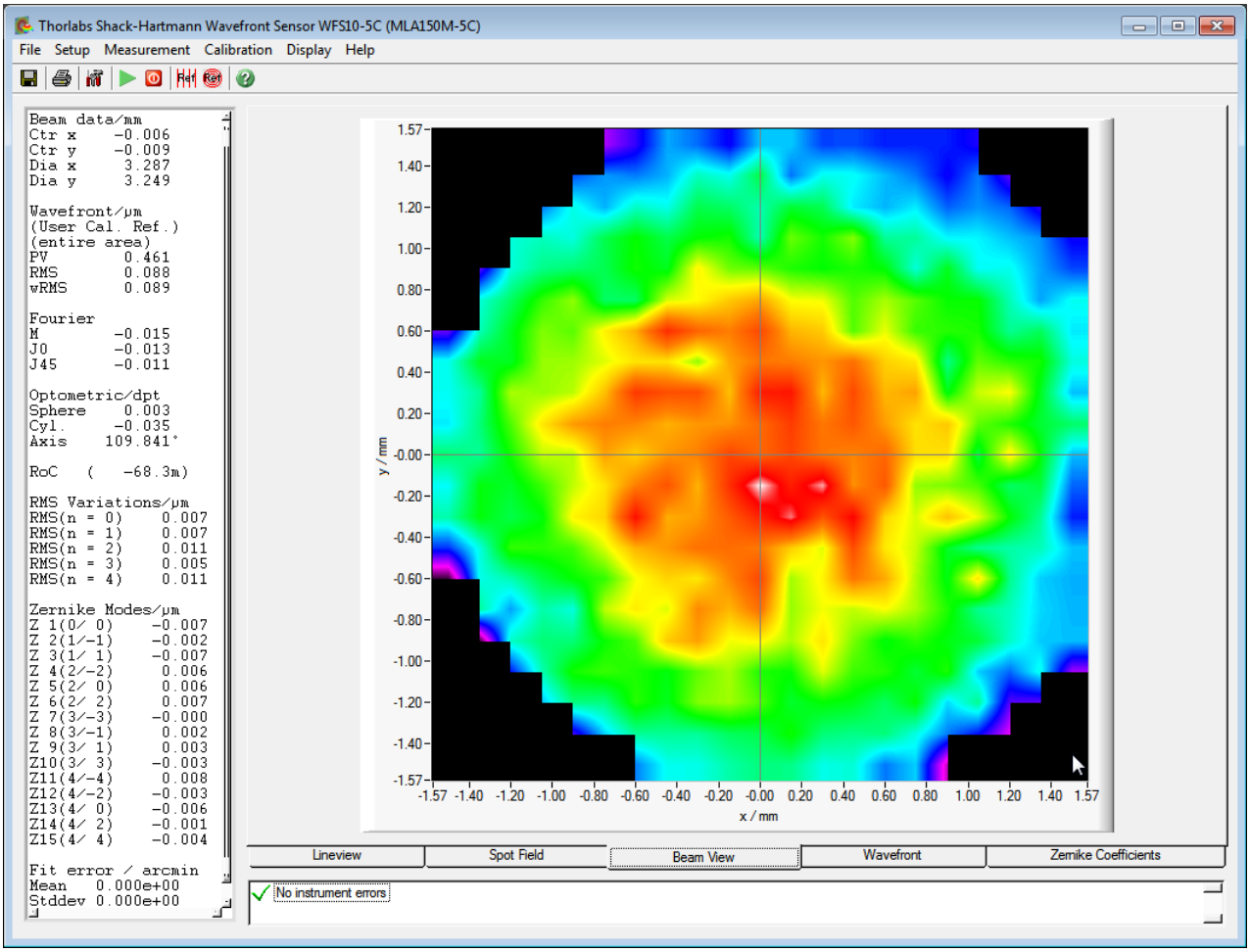


Then turn the adjusters of the KM200 to get the Z1 through Z3 to a minimum. Observe the pupil centering. If the beam has shifted, move the entire beam forming unit and repeat the Z1 to Z3 minimization.

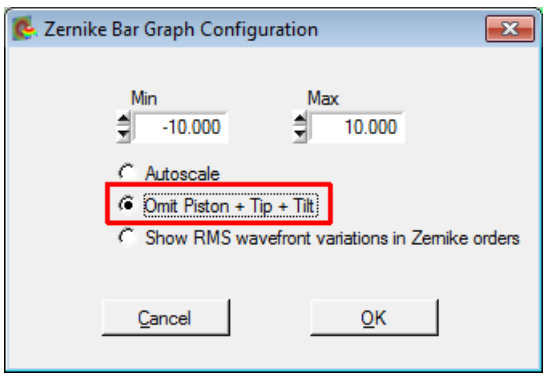
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Alignment of the DMP40

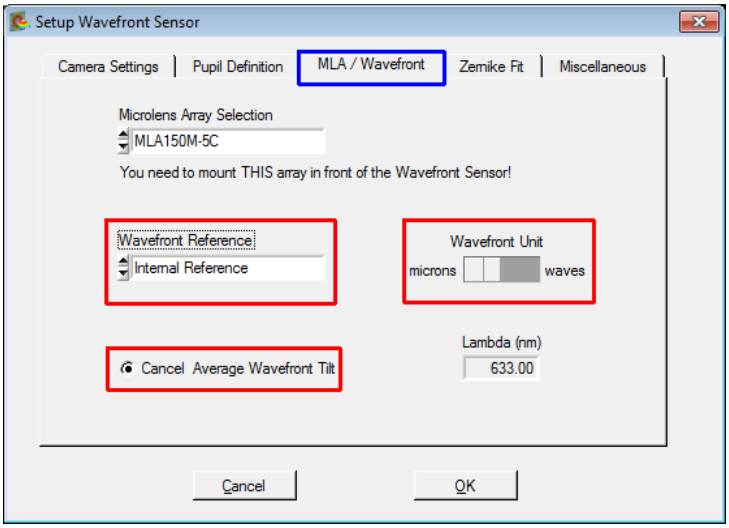
1. Remove the alignment mirror, place the DMP40 assembly back onto the rods, and adjust the correct distance 65 of the DMP40.
2. Connect the DMP40 to the power supply and to the PC, start the DMP40 software and flatten the mirror (Relax function).
3. Now, turn the adjusters of the KC1-T/M that holds the DMP40 in such way that you will get a minimum tip/tilt.
4. As a final step, check the Beam View panel - the maximum intensity should also be close to the center (red area):



5. After alignment, it is recommended to hide Zernike indices 1 to 3, as these represent Piston, Tip Y and Tilt X , and fix the scaling to values between, say, -5 and +5 µm



6. As a final step, return to the WFS settings, tab **MLA / Wavefront** and check the box "Cancel Average Wavefront Tilt":



Now, the adjustment of the setup is finished.

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7.4.4 List of Materials for Closed Loop Setup

All used components are listed in the following table. The item numbers are linked to the Thorlabs' web site - just click and find out more about the products.

Note

- The following list contains metric items. If required, all metric items can be replaced by their imperial complement.
- This list comprises of optical components with AR coating "A" for the wavelength range of 400 to 650 nm, as the setup was designed for a DMP40-P01 (Protected Silver Coating). For use with a DMP40-F01 (UV-Enhanced Aluminum Coating), the optical components must be selected with respect to the enhanced UV range!
- The WFS20-5C can be operated from 300 nm up.

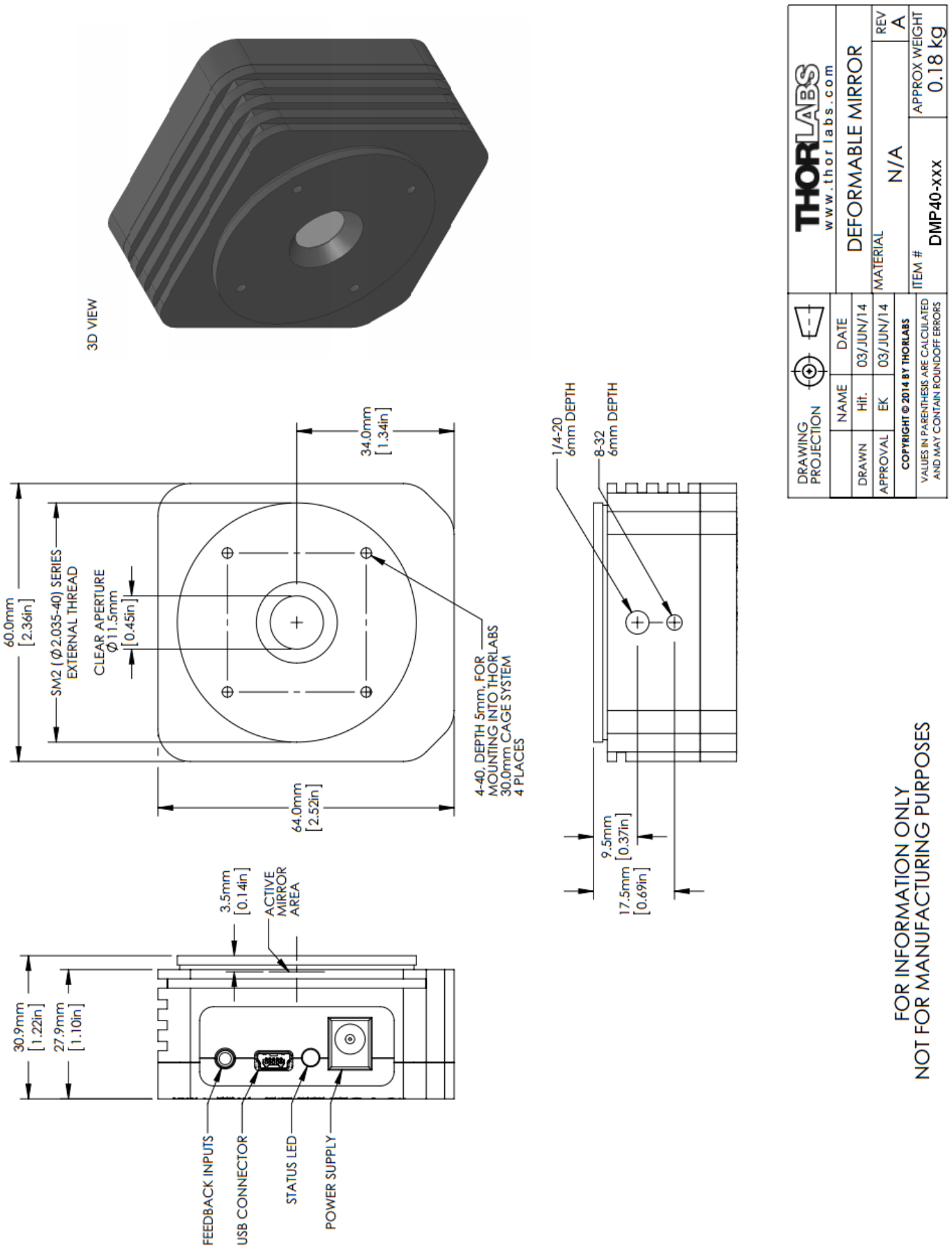
Item Number	Description	Quantity
AD15F	SM1-Threaded Adapter for Ø15 mm Cylindrical Components	1
GBE03-A	3x Achromatic Galilean Beam Expander, AR Coated: 400 - 650 nm	1
CF125	Small Clamping Fork, 1.25"	4
CCM1-BS013	Cube-Mounted, Non-Polarizing, 50:50 Beam Splitter	1
CP02/M	SM1-Threaded 30 mm Cage Plate	2
CP06/M	Post-Mountable Cage Plate with Ø1.0" Double Bore	1
CP02B	30 mm Cage Plate Adapter	2
CP07	Ø2" Round Cage Plate	1
ER1-P4	Cage Assembly Rod, 1", 4 Pack	1
ER3-P4	Cage Assembly Rod, 3", 4 Pack	1
ER4-P4	Cage Assembly Rod, 4", 4 Pack	1
ER8-P4	Cage Assembly Rod, 8", 4 Pack	1
F810FC-635	635 nm FC/PC Collimation Package	1
KC1-T/M	Kinematic, SM1 threaded 30 mm-Cage Mount	1
KM200	Ø2" Kinematic Mount	1
LB1437-A	Biconvex Lens, Ø1", 150 mm, 350-700nm	1
LB1471-A	Biconvex Lens, Ø1", 50 mm, 350-700nm	1
MB3045U/M	Unanodized Aluminum Breadboard, 300x450x12.7mm, M6	1
NE10A	Ø25 mm Absorptive ND Filter, OD 1.0	1
PF10-03-P01	Protected Silver Mirror, Ø1"	1
PH40E/M	Pedestal Post Holder, L = 44.7 mm	1
PH50E/M	Pedestal Post Holder, L = 54.7 mm	3
SM1A2	Adapter - External SM1 thread, internal - SM2	1
SM1A9	Adapter C-Mount SM1	1

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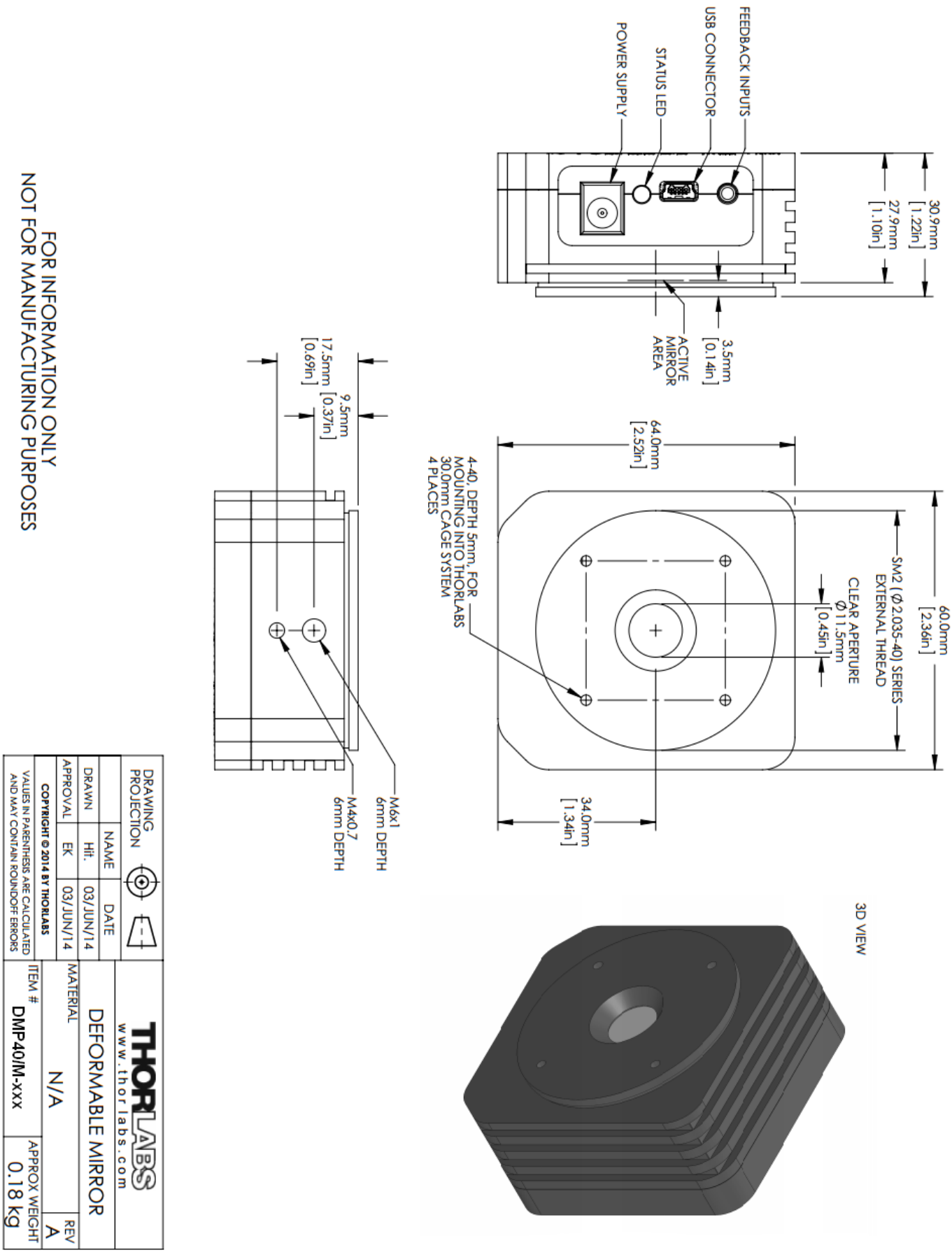
Item Number	Description	Quantity
SM1CP2	Externally SM1-Threaded End Cap	1
SM1L03	SM1 Lens Tube, 0.3"	2
SM1L10	SM1 Lens Tube, 1.0"	1
SM1L40	SM1 Lens Tube, 4.0"	1
SM1T2	SM1 Coupler, External Threads	2
TR40/M	Ø12.7 x 40 mm Stainless Steel Post	1
TR50/M	Ø12.7 x 50 mm Stainless Steel Post	3
WFS20-5C	Fast Shack-Hartmann WFS, Chrome Masked	1

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7.5 Dimensions DMP40-xxx (Imperial)



7.6 Dimensions DMP40/M-xxx (Metric)



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7.7 Safety

Attention

All statements regarding safety of operation and technical data in this instruction manual will only apply when the unit is operated correctly as it was designed for.

Prior to applying power to the DMP40, make sure that the protective conductor of the 3 conductor mains power cord is correctly connected to the protective earth ground contact of the socket outlet! Improper grounding can cause electric shock with damages to your health or even death!

The DMP40 must not be operated in explosion endangered environments!

Do not open the cabinet, there are no parts serviceable by the operator inside!

Refer servicing to qualified personnel!

Only with written consent from *Thorlabs* may changes to single components be made or components not supplied by *Thorlabs* be used.

This precision device is only serviceable if properly packed into the complete original packaging. If necessary, ask for a replacement package prior to return.

Attention

Mobile telephones, cellular phones or other radio transmitters are not to be used within the range of three meters of this unit since the electromagnetic field intensity may then exceed the maximum allowed disturbance values according to IEC 61326-1.

This product has been tested and found to comply with the limits according to IEC 61326-1 for using connection cables shorter than 3 meters (9.8 feet).

Warning

The piezoelectric actuators are operated by a high DC voltage. Immediately disconnect the power supply if the mirror surface is damaged accidentally, do NOT touch any parts inside!

7.8 Manufacturer Address

Manufacturer Address Europe
Thorlabs GmbH
Münchner Weg 1
D-85232 Bergkirchen
Germany
Tel: +49-8131-5956-0
Fax: +49-8131-5956-99
www.thorlabs.de
Email: europe@thorlabs.com

EU-Importer Address
Thorlabs GmbH
Münchner Weg 1
D-85232 Bergkirchen
Germany
Tel: +49-8131-5956-0
Fax: +49-8131-5956-99
www.thorlabs.de
Email: europe@thorlabs.com

7.9 Certifications and Compliances

EU Declaration of Conformity

in accordance with EN ISO 17050-1:2010

We: Thorlabs GmbH

Of: Münchner Weg 1, 85232 Bergkirchen, Deutschland

in accordance with the following Directive(s):

2014/35/EU	Low Voltage Directive (LVD)
2014/30/EU	Electromagnetic Compatibility (EMC) Directive
2011/65/EU	Restriction of Use of Certain Hazardous Substances (RoHS)

hereby declare that:

Model: ***DMP40(/M)-x***

Equipment: ***Deformable Mirror-Series***

is in conformity with the applicable requirements of the following documents:

EN 61010-1	Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use.	2010
EN 61326-1	Electrical Equipment for Measurement, Control and Laboratory Use - EMC Requirements	2013

and which, issued under the sole responsibility of Thorlabs, is in conformity with Directive 2011/65/EU of the European Parliament and of the Council of 8th June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, for the reason stated below:

does not contain substances in excess of the maximum concentration values tolerated by weight in homogenous materials as listed in Annex II of the Directive

I hereby declare that the equipment named has been designed to comply with the relevant sections of the above referenced specifications, and complies with all applicable Essential Requirements of the Directives.

Signed:  *On:* 07 November 2019

Name: Bruno Gross

Position: General Manager

EDC - DMP40(/M)-x, DMH40(/M)-x -2019-...

CE

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7.10 Warranty

Thorlabs warrants material and production of the DMP40 for a period of 24 months starting with the date of shipment. During this warranty period Thorlabs will see to defaults by repair or by exchange if these are entitled to warranty.

For warranty repairs or service the unit must be sent back to Thorlabs. The customer will carry the shipping costs to Thorlabs, in case of warranty repairs Thorlabs will carry the shipping costs back to the customer.

If no warranty repair is applicable the customer also has to carry the costs for back shipment.

In case of shipment from outside EU duties, taxes etc. which should arise have to be carried by the customer.

Thorlabs warrants the hard- and/or software determined by Thorlabs for this unit to operate fault-free provided that they are handled according to our requirements. However, Thorlabs does not warrant a fault free and uninterrupted operation of the unit, of the software or firmware for special applications nor this instruction manual to be error free. Thorlabs is not liable for consequential damages.

Restriction of Warranty

The warranty mentioned before does not cover errors and defects being the result of improper treatment, software or interface not supplied by us, modification, misuse or operation outside the defined ambient stated by us or unauthorized maintenance.

Further claims will not be consented to and will not be acknowledged. Thorlabs does explicitly not warrant the usability or the economical use for certain cases of application.

Thorlabs reserves the right to change this instruction manual or the technical data of the described unit at any time.

7.11 Copyright and Exclusion of Liability

Thorlabs has taken every possible care in preparing this document. We however assume no liability for the content, completeness or quality of the information contained therein. The content of this document is regularly updated and adapted to reflect the current status of the hardware and/or software. We furthermore do not guarantee that this product will function without errors, even if the stated specifications are adhered to.

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7.12 References

[1] ANSI Z80.28-2010 Ophthalmics - Methods of Reporting Optical Aberrations of Eyes: ANSI eStandards.

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7.13 Thorlabs Worldwide Contacts and WEEE policy

For technical support or sales inquiries, please visit us at www.thorlabs.com/contact for our most up-to-date contact information.



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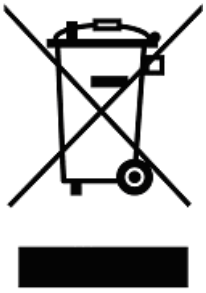
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Thorlabs 'End of Life' Policy (WEEE)

Thorlabs verifies our compliance with the WEEE (Waste Electrical and Electronic Equipment) directive of the European Community and the corresponding national laws. Accordingly, all end users in the EC may return “end of life” Annex I category electrical and electronic equipment sold after August 13, 2005 to Thorlabs, without incurring disposal charges. Eligible units are marked with the crossed out “wheelie bin” logo (see right), were sold to and are currently owned by a company or institute within the EC, and are not dissembled or contaminated. Contact Thorlabs for more information. Waste treatment is your own responsibility. “End of life” units must be returned to Thorlabs or handed to a company specializing in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.



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