ZMI
DPMI
Accessory Manual
OMP-0223D

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MANUAL REVISION INFORMATION

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B	December 1992
C	July 1993
D	March 1999

MANUAL NOTATIONS

⚠ **Warning!** Denotes a hazard that could cause injury to personnel, and can also cause damage to the equipment.

Note: Provides helpful information.

ZYGO TECHNICAL SUPPORT

For help within the United States, Canada, and Mexico, please use the contacts listed below. For help in other countries, please contact your local Zygo representative.

Be sure to supply the instrument model and serial number, and the software version.

PHONE (860) 704-5191 Customer Support Center, 8 a.m. - 8 p.m. (EST)
(860) 347-8506 Zygo Corporation

FAX (860) 347-3968, 24 hours per day

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ZYGO STATEMENT OF WARRANTY AND PRODUCT SUPPORT

Zygo Corporation provides this warranty to protect its customers from defects in product workmanship or product materials. This warranty covers all products manufactured by Zygo Corporation. Zygo warrants that the equipment purchased will be free from any defects in material and/or workmanship under normal operating conditions for a period of one year from the date of shipment.

In addition, being committed to providing our customers with superior service, Zygo will support all standard products for a period of five years after the sale of the last newly-manufactured unit. Beyond this five-year period, we will continue to support these products on a "best-effort" basis.

WARRANTY SERVICE

Zygo's responsibility under this warranty shall be limited to the repair or replacement (at Zygo's option) of defective equipment at no cost to the buyer, except for transportation, cleaning, and recalibration charges.

Zygo will perform warranty service by: (1) sending replacement parts with appropriate installation instructions to the buyer, the buyer returning his defective part to Zygo or; (2) repairing the product at a Zygo repair facility after it has been returned freight prepaid, or; (3) at the buyer's request, dispatching a service representative to the buyer's facility. The buyer shall pay Zygo's travel and living expenses as well as travel time.

Defective products or parts will be repaired or replaced with new or like-new parts. These replacement parts will be warranted for a period of 90 days after they are shipped, or for the remainder of the original warranty period, whichever is longer. Warranty service will be performed only if the buyer notifies Zygo within 14 days of discovering any defects. Equipment or parts that are to be returned to Zygo must be issued a Return Authorization number. This number can be obtained by contacting the Zygo Service Department. Should Zygo's subsequent inspection reveal that the parts were not defective, all expenses incurred by Zygo shall be charged back to the buyer. Defective equipment that is replaced shall become the property of Zygo.

Warranty period begins when the product is shipped from Zygo. Replacement parts, service workmanship, used equipment, and refurbished equipment are warranted for a period of 90 days.

RETURNS

Unused and undamaged products, in their original shipping containers, may be returned for credit within 30 days of receipt. All such products will be subject to a restocking fee equal to 20 percent of the purchase price. Custom products are not returnable.

EXCLUSIONS

The above warranty and product support statement applies only to equipment that is an integral part of a Zygo manufactured product. It does not apply to peripheral equipment manufactured by others, such as: computers, printers, vibration isolation tables, etc. In such cases, the warranty and the support that the original manufacturer supplies will apply.

In addition, warranty service does not include or apply to any product or part which, in Zygo's judgment:

a. Has been repaired by others, improperly installed, altered, modified, or damaged in any way.
b. Malfunctions because the customer has failed to perform maintenance, calibration checks or good operating procedures.
c. Is expendable or consumable (such as panel lights, fuses, batteries, windows, and filters) if such items were operable at the time of initial use.
d. Requires replacement because of decomposition due to chemical action.
e. Fails because of poor facility, operating conditions, or utilities.

Other than expressly described above, Zygo makes no express or implied warranties, including any regarding merchantability or fitness for a particular purpose relating to the use or performance of the equipment. Zygo will not be liable for personal injury or property damage (unless caused solely by its own negligence), loss of profit or other incidental or consequential damages arising out of the use or inability to use the equipment. Nor does this warranty apply to any equipment which has been subject to misuse, neglect or accident; or repaired or altered by other than service representatives qualified by Zygo.

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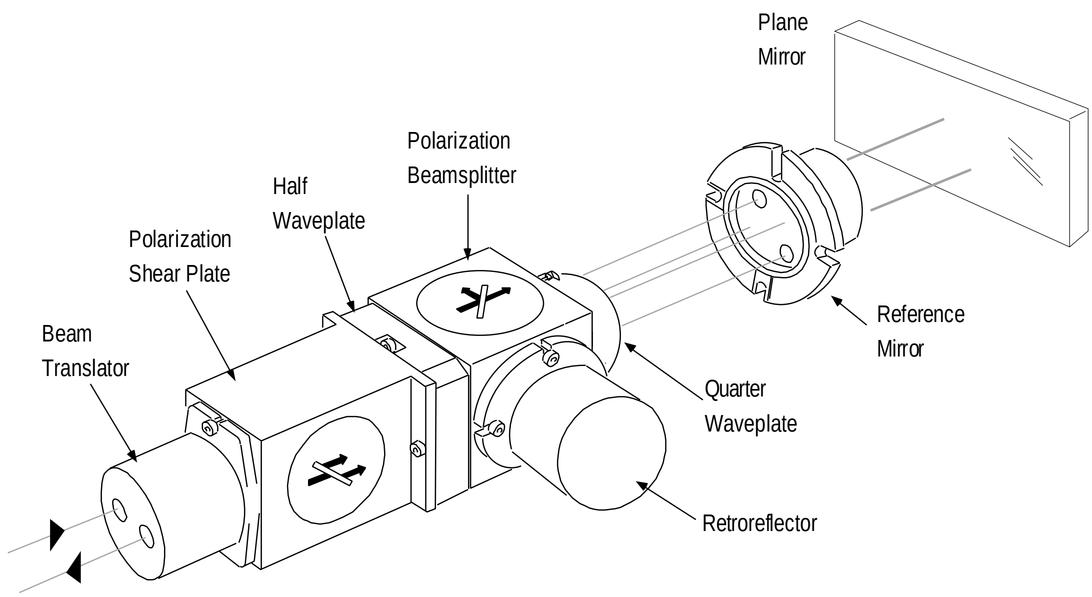
DIFFERENTIAL PLANE MIRROR INTERFEROMETER

Introduction

The Zygo Differential Plane Mirror Interferometer* or DPMI, Model 7015, is a versatile, high performance double pass interferometer, designed to be used in conjunction with a Zygo motion measurement interferometry system. The DPMI can be used to measure either linear or angular displacement. To form a complete interferometric assembly, a Reference Mirror (or Angle Prism) and a plane mirror are required in addition to the DPMI. The DPMI is shown in Figure 1.



DPMI
Figure 1

The DPMI is ideal for high accuracy linear and angular displacement applications because the nominal optical path distance of the measurement and reference beams are the same. The only optical path differentiation is between a fixed optical element and a moving optical element. This results in an interferometer which is extremely insensitive to environmental changes.

*U.S. Patent Numbers 4,693,605; 4,717,250; 4,752,133; 4,746,216, Foreign Patents Pending.

What This Manual Covers

The following topics are covered:

- Description
  - Theory of Operation
- Installation
  - Assembling the DPMI
  - Mounting
- Optical Alignment
- Accuracy and Installation Considerations
- Maintenance
- Specifications

This manual explains the use of the DPMI with Models 7017 and 7018 Reference Mirrors. It *does not* explain the use of the DPMI with Model 7026 Angle Prism to measure medium angle displacement. For information about the Angle Prism, refer to the Angle Prism Accessory Manual, OMP-0224.

Description

The DPMI is used to measure linear or angular displacement between a remotely mounted Reference Mirror and a movable plane mirror. The DPMI is comprised of a Beam Translator, a Polarization Shear Plate, a Half Waveplate, a Polarization Beamsplitter, a Retroreflector, and a Quarter Waveplate. These components manipulate the incoming laser beam so that displacement information can be calculated by a Zygo Measurement Board.

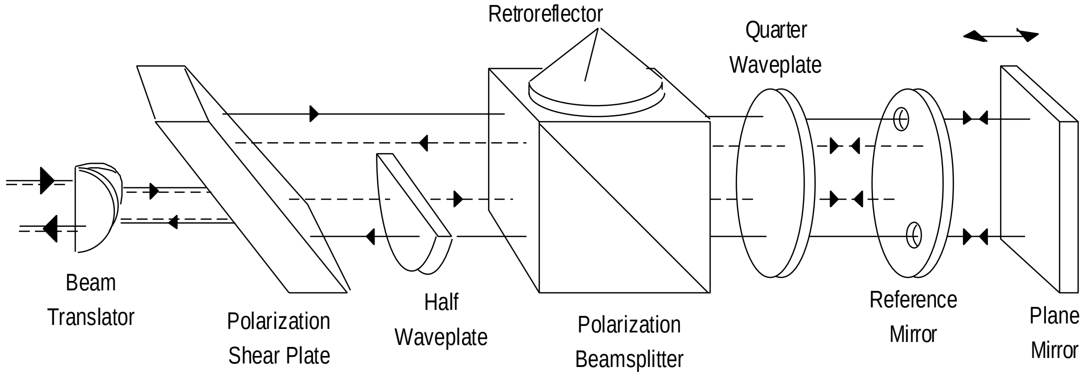
Model	*Component*	*Function*
7003	Retroreflector	Reflects the beam back parallel to the incident beam.
7008	Polarization Beamsplitter	Divides the beam into two perpendicular beams with different polarizations.
7012	Polarization Shear Plate	Splits the beam into two parallel beams of different polarizations, which are equally displaced from the incoming beam.
7016	Beam Translator	Converts 12.7 millimeter beam spacing to 9 millimeter spacing inside the DPMI.
7021	Half Waveplate	Rotates the beam polarization 90 degrees with *one* pass.
7022	Quarter Waveplate	Rotates the beam polarization 90 degrees with *two* passes.

DPMI Components
Table 1

Depending on the Reference Mirror used with the DPMI, the DPMI can measure linear or angular displacement. The Model 7017 Reference Mirror is used with the DPMI to measure linear displacement. The Model 7018 Reference Mirror is used with the DPMI to measure angular displacement.

Theory of Operation

Linear Displacement DPMI Refer to Figure 2 during the following explanation of the DPMI used to measure linear displacement with the Model 7017 Reference Mirror. The incoming laser beam is comprised of twoorthogonally polarized beams, F1 and F2. The combination beam enters one hole in the Beam Translator, which optically shifts the beam toward the center of the Polarization Shear Plate. The shear plate splits the beam into two parallel beams of differentpolarizations; one of these beams passes through a Half Waveplate which rotates the beam polarization 90 degrees. so that both beams are identically linearly polarized. The Polarization Beamsplitter, Quarter Waveplate, and Retroreflector permit one beam to be reflected twice by the Reference Mirror and the other beam to be reflected twice by the movable mirror.



Linear DPMI Isometric
Figure 2

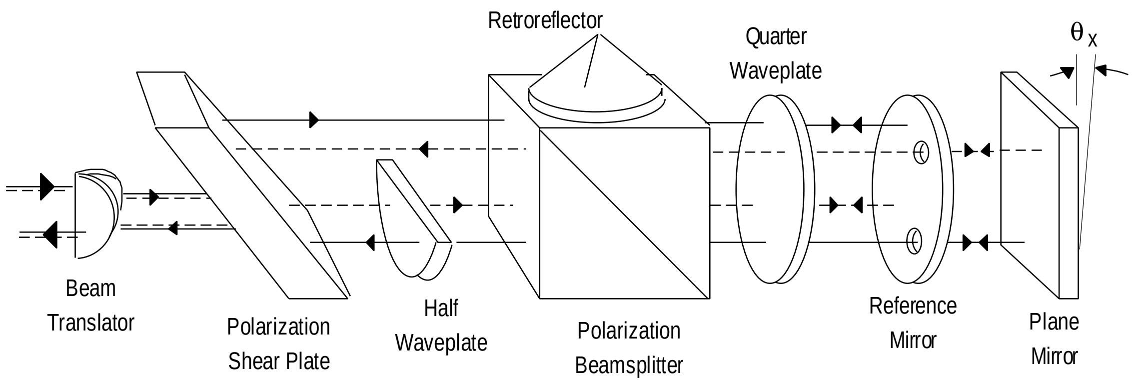
The beams return traveling parallel to each other, the polarization of one beam being rotated by the Half Waveplate so that it is orthogonal to the other beam. The beams are then recombined by the Polarization Shear Plate, shifted again by the Beam Translator and output to the Receiver. Displacement of the movable plane mirror causes the optical path of the measurement beam to change relative to that of the reference beam.

Linear displacement is represented mathematically by:

$$d = \frac{N\lambda}{x} \qquad (1)$$

where d is displacement, N is the output data from the Measurement Board,λ is the compensated wavelength of the measurement beam in air, and x is 508 (Zygo 2/20), 512 (ZMI 1000), or 2048 (ZMI 2000). (X is a representation of the resolution in the electronics.)

Angular Displacement DPMI Refer to Figure 3 during the following explanation of the DPMI used to measure angular displacement with the Model 7018 Reference Mirror. The operation of the angular displacement DPMI is similar to the linear displacement DPMI. The only difference is caused by the Reference Mirror, which has a different hole pattern. In the angular displacement configuration, each beam is reflected once from the Reference Mirror and once from the movable plane mirror. The beams return traveling parallel to each other. Any rotation of the plane mirror causes the angle of incidence of the two beams on the Polarization Shear Plate to change. This in turn introduces an optical path change between the two beams when they are recombined by the Polarization Shear Plate.



Angular DPMI Isometric
Figure 3

Angular displacement is represented mathematically by:

$$\theta_x = \frac{\sqrt{1 - \left(\frac{\sin\alpha}{n_g}\right)^2}}{\sin 2\alpha} \; \frac{n_g \lambda}{x\ h} N \tag{2}$$

Where θ_X is the displacement value about the x-axis in radians; x is 254 (Zygo 2/20), 256 (ZMI 1000), or 1024 (ZMI 2000) (X is a representation of the resolution in the electronics.); α is the angle of incidence of the beam on the Polarization Shear Plate (48.75°); n_g is the refractive index of the shear plate (1.5151);λ is the compensated wavelength of the measurement beam in air; h is the thickness recorded on the Polarization Shear Plate (12.0 mm nominal); and N is the output data from a Measurement Board.

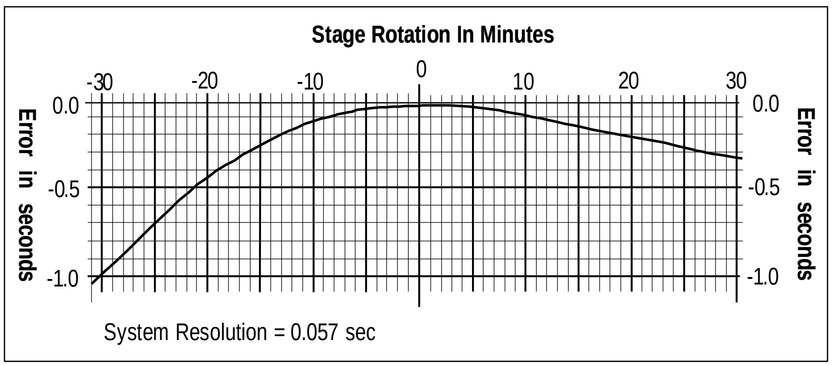
Substituting the nominal values of α, n_g, h, and λ into equation 2, this reduces to:

θ_X = 0.057 (Zygo 2/20) (where θ_X is now in arc seconds) (3)

θ_X = 0.056 (ZMI 1000)

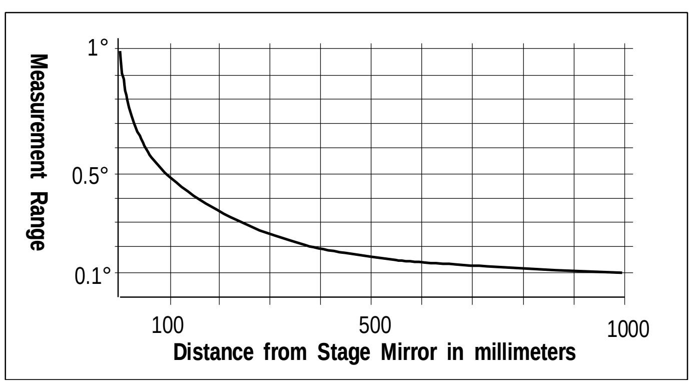
θ_X = 0.015 (ZMI 2000)

Since equation 2 is approximate, there is an error associated with it. For rotations up to 8 minutes, the approximation is good to within 0.06 arc seconds. For rotations of 30 minutes, the error is 1 arc second. When greater accuracy is required, the angular displacement equation can be compensated with a look-up table based on the Table 2.



Equation 2 Approximation Error
Table 2

The angular DPMI has a limited range over which the movable mirror can rotate. This range is dependent on the separation between the interferometer and the movable mirror. The closer the user's mirror is to the interferometer the greater the measurement range; refer to Table 3. This data assumes a 6 mm beam.



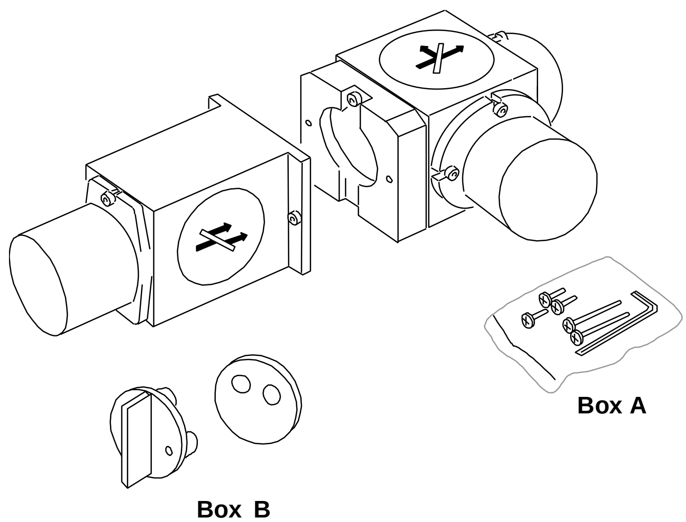
Angular DPMI Measurement Range
Table 3

Installation

The DPMI is shipped partially assembled in two separate boxes and must be put together prior to use. If the DPMI is assembled as shipped from Zygo, it will result in a straight-through configuration.

Box A contains a Polarization Beamsplitter with a Quarter Waveplate, a Half Waveplate, and a Retroreflector attached. A hardware packet is inside the top cover of the box; it contains an 3/32-inch Allen wrench, various socket head screws for assembling the interferometer, and mounting screws.

Box B contains a Polarization Shear Plate with a Beam Translator attached. An Alignment Target and a small, white, plastic Alignment Aid are included.



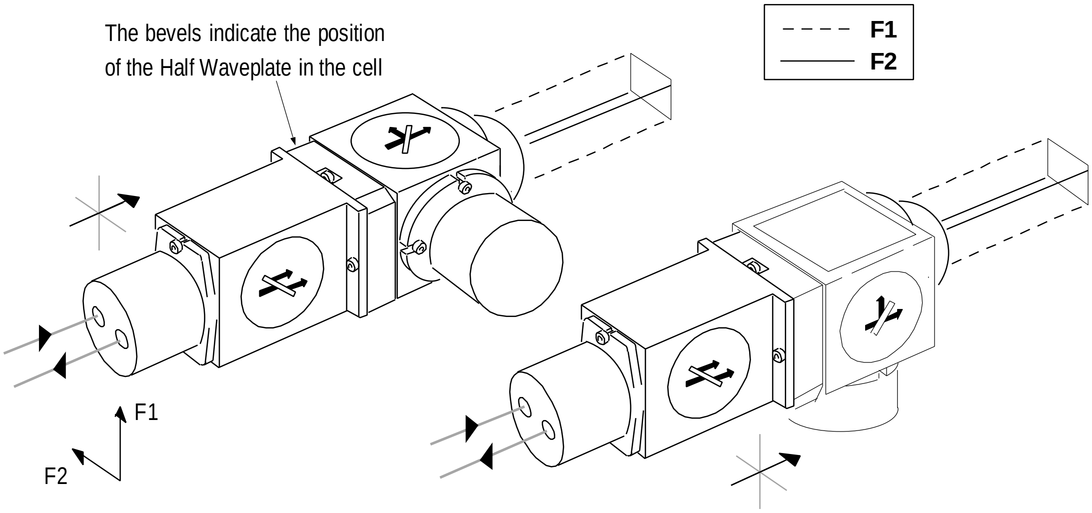
DPMI Shipping Boxes
Figure 4

There are two basic assembly configurations, straight-through and perpendicular, with four variations of both configurations. "Straight-through" and "perpendicular" refer to the path the output beam takes as referenced to the input laser beam. Some of the various configurations are shown in Figure 5.

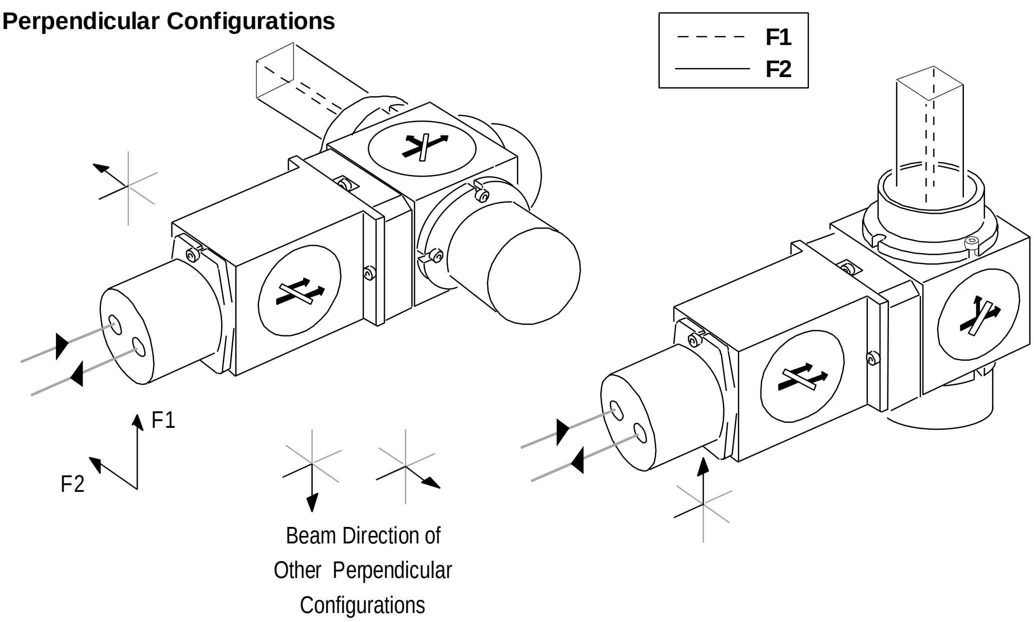
The measurement beam can be directed by rearranging the optical components and by rotating the interferometer. The intended application will dictate the configuration of the DPMI. Before disassembling and reassembling the DPMI, you should have an understanding of how the components work together.

> **Note:** The Half Waveplate has glass in only half of its metal cell. The bevels on the metal cell indicate the side with the glass.

Straight-through Configurations



Perpendicular Configurations



DPMI Configurations
Figure 5

Assembling the DPMI

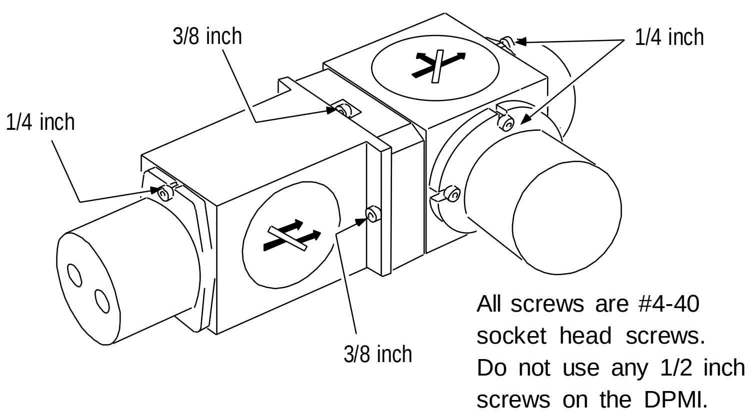
> **Warning!**
> DO NOT get fingerprints, dirt, oil, or dust on the mirrors, glass, or openings in the optics. DO NOT handle roughly or shake.

1. Remove the contents of each box.
2. If required by your application, disassemble the components you must move.

> **Warning!**
> Use care when assembling the optical components into different configurations. Using screws that are too long can make mounting difficult, obstruct beams, or damage components. Refer to Figure 6.

3. Assemble and loosely secure the components together. Tighten the screws after the components have been aligned and leveled on a flat and clean surface.

Note: DO NOT overtighten screws; sufficient torque is obtained with the supplied 3/32-inch Allen wrench. The recommended torque for the interferometer screws is 2.5 inch-pounds (0.3 Newton-meters).



DPMI Screw Sizes
Figure 6

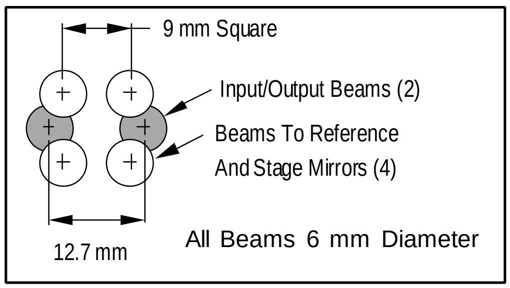
4. Determine if the measurement beam is F1 or F2 to ensure high accurate measurements. Depending on how the DPMI is assembled, the measurement beam may be F1 or F2. In the straight-through configuration the measurement beam is F1, as shipped from the Zygo.

Note: When movement is away from the interferometer and the counts are positive, the measurement beam is F2; when the counts are negative, the measurement beam is F1.

Mounting

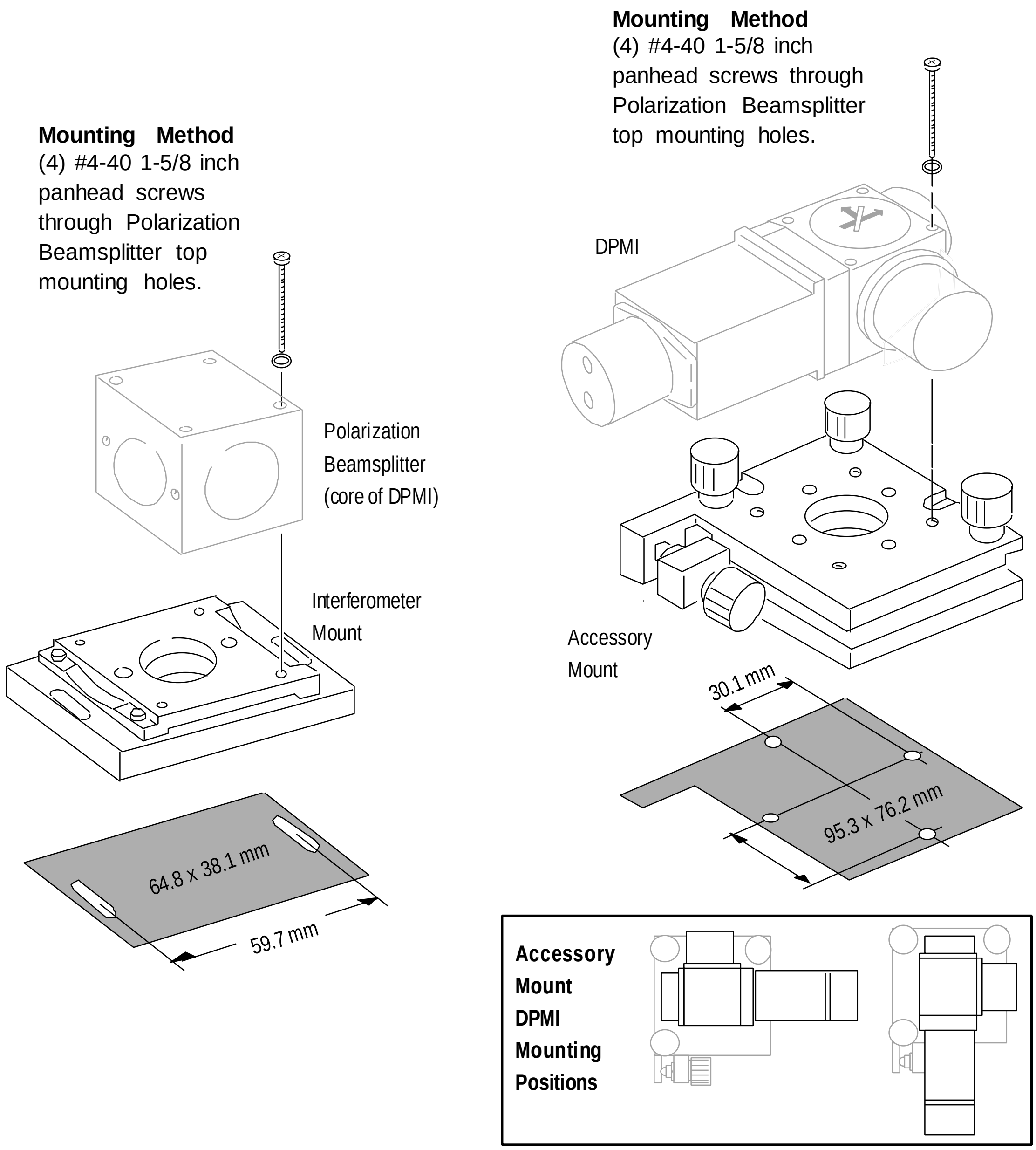
The DPMI must be mounted so that the bottoms or sides are parallel or perpendicular to the plane defined by the Laser Head to within ±1 degree. Locate the DPMI so the beams do not become subject to thermal gradients or fluctuations and so the DPMI is not subject to machine vibrations. In unclean applications, the laser beam and the DPMI must be housed in protective enclosures.

In addition, beam spacing of the DPMI must be taken into consideration to ensure that the beams are not obstructed. This is shown below.



Beam Spacing
Figure 7

When performing alignment, it is necessary to adjust the position of the interferometer. For this reason, the DPMI should be used with some type of adjustable mount. Either the Zygo Interferometer Mount or the Accessory Mount work with the DPMI. The Accessory Mount provides for fine positioning adjustment of the DPMI; but because clearance is needed for the Accessory Mounts four adjustment screws, the DPMI can only be mounted in two orientations. Figure 8 shows how the DPMI can be mounted using either of these mounts.



DPMI Mounting
Figure 8

Optical Alignment

To achieve the maximum accuracy possible with an interferometer, the entire interferometer system must be properly aligned. Careful alignment minimizes the cosine error, which occurs when the measurement beams are not perpendicular to the plane mirrors or to the axis of travel. The acceptable misalignment depends upon the application. (For example, a 1° misalignment causes a 152 ppm error, a 0.1° misalignment causes a 1.5 ppm error, and a 1 arc minute misalignment causes a 0.04 ppm error.)

> **Note:** It is recommended that the user have previous experience in optical alignment techniques. Alignment requires meticulous effort and repetition of steps. For a complete discussion of alignment, refer to Chapter 3 in the ZMI Optics Guide, OMP-0326, or Chapter 4 in the ZYGO 2/20 Operation and Reference Manual, OMP-0220.
>
> Additional alignment aids, not provided with the interferometer, such as a plane mirror, may simplify optical alignment.

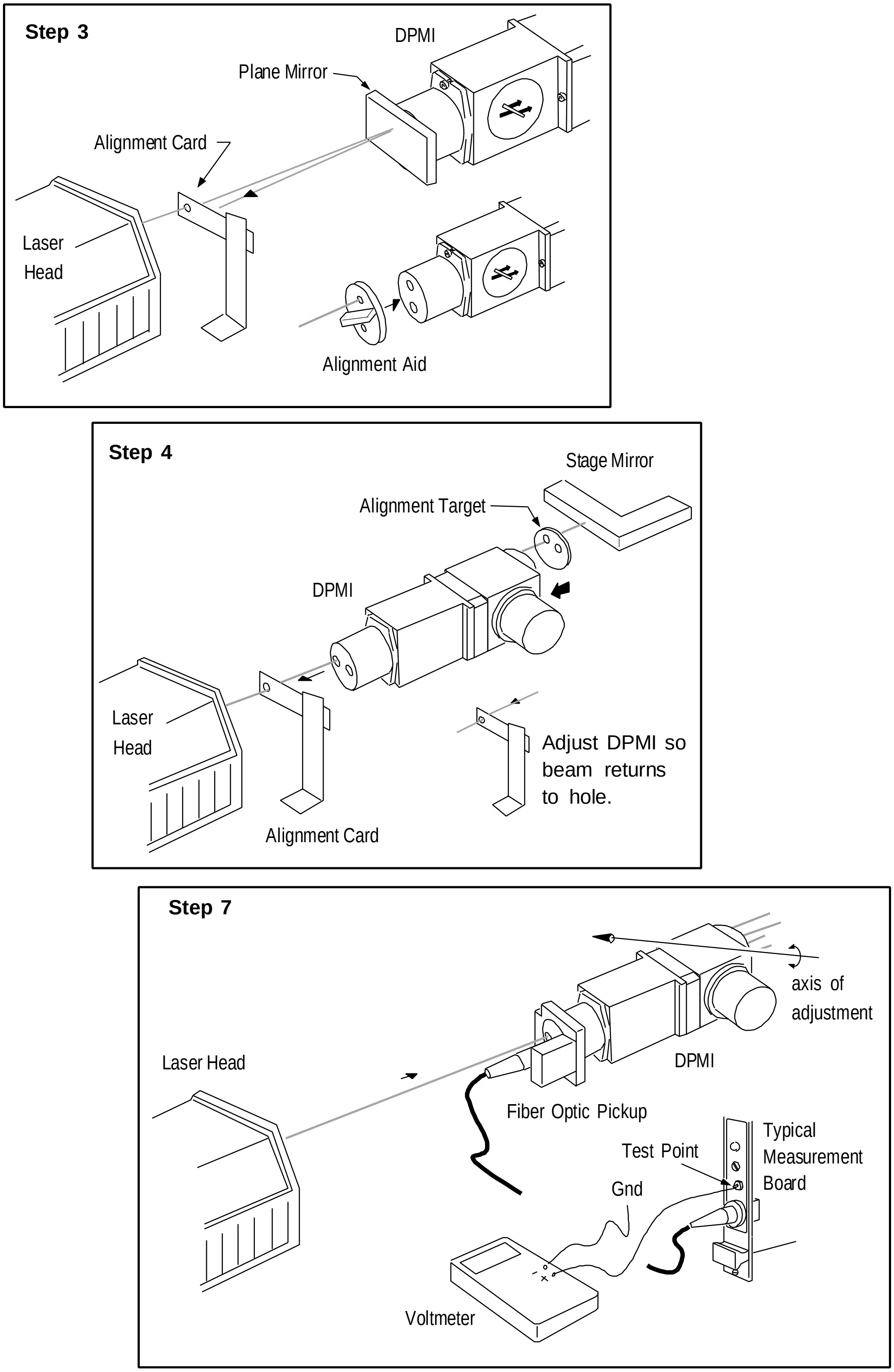
Preparation

1. Align the *stage mirror* to the stage. The stage mirror surfaces should be perpendicular to each other, to their direction of travel, and to the reference plane on which the interferometer is mounted.
2. Align the *Laser Head* so that its output beam is perpendicular to the stage mirror. Adjust the laser head beam height so the beam is centered in the optical component(s) aperture.
3. Align all *fold mirrors* and *beamsplitters* used in the measurement system, parallel and perpendicular to the laser beam. Start with the mirrors and beamsplitters nearest to the laser head and work outward.

Aligning Straight-through DPMI Configurations

Refer to Figure 9.

1. Mount the DPMI and place the plastic Alignment Aid in the DPMI's Beam Translator. Adjust the DPMI position so that the beam from the laser head is centered on the input hole.
2. Select the 3 mm (small) laser beam. Place the Alignment Card in front of the Laser Head so the beam goes through the pinhole.
3. Adjust the DPMI until two conditions are met: a) so the beam enters a hole in the plastic Alignment Aid and b) so the beam reflects back to the pinhole from a plane mirror when it is placed in front of the DPMI. Also, ensure that the DPMI is aligned at both ends of the measurement path length. Then, remove the Alignment Aid and plane mirror.
4. Align the beam output by the interferometer to the stage mirror by performing the following steps: (This step compensates for beam deviation through the polarization beamsplitter.)
   a. Place the Alignment Target on the DPMI's quarter waveplate such that both output beams are centered on the holes in the Aid.
   b. Adjust the position of the *input laser beam* so that the retroreflected beam is coincident with the pinhole in the Alignment Card.
5. Recheck the alignment of the interferometer as instructed in step 3. If the alignment is off, then repeat steps 3 and 4 until both conditions are met. Then, remove the Alignment Target and Alignment Card.
6. Install the receiver or fiber optic pickup and adjust its position so that the output beam from the DPMI is centered in its lens. The applicable signal okay LED on the receiver or ZMI Measurement Board should be on.
7. Select the 6 mm (large) laser beam and allow all four beams from the DPMI to reflect back from the stage mirror. Connect a voltmeter to the applicable test point on the receiver or ZMI Measurement Board. Carefully adjust the position of the DPMI, by rotating the DPMI around the axis of the normal to the polarization beamsplitter hypotenuse, until the voltage is maximized.

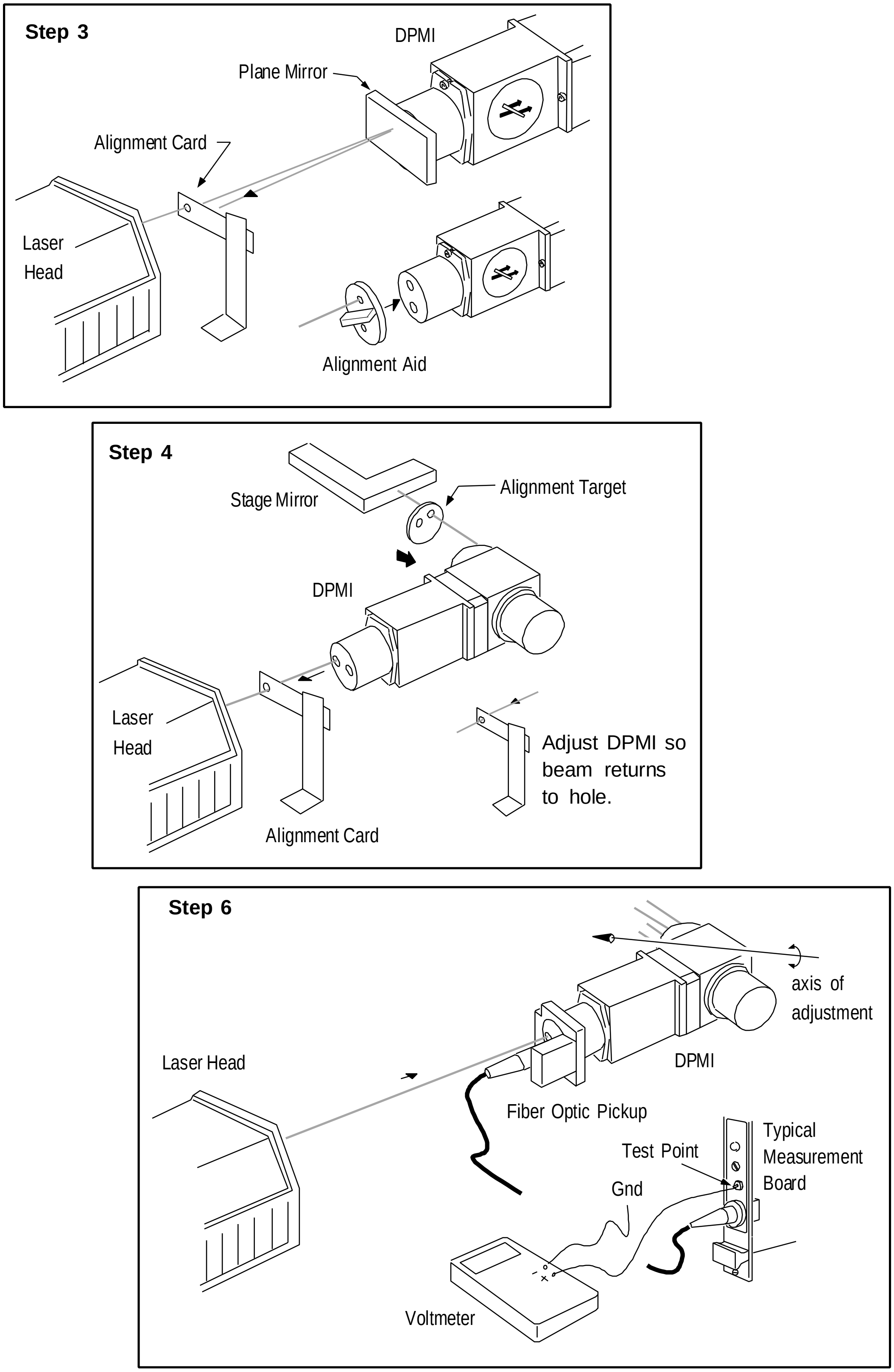


DPMI Straight-through Alignment
Figure 9

Aligning Perpendicular DPMI Configurations

Refer to Figure 10.

1. Mount the DPMI and place the plastic Alignment Aid in the DPMI's Beam Translator. Adjust the DPMI position so that the beam from the laser head is centered on the input hole.
2. Select the 3 mm (small) laser beam. Place the Alignment Card in front of the Laser Head so the beam goes through the pinhole.
3. Adjust the DPMI until two conditions are met: a) so the beam enters a hole in the plastic Alignment Aid and b) so the beam reflects back to the pinhole from a plane mirror when it is placed in front of the DPMI. Also, ensure that the DPMI is aligned at both ends of the measurement path length. Then, remove the Alignment Aid and plane mirror.
4. Align the beam output by the interferometer to the stage mirror by performing the following steps:
   a. Place the Alignment Target on the DPMI's quarter waveplate such that both output beams are centered on the holes in the Aid.
   b. Adjust the position of interferometer so that the retroreflected beam is coincident with the pinhole in the Alignment Card.
   c. Remove the Alignment Target and Alignment Card.
5. Install the receiver or fiber optic pickup and adjust its position so that the output beam from the DPMI is centered in its lens. The applicable signal okay LED on the receiver or ZMI Measurement Board should be on.
6. Select the 6 mm (large) laser beam and allow all four beams from the DPMI to reflect back from the stage mirror. Connect a voltmeter to the applicable test point on the receiver or ZMI Measurement Board. Carefully adjust the position of the DPMI, by rotating the DPMI around the axis of the normal to the polarization beamsplitter hypotenuse, until the voltage is maximized.
7. Recheck the alignment of the interferometer as instructed in step 3.



DPMI Perpendicular Alignment
Figure 10

Aligning the Reference Mirror

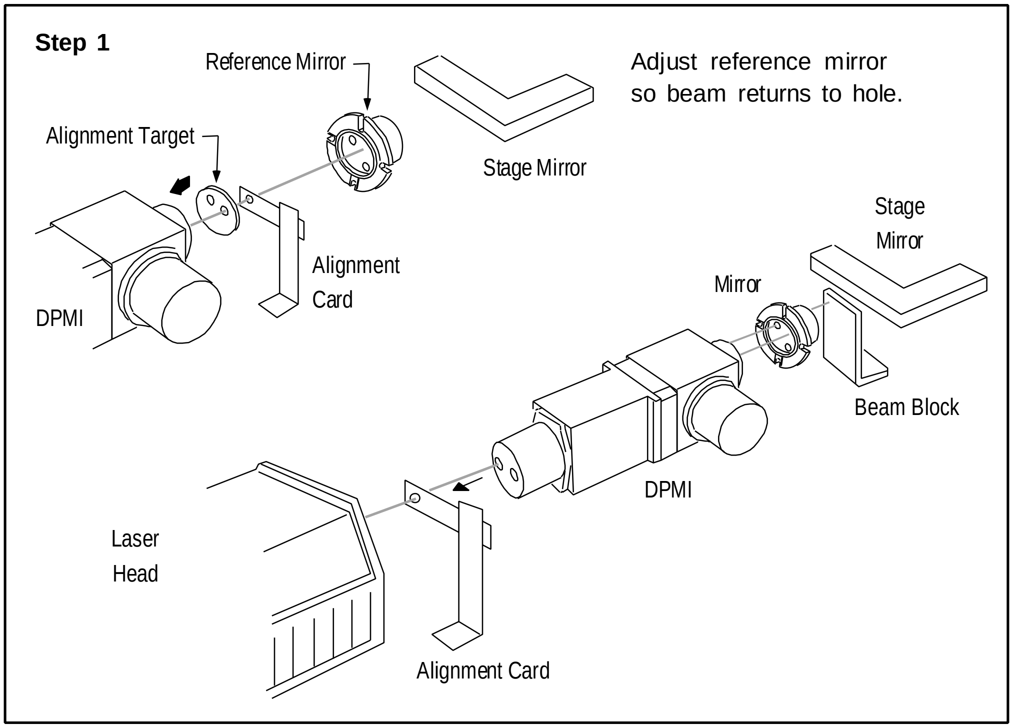
Refer to Figure 11.

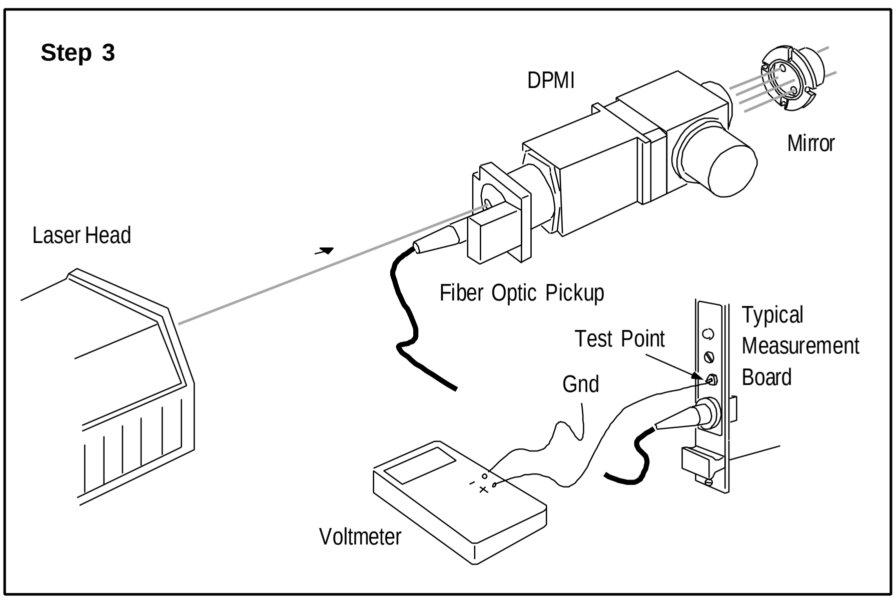
1. To align the reference mirror to the interferometer output beam:
   a. Mount the reference mirror.
   b. Place the Alignment Target on the DPMI and place the Alignment Card just after the DPMI with the reference beam centered in the pinhole. Ensure that the reference beam strikes the reference mirror and that it does not go through one of the holes in the mirror.
   c. Adjust the position of the reference mirror until the beam reflects back through the hole in the card.
   d. Block the measurement beam between the reference mirror and the stage mirror. Place the Alignment Card directly in front of the laser head and adjust the card so that the beam goes through the hole.
   e. Adjust the position of the reference mirror until the reflected beam is centered in the hole in the card.

   Note: Temporarily select the large beam to ensure that the measurement beams are not clipped going through the holes in the reference mirror.

2. To verify the alignment of the interferometric axis:
   a. Remove the Alignment Target and the Alignment Card. Select the 6mm (large) laser beam. The applicable signal okay LED on the receiver or ZMI Measurement Board should be on.
   b. Move the stage perpendicular to the measurement beams; no measurement should occur. If measurement is indicated when the stage moves, it occurs because the stage mirror is not parallel to the travel axis (or the mirror is not flat). If necessary, correct the alignment of the stage mirrors to the axis of travel.

3. Connect a voltmeter to the applicable test point on the receiver or ZMI Measurement Board. Carefully adjust the position of the reference mirror until the voltage is maximized.





Reference Mirror Alignment
Figure 11

Accuracy and Installation Considerations

The overall accuracy of any laser interferometry system is dependent upon a number of factors. These factors include: 1) the wavelength stability of the laser beam, 2) polarization mixing error in the laser head, 3) the accuracy of the electronics, 4) system design errors, 5) alignment induced errors, 6) stability of the environment, and 7) interferometer errors. The sections that follow only discuss the factors associated with the DPMI.

> **Note:** For a general discussion of these accuracy and installation factors, refer to Chapter 5 of the ZMI Optics Guide, OMP-0326, or Chapter 11 of the ZYGO 2/20 Operation and Reference Manual, OMP-0220.

This section discusses the errors associated with the DPMI known as polarization mixing, temperature coefficient, and Dead Path Error (environmentally induced).

Polarization Mixing

The DPMI has accuracy limitations due to polarization mixing within the optical components. Polarization mixing is a cyclic error with a period of 360 degrees; it occurs about every 158 nanometers of displacement for a double pass interferometer. The cyclic error is noncumulative.

The cyclic errors in the DPMI due to polarization mixing in the optical components is typically ±1.0 nanometers up to a maximum of ±2.0 nanometers.

Temperature Coefficient

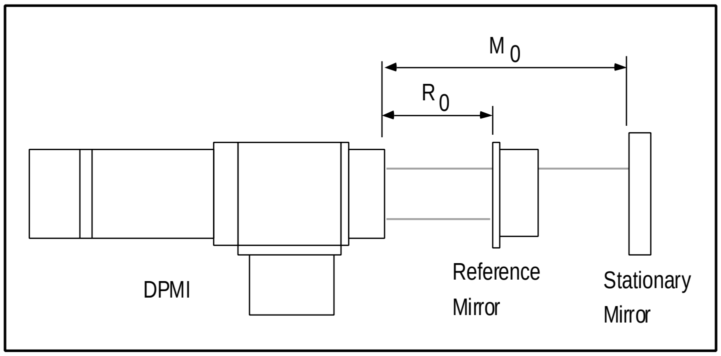
A uniform variation in temperature can cause some interferometers to introduce an error in the displacement measured or in shift of the zero. The temperature coefficients for the DPMI is <0.01 micrometer/degree Celsius.

For an environment controlled to 0.1°C, less than a 0.001 micrometer error will result.

Dead Path Error

Dead path is the difference in distance in air between the reference and measurement paths when the interferometric measurement is initiated or zeroed. There is dead path error only when the environmental conditions change during the measurement.

Dead Path is represented by: DP = M_0 - R_0. Where M_0 is the measurement path distance in air and R_0 is the reference path distance in air.



DPMI Dead Path
Figure 12

The difference between the reference path and the measurement path in the DPMI is as follows:

M_0 (minimum) (mm)	*R_0 (mm)*	*DP nominal (mm)*
43.63 ±1.4	25.42 ±0.9	18.21

Maintenance

Zygo optical components are ruggedly designed and built to deliver optimal performance. All the optical surfaces should be kept completely free of contaminants. Improper or unnecessary cleaning can damage optics.

⚠ **Warning!**
Zygo is not responsible for any damage that occurs to an optical component as a result of improper cleaning.

Guidelines for handling and cleaning optical components:

- Do not attempt to clean the optical surface of any component unless experienced in optical cleaning techniques.
- Never touch the optical surfaces of the components with your bare hands. Acids and salts in the skin can cause permanent degradation of surfaces.
- Store unused optical components in the supplied plastic bags and product boxes.
- The exterior metal cells of the components may be cleaned with a cloth dampened with a mild cleaning solution, such as methanol.

Note: Detailed cleaning procedures for optical components are located in Chapter 6 of ZMI Optics Guide, OMP-0326, and Chapter 8 of the ZYGO 2/20 Operation and Reference Manual, OMP-0220.

Differential Plane Mirror Interferometer (DPMI)

Zygo Part Number: 6191-0188-02

Model: 7015

Dimensions: See Figure.

Weight: 528 grams (18.6 oz)

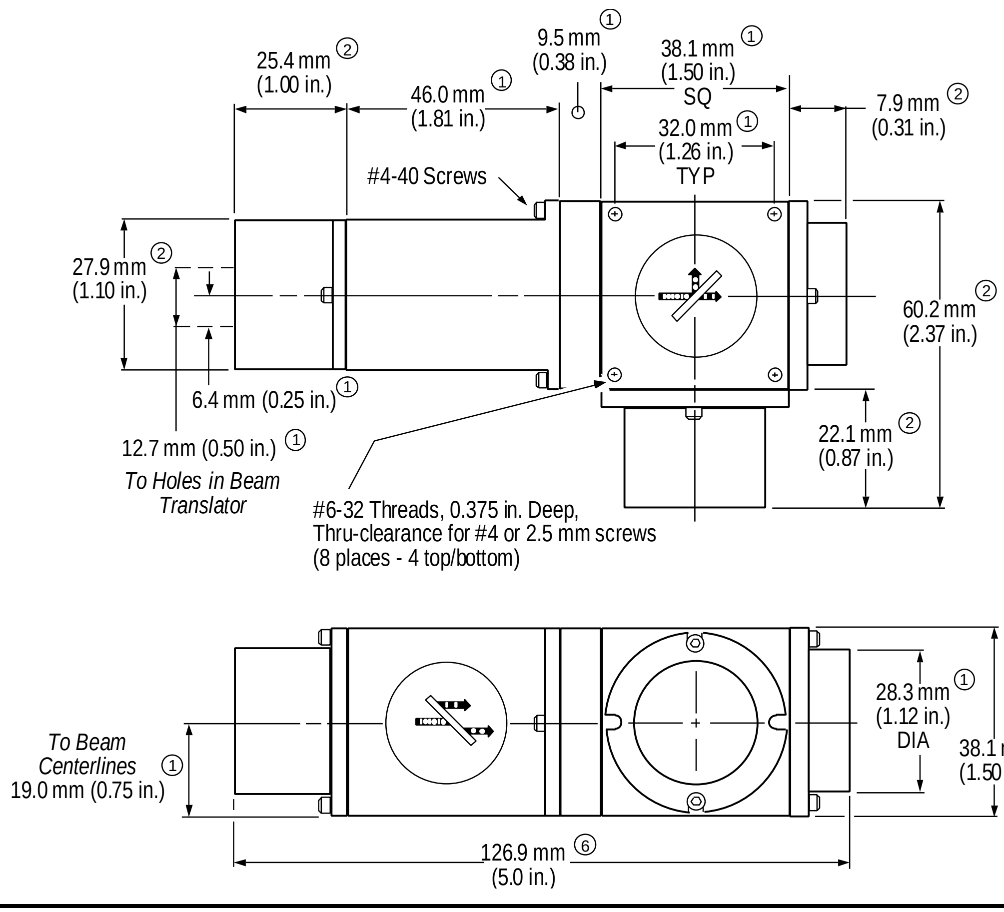
Components Included:
Polarization Beamsplitter, Retroreflector, Quarter Waveplate, Half Waveplate, Beam Translator, Polarization Shear Plate

Additional Components Required:
Reference Mirror, Plane Mirror or Target Mirror

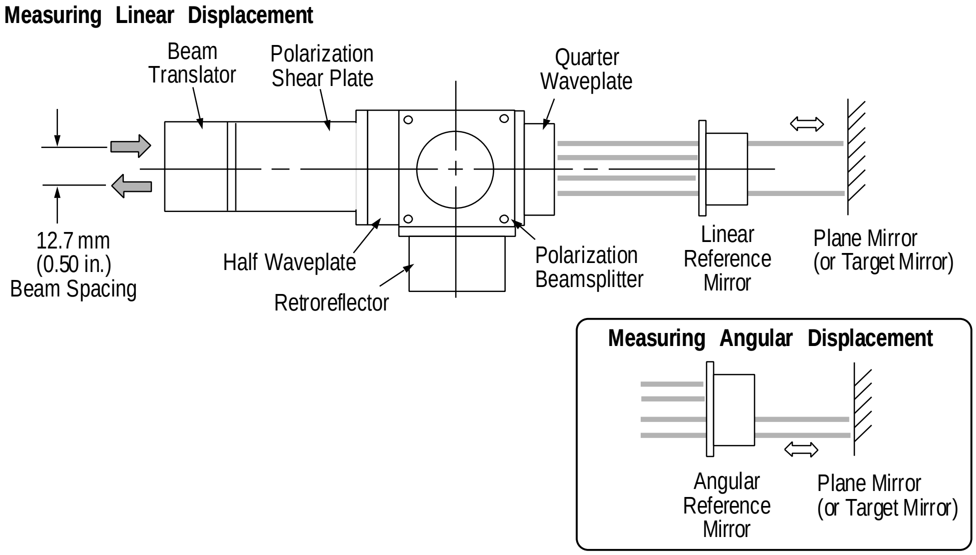
Materials:
Housing: Magnetic Stainless Steel
Optics: BK-7 and Crystalline Quartz
Adhesives: Vacuum Grade -- low volatility

Optical:
Linear Displacement Resolution (nominal):
1.24 nm (ZMI 1000)   0.31 nm (ZMI 2000)
Angular Displacement Resolution (nominal):
0.06 arc sec (ZMI 1000)   0.015 arc sec (ZMI 2000)
Out-of-parallelism of transmitted beam to input beam:
≤11 arc min
Maximum error due to tolerances in polarizing optical elements: ± 2 nm (0.08 µin)
Thermal drift coefficient (change of indicated distance per degree C temperature change) (typical):
< 0.01 micrometer/degree C
(< 0.4 microinch/degree C)
(Calculated thermal drift is zero.)

Optical Signal Efficiency:
>52% with a plane mirror having 99% reflectance at 633 nm at normal incidence.



DPMI (continued)



DPMI Mirrors

Configuration	Zygo Part Number	Model
Linear Reference Mirror	6191-0437-01	7017A
Angular Reference Mirror	6191-0437-02	7018A
Target Mirror	6191-0437-03	7019A
Reverse Linear Ref Mirror	6191-0437-04	7017AR
Reverse Target Mirror	6191-0437-05	7019AR

Dimensions: See Figure.

Weight: ≈42 grams (1.5 oz)

Materials:
- Housing: Magnetic Stainless Steel
- Optics: Zerodur
- Adhesives: Vacuum Grade -- low volatility

Optical Signal Efficiency (typical): >99%