

Flexible Optical B.V.



Adaptive Optics • Optical Microsystems • Wavefront Sensors

37 (19) - channel piezoelectric deformable mirror system technical passport

OKO Technologies,

OKO Technologies is the trade name of Flexible Optical BV

1 Technical data

The mirror, shown in Fig. 1, consists of 37 (19) piezoelectric column actuators bonded to the base holder. Reflective plate is bonded to the top of the actuator structure and coated to form the mirror. The shape of the faceplate is controlled by the voltages applied to the actuators.

The device can be used for fast dynamic correction of low-order optical aberrations such as defocus, astigmatism, coma, etc, in lasers, telescopes, ophthalmology, displays and general imaging optics.

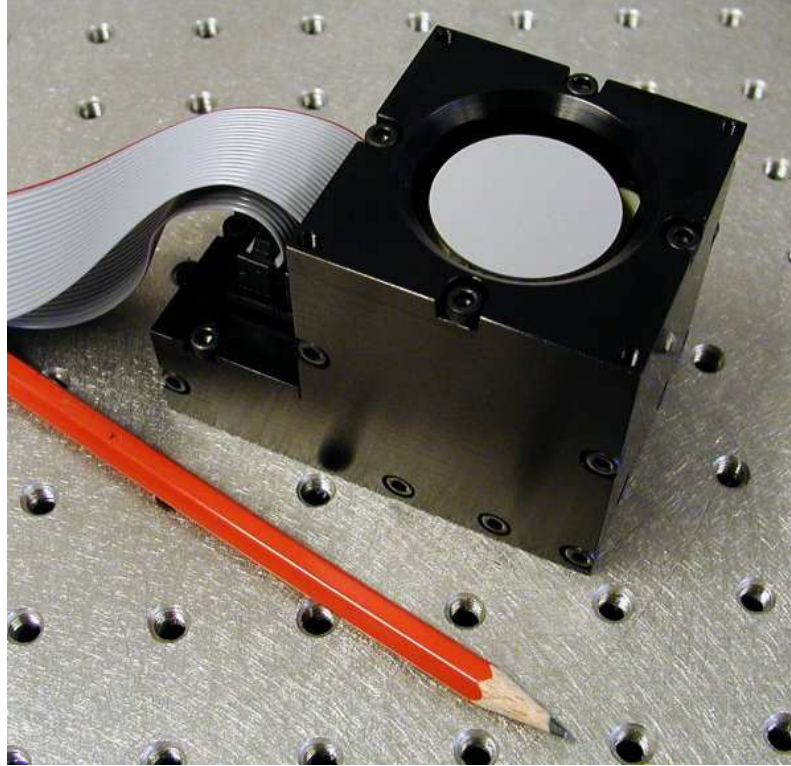


Figure 1: Typical view of a 37-ch piezoelectric deformable mirror. Please note that these mirrors can be fabricated with different package designs, so the mirror you have may look differently.

Table 1: Technical parameters of the mirror.

Parameter	Value
Aperture shape	circular 30 mm in diameter
Mirror coating	Al
Actuator voltages	0 + 400V (with respect to the ground electrode)
Number of electrodes	37 (see Fig. 2)
Actuator capacitance C_a	5 nF
Initial RMS deviation from reference sphere	less than 0.9 μm
Main initial aberration	sphere with $R \sim 100 \text{ m}$
Maximum stroke	8 μm at +400V
Actuator pitch	4.3 mm

The mirror can be supplied with initially slightly curved spherical surface. This sphericity is caused by the stress in the mirror coating. It does not influence the parameters of the mirror, but should be taken into account when the mirror is incorporated into the optical setup.

Due to hysteresis of actuators, the initial aberration may change during the mirror usage and deviate more from the reference sphere. This deviation is a superposition of actuator response functions and is irrelevant in active setups with closed-loop control, though it may slightly reduce the correction range.

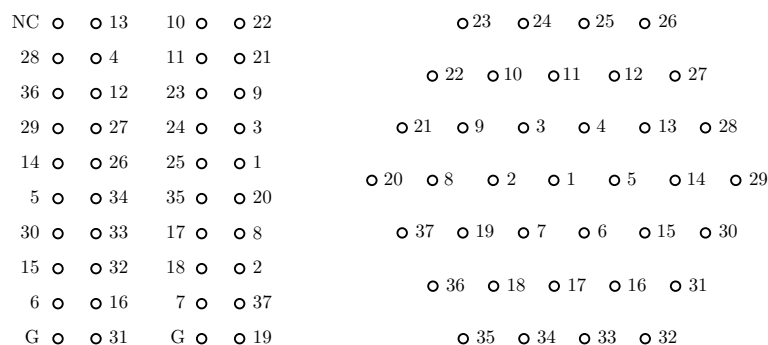


Figure 2: The connector pinout and the geometry of mirror actuators for the 37-ch mirror (view from the back side which is the bottom of the mirror).

2 Control amplifier unit

The mirror is controlled by a high-voltage amplifier unit. To use the unit, you must connect it to the mirror, to a DAC USB unit (or PCI boards) and to the wall outlet (85 to 250V AC, 50 to 60 Hz). Connect the mirror with a supplied flat ribbon cables to the 20-pin connectors on the front side, and the driver boards or the USB unit to the 26-pin connectors.

The HV unit supplied with your mirror is tuned to secure safe operation of the mirror.



Figure 3: 40 channel high-voltage amplifier unit.

In case of OEM version of the system, the mirror is controlled by two high-voltage amplifier boards. Each board contains 20 non-inverting DC amplifiers with gain 35, 59, or 79 depending on the board type, and should be connected to a high-voltage (< 400V) power supply and to



Figure 4: Front and back panels of 40 channel high-voltage amplifier unit.

a stabilized $\pm 15\text{V}$ DC supply. Connect the ground, $+15\text{V}$ and -15V to the pins marked G, + and -. Connect positive high-voltage stabilized DC supply to the pin marked V_high, connect negative high voltage terminal to the ground (see Fig. 5). **The high voltage supply should not exceed 400 V DC.** Use the flat ribbon cable supplied to connect the driver board to the mirror socket.

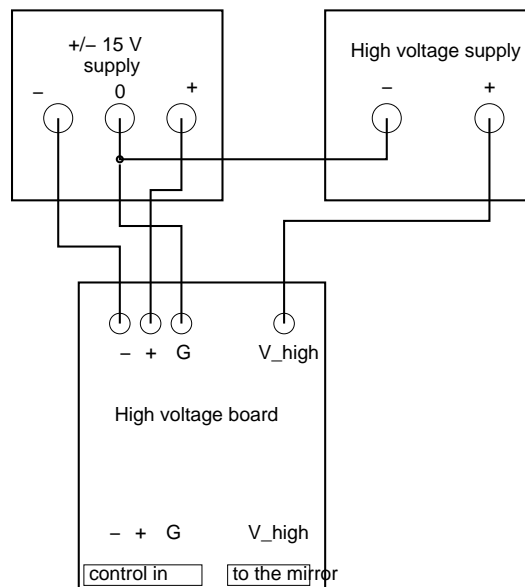


Figure 5: Power supply wiring for OEM version of the system. Position of the connectors can be different; refer to the board manual and/or marking on the board.

3 Digital boards

The output voltage of the channel N [$N=0\dots 23$] of the 8-bit 24-channel DAC board is controlled by sending control byte V [$0\dots 255$] to the output port $BA+N*4$. Please see the separate board description for detailed installation guide.

The pinout of the board and the pinouts of the board cable and the cable coming from the high voltage board are shown in Fig. 7. The board connector pinout is given for the board make connector. The cable pinouts are given for the cable female connectors viewed from the front side.

The actuator addresses of the 37ch mirror are given below:

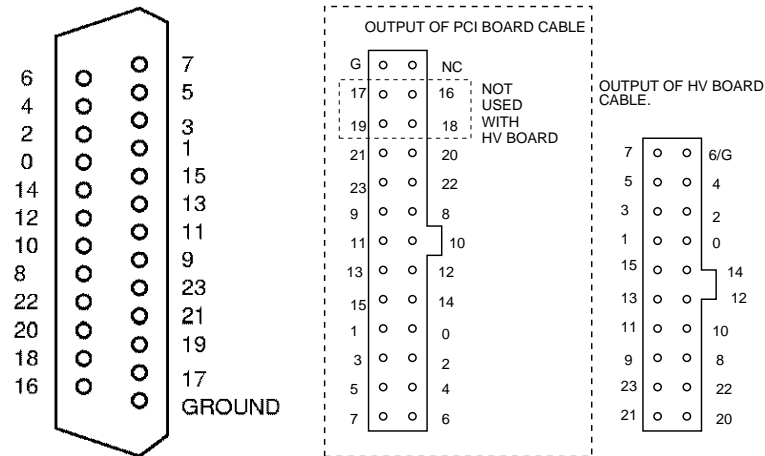


Figure 6: Pinouts of the digital board and cables. The numbers correspond to the addresses of the pin with respect to the base address of the board.

```
i=PCI_CH_OFFSET;
```

```
addr[ 1]=b1+13*i; addr[ 2]=b1+ 3*i; addr[ 3]=b1+11*i;
addr[ 4]=b2+23*i; addr[ 5]=b2+14*i; addr[ 6]=b2+ 4*i;
addr[ 7]=b1+ 4*i; addr[ 8]=b1+ 1*i; addr[ 9]=b1+ 9*i;
addr[10]=b1+20*i; addr[11]=b1+22*i; addr[12]=b2+ 9*i;
addr[13]=b2+21*i; addr[14]=b2+12*i; addr[15]=b2+ 2*i;
addr[16]=b2+ 5*i; addr[17]=b1+ 0*i; addr[18]=b1+ 2*i;
addr[19]=b1+ 7*i; addr[20]=b1+15*i; addr[21]=b1+23*i;
addr[22]=b1+21*i; addr[23]=b1+ 8*i; addr[24]=b1+10*i;
addr[25]=b1+12*i; addr[26]=b2+13*i; addr[27]=b2+11*i;
addr[28]=b2+22*i; addr[29]=b2+10*i; addr[30]=b2+ 0*i;
addr[31]=b2+ 7*i; addr[32]=b2+ 3*i; addr[33]=b2+ 1*i;
addr[34]=b2+15*i; addr[35]=b1+14*i; addr[36]=b1+ 5*i;
addr[36]=b2+ 8*i; addr[37]=b1+ 5*i;
```

4 DAC Unit

A single “DAC-40-USB” unit can control up to 40 channels. Please see the separate unit description for detailed installation guide.

The pinout of the DAC unit and the pinouts of the board cable and the cable coming from the high voltage board are shown in Fig. 7. The DAC unit connector pinout is given for one of its male connectors. The cable pinouts are given for the cable female connectors viewed from the front side.

5 Optical quality

The interferograms of the mirror obtained before shipping are shown in Fig. 8.

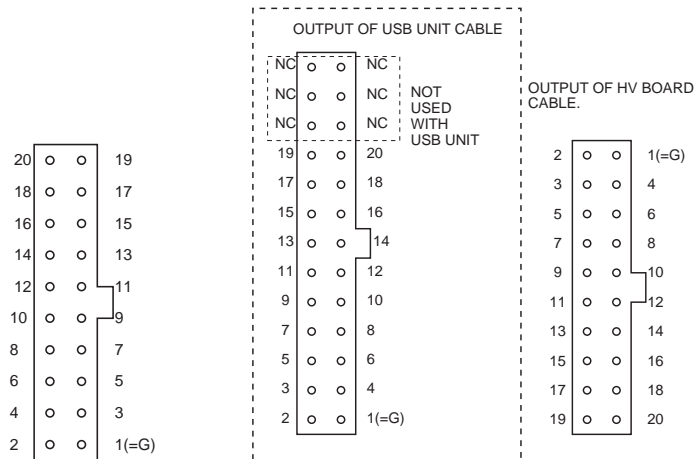


Figure 7: Pinouts of the first connector of the “DAC-40-USB” unit and cables. The numbers correspond to the numeration of “DAC-40-USB” output channels. Second connector is connected in a similar way.

6 First run of the system

- **Read this document through before performing any practical steps.** Follow the instructions exactly, if it’s written connect the board, connect the mirror — **first** connect the board and **then** connect the mirror.
- All following operations refer to DAC-40-USB unit connected to a computer running Windows - we used XP SP2 for final tests.
- Connect the DAC USB unit to the computer USB port. Install the software (refer to the DAC USB unit guide) and determine the base address (look at /proc/pci for PROTO 3 boards). Run the example programs supplied with the CD to test the DAC USB unit functionality.
- Switch the computer off. Connect band cables to the connector(s) in the mirror holder. Connect the amplifier unit to the DAC USB unit. At this stage the system is fully assembled but the adaptive mirror is not used yet. Switch on the amplifier unit. Test the output voltages in the mirror socket. These voltages must be in the range 0...2V. Turn the computer on. At this stage the voltages in mirror socket may have values between 0V and V_{\max} (V_{\max} can be in the range 150...400 V). Run the test programs. Control all channels. Switch off the amplifier unit and computer.
- *For OEM version.* Switch the computer off. Connect band cables to the connector(s) in the mirror holder. Connect the amplifier boards to the DAC USB unit or to the PCI DAC boards, then to low and high voltage power supplies. At this stage the system is fully assembled but the adaptive mirror is not used yet. Switch on the power supplies in the order: +15V, -15V, +V_high. Do not use V_high higher than 120V for the first test. The current (positive supply to ground) should not exceed 0.125A for one board (zero output of all 20 amplifiers) and 0.25A for two boards (40 amplifiers). The high voltage current should not exceed 0.05A for V_high=150V for two boards. Test the output voltages in the mirror socket. These voltages must be in the range 0...2V. Turn the computer on. While turned on, the boards are initialized to random output voltages. At this stage the voltages in mirror socket may have values between 0V and V_high. Run the test

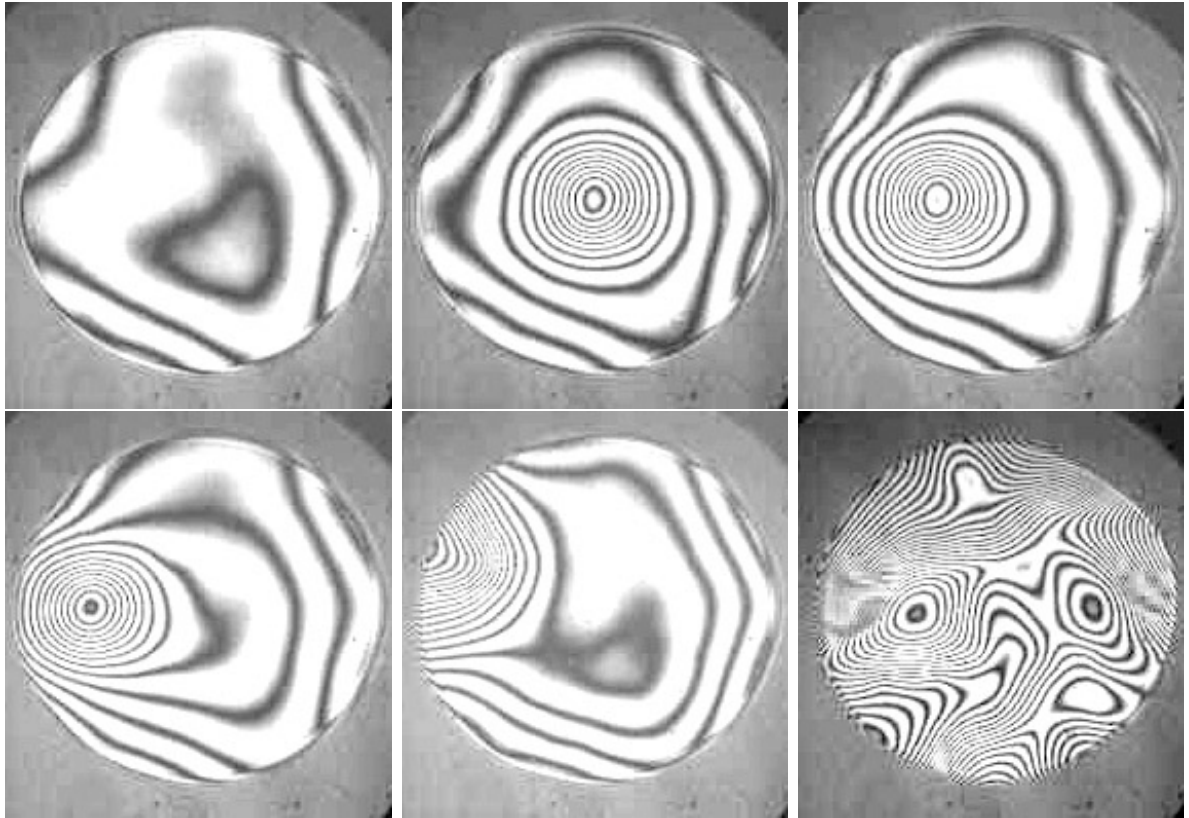


Figure 8: Test of the mirror: zero voltage applied, 300V applied to the central, internal and edge actuators, random voltages to all actuators.

programs. Control all channels. Switch off power supplies and computer (in the order V_high, +15V, -15V, computer).

- Place the mirror into interferometer or a setup with a wavefront sensor. Fix the cables to the optical table. You can also test the mirror by reflecting a good collimated beam from the mirror surface and observing the near field intensity distribution.
- Control the initial mirror figure (should be close to sphere).
- Switch on the amplifier unit or all supply voltages (in the order +15V, -15V, V_high). Do not use V_high higher than 100V at this stage.
- Switch on the computer. Use test programs to control the mirror figure.
- You may start to use the mirror if all channels work. Use “am_set” and “rotate” as templates to write your own control programs.

7 Remarks

For OEM version. Use high-quality stabilized filtered high-voltage supply. Some high-voltage supplies generate short high-voltage spikes at the output, these deviations can destroy the mirror, driver electronics and even the control computer. Do not turn on V_high directly to its maximum value. Set V_high to 100V before switching the system off. Switch the system

on with V_{high} not higher than 120V. Increase V_{high} to its working value after switching on the digital boards and setting the control voltages to zero.

The jumpers on the amplifier board or in the amplifier unit, in the DAC USB control unit are preset before shipping; this configuration should not be changed. **The system and jumper configuration were tested before shipping.**

Do not touch or clean the mirror. We are not responsible for any damage to the mirror due to a cleaning attempt. If you need to clean the mirror, please contact us; we can clean it for you.

8 Warranty and Export Disclaimers

8.1 Warranty

The equipment is covered by a one-year factory-defect warranty.

If the mirror is damaged during shipping, it will be replaced by a similar device within two months. A photo of the damaged device should be sent to Flexible Optical B.V. (OKO[®] Technologies) within 3 days after the damaged device is received.

EXCEPT WHEN OTHERWISE STATED IN WRITING FLEXIBLE OPTICAL B.V. (OKO[®] TECHNOLOGIES) AND/OR OTHER PARTIES PROVIDE THE SYSTEM "AS IS" WITHOUT WARRANTY OF ANY MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. THE ENTIRE RISK AS TO THE QUALITY AND PERFORMANCE OF THE EQUIPMENT IS WITH YOU.

IN NO EVENT UNLESS REQUIRED BY APPLICABLE LAW OR AGREED TO IN WRITING WILL FLEXIBLE OPTICAL B.V. (OKO[®] TECHNOLOGIES) BE LIABLE TO YOU FOR DAMAGES, INCLUDING ANY GENERAL, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OR INABILITY TO USE THE HARDWARE AND SOFTWARE DESCRIBED IN THIS DOCUMENT.

8.2 Export

According to the European export law, to export outside the EU, Flexible Optical B.V. (OKO[®] Technologies) will need to obtain the export license for any product that matches the definition:

"Deformable mirrors having either continuous or multi-element surfaces, and specially designed components therefor, capable of dynamically repositioning portions of the surface of the mirror at rates exceeding 100 Hz."

Export inside the EU is free from this restriction.

9 Contact person

All questions about the technology, quality and applications of adaptive mirror should be addressed to:

Flexible Optical B.V.
Röntgenweg 1,
2624 BD, Delft
The Netherlands

Date:

Signature:

typical
December 13, 2006