ZMI 1000 System Manual

OMP-0411E

OMP-0402
ZMI Laser Head Manual

OMP-0358
ZMI 1000A
Measurement Bd. Manual

OMP-0328
ZMI 1000 Chassis and
Control Board Manual

OMP-0333
ZMI Cable Guide

OMP-0326
ZMI Optics Guide

OMP-0355
ZMI Optical
Table Accessories

Zygo Corporation
Laurel Brook Road
P.O. Box 448
Middlefield, Connecticut 06455-0448

Telephone: (860) 347-8506
Fax: (860) 347-8372
E Mail: inquire@zygo.com
Website: www.zygo.com

ZMI 7702 Laser Head
P/N 8070-0102-XX
Operating Manual
OMP-0402E

Zygo Corporation
Laurel Brook Road
P.O. Box 448
Middlefield, Connecticut 06455-0448

Telephone: (860) 347-8506
Fax: (860) 346-4188
E-mail: inquire@zygo.com
Website: www.zygo.com

ZYGO CUSTOMER SUPPORT

For help within North America, 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	Monday - Friday, 8 a.m. - 8 p.m. (Eastern Standard Time) (800) ZYGO NOW (800) 994-6669 *or* (860) 704-5191
FAX	(860) 346-4188
INTERNET	www.zygo.com support@zygo.com
WRITE	Zygo Corporation Laurel Brook Road P.O. Box 448 Middlefield, CT 06455-0448 Attn: Customer Support

MANUAL REVISION INFORMATION

The document (OMP) number and the applicable revision letter for this manual appear on the title page. The publication date appears below.

Revision	*Publication Date*	*Revision*	*Publication Date*
original	August 1996		
B	September 1997		
C	August 2000		
D	August 2001		
E	December 2001		

MANUAL NOTATIONS

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

Note: Provides helpful information.

NOTICE: The descriptions, drawings, and specifications contained herein are subject to change. Zygo is not responsible for errors or omissions herein or for incidental damages in connection with the furnishing or use of this information. This document shall not be reproduced, photocopied, or duplicated, in whole or in part, without prior written approval of Zygo Corp.

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.

01/96

CE Notice

Marking by the CE symbol indicates compliance of this Zygo Corp. instrument to EMC (electromagnetic compatibility) Directive and the Low Voltage Directive of the European Union. Such marking indicates that this system meets the following technical standards:

- EN 55011 – "Limits and methods of measurements or radio disturbance characteristics of ISM (Industrial Scientific & Medical) radio frequency equipment." Class A, for use in typical commercial environments.
- EN 55022 – "Limits and methods of measurements of radio disturbance characteristics of ITE (Information Technology Equipment)." Class A, for use in typical commercial environments.
- EN 50082-1 1992 – "Electromagnetic compatibility generic immunity standard for the residential, commercial and light industrial environments."
- EN 61010-1 1993 + A2: 1995 – "Safety requirements for electrical equipment for measurement, control and laboratory use – Part 1: General requirements."
- EN 60825-1:1994 + A11: 1996 + A2: 2001 – "Safety of laser products – Part 1. Equipment classification, requirements and user's guide.

A Declaration of Conformity in accordance with the preceding directives and standards has been made and is on file at Zygo Corporation, Middlefield, Connecticut, USA.

Page intentionally left blank

Page intentionally left blank

In This Chapter

- What This Manual Covers
- ZMI Laser Head
  - Compatibility
- Laser Safety
  - Laser Safety Standards
- Electrical Safety
- Safety Labels
- Specifications

What This Manual Covers

This manual describes the ZMI Model 7702 Laser Head[1], part number 8070-0102-XX. The Laser Head is part of a complete displacement measuring interferometer system, as shown in Figure 1-1. For additional information on displacement measuring interferometry, refer to the *ZMI Optics Guide*, OMP-0326.

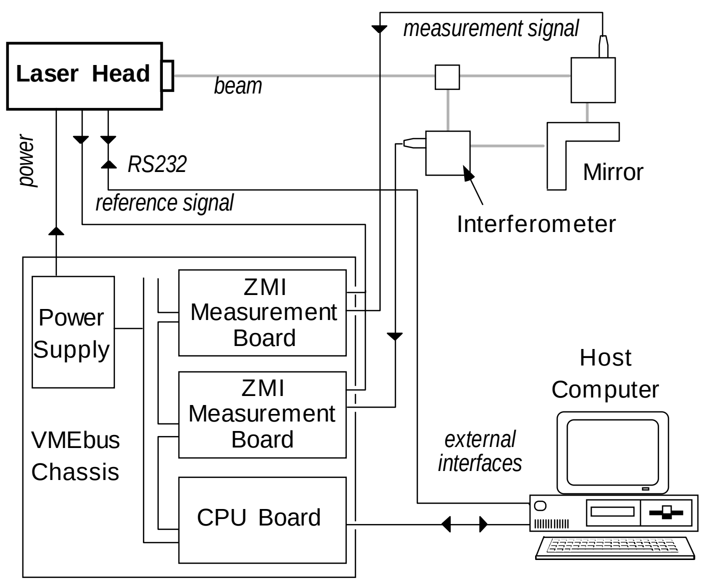


Figure 1-1 Typical Interferometer System

[1] U.S. Patents 4,688,940 and 4,684,828. Other U.S. Patents Pending.

The manual is divided into three main chapters:

Chapter 1	Describes the Laser Head' s features and specifications.
Chapter 2	Describes installing and aligning the Laser Head.
Chapter 3	Covers operation of the Laser Head.

For information on other Zygo motion measurement components refer to their respective manuals.

ZMI Laser Head

The ZMI Laser Head is the heart of a Zygo motion measuring system. In overview, the Laser Head:

- Outputs the dual frequency laser beam used in ZMI systems.
- Stabilizes the laser wavelength in less than 10 minutes.
- Supplies an electrical reference signal for ZMI-764 and ZMI-1000 series of Measurement boards.
- Supplies an optical reference signal for the ZMI-2000 series of Measurement boards.
- Provides an RS232 serial communication port for a direct link to a host computer.
- Two versions of the laser head provide a synchronization capability so multiple laser heads operate with the same reference frequency.

The Laser Head uses a Helium-Neon frequency stabilized laser to generate a laser beam with two frequency components (F1 and F2) that are orthogonally polarized, and offset by 20 MHz.

Beam Component	*Polarization*	*Vacuum Wavelength (nominal)*	*Frequency*
F1	Vertical	632.991501 nm	20 MHz higher than F2
F2	Horizontal	632.991528 nm	20 MHz lower than F1

Table 1-1 Laser Beam Components

The available configurations are shown below.

Configuration	*Beam Size (mm)*	*Mounting Pattern*	*Sync Capability*
8070-0102-01	6	Narrow	No
8070-0102-02	3	Narrow	No
8070-0102-03	6	Wide	No
8070-0102-04	3	Wide	No
8070-0102-05	6	Narrow	Yes
8070-0102-06	3	Narrow	Yes

Table 1-2 Laser Head Configurations

The Laser Head and its main components are shown in Figure 1-2. The laser tube (the internal part of the Laser Head that generates the light beam) is wavelength stabilized in less than 10 minutes, and reaches full accuracy operation over the next 70 minutes. The laser beam exits the Laser Head through a three position aperture. The aperture contains a "turret" to switch the beam from full size (either 3 or 6 millimeters), to no beam output, to small size. The small beam is approximately 2 millimeters in diameter; it is used in the initial alignment of the optics.

The Laser Head is connected to a user-supplied ±15 VDC power supply or the Zygo VME Chassis (p/n 8010-0100-xx) via the laser cable. The laser cable provides power for the laser, supplies an electrical reference signal for the ZMI-764 and the ZMI-1000 series of Measurement boards. A fiber optic connector on the back panel of the Laser Head supplies an optical reference signal for the ZMI-2000 Measurement board family.

The synchronization capability of the 8070-0102-05/06 Laser Heads allows two or more Laser Heads to have the same optical reference frequency. Synchronizing two Laser Heads increases the optical power available in multiple axis systems while maintaining a common reference signal.

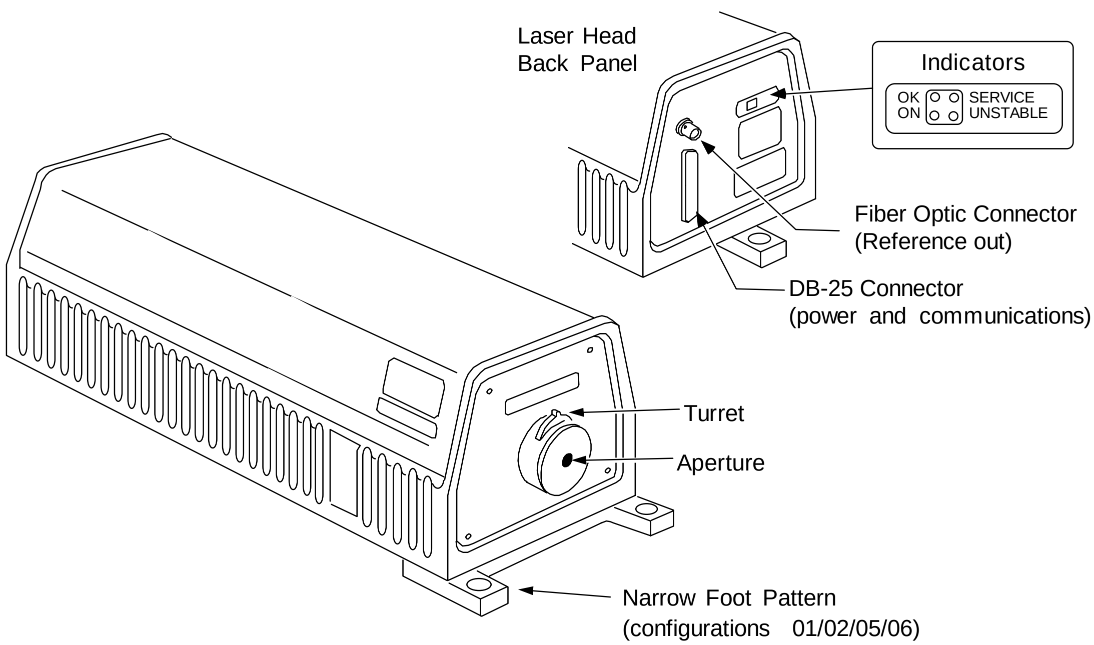


Figure 1-2 Typical ZMI Laser Head

The Laser Head has four indicator lights on its rear panel as explained below.

Indicator	*Color*	*Function*
ON	green	When lit, power is being supplied to the laser and laser radiation may be emitted from the Laser Head’ s aperture.
OK	green	When lit, the laser tube is warmed up to operating temperature and the wavelength is stable. It is off whenever the wavelength is unstable. Electrical and optical reference signals are output when the LED is lit.
SERVICE	yellow	When lit, the Laser Head requires servicing. Contact Zygo for Technical Support (page i).
UNSTABLE	yellow	When lit, the laser is unstable; the laser wavelength exceeds a tolerance of approximately ± 0.01 ppm. It is normal for this light to be on during warm-up; when the Laser Head is warmed up, this light should remain off. After warm-up the causes for an Unstable light may be: excessive vibration, optical feedback, or an ambient temperature exceeding the specified range.

Table 1-3 Laser Head Indicator Lights

Compatibility

The 8070-0102-XX Laser Head configurations -01, -02, -03, and -04 are mechanically and optically backward compatible with Laser Head 6191-0460-XX configurations -01, -02, -03, and -04 respectively. All 8070-0102-XX Laser Head configurations supply an electronic reference signal for the ZMI-764, and the ZMI-1000 series of Measurement boards, and an optical reference signal for the ZMI-2000 family of Measurement boards.

Laser Head configurations 8070-0102-05 and -06 are mechanically and optically compatible with the 6191-0460-01 and -02 Laser Heads, respectively. Note that the 8070-0102-05 and -06 Laser Heads have an additional host computer communication and laser head synchronization capability.

Laser Head Mounting Kits

There are two optional laser head mounting kits available for the laser head to mount it on optical tables with ¼ x 20 threaded holes on 1-inch centers. These kits provide an optical axis height of 2.75 inches (69.9 millimeters).

Laser head mounting kit 6191-0519-01 is for laser heads 8070-0102-01/-02/-05/-06; it is a narrow foot thermoplastic design that reduces stresses placed on the laser.

Mounting kit 6191-0520-01 is for laser heads 8070-0102-03/-04; adapter feet are attached to the front cast feet of the laser head; spherical washers sets provide for secure adjustment of the laser head.

For more information see the *ZMI Optical Table Accessories* manual, OMP-0355.

Laser Safety

Before operating the Laser Head, please read the following material to become familiar with safety controls, markings, and warnings.

The Laser Head emits visible red light. The external radiant intensity output by the Laser Head is low; however, the intensity inside the Laser Head is greater. The external and internal radiation cannot burn or drill holes, even if a lens is used to focus the light. However, the laser light emitted by the laser should be treated with caution. It will not damage skin, but to protect your eyes, do not look directly into the laser beam or stare at its bright reflections.

Laser Safety Standards

The American National Standard for the Safe Use of Lasers (ANSI Z136.1-1986) classifies this laser product as Low Power - Class II (per Table A1), and provides reasonable and adequate guidelines for its safe use. The user and personnel responsible for the safe use of the Laser Head in the user's organization should consult this ANSI standard, available from:

American National Standards Institute
1430 Broadway
New York, New York 10018

The Laser Head conforms to the National Center for Devices and Radiological Health (NCDRH) of the Food and Drug Administration and to international laser safety regulations.

To encourage proper laser safety and to abide by the above laser safety regulations, Zygo supplies the information listed on the next page. To locate the controls and the labels listed on the next page, refer to Figure 1-3.

Product Use Warning

Warning!
Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

Output Beam Data

Laser medium: Helium-Neon

Emission Duration: more than 0.25 second

Radiant Power: <1 milliwatt

Wavelength: 632.8 nanometers

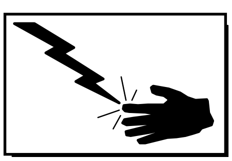
Laser Emission Control Devices

Device	*Function*
Rear Panel ON Indicator (Green LED)	When lit, indicates that power is being supplied to the laser, and that Class II laser radiation may be emitted from the Laser Head’ s aperture.
Beam Attenuator	When placed in no-output position, the laser beam is blocked from being emitted from the instrument.

Laser Safety Labels

Label	*Purpose*
Class II Laser Warning	Federal requirement for Class II lasers.
Aperture	Labels the instrument's aperture through which laser radiation is emitted.
Noninterlocked Protective Housing	Reminds you that when the covers are removed, and the system is turned on, Class II laser radiation is being emitted.
Certification	Shows that Zygo Corporation has conformed to the DHHS standard.
Identification	Provides information about the instrument - description, part number, model, etc...

Electrical Safety



The Laser Head must be provided with earth ground through the Laser Cable. The Laser Head is electrically isolated from its mounting surface.

Warning!
Ensure that the Laser Head is properly grounded.
Do NOT connect cables, install, or repair the Laser Head with power on.
Do NOT attempt to repair or service the Laser Head. Voltages from 1,800 to 12,000 volts may be present on the anode of the laser tube.

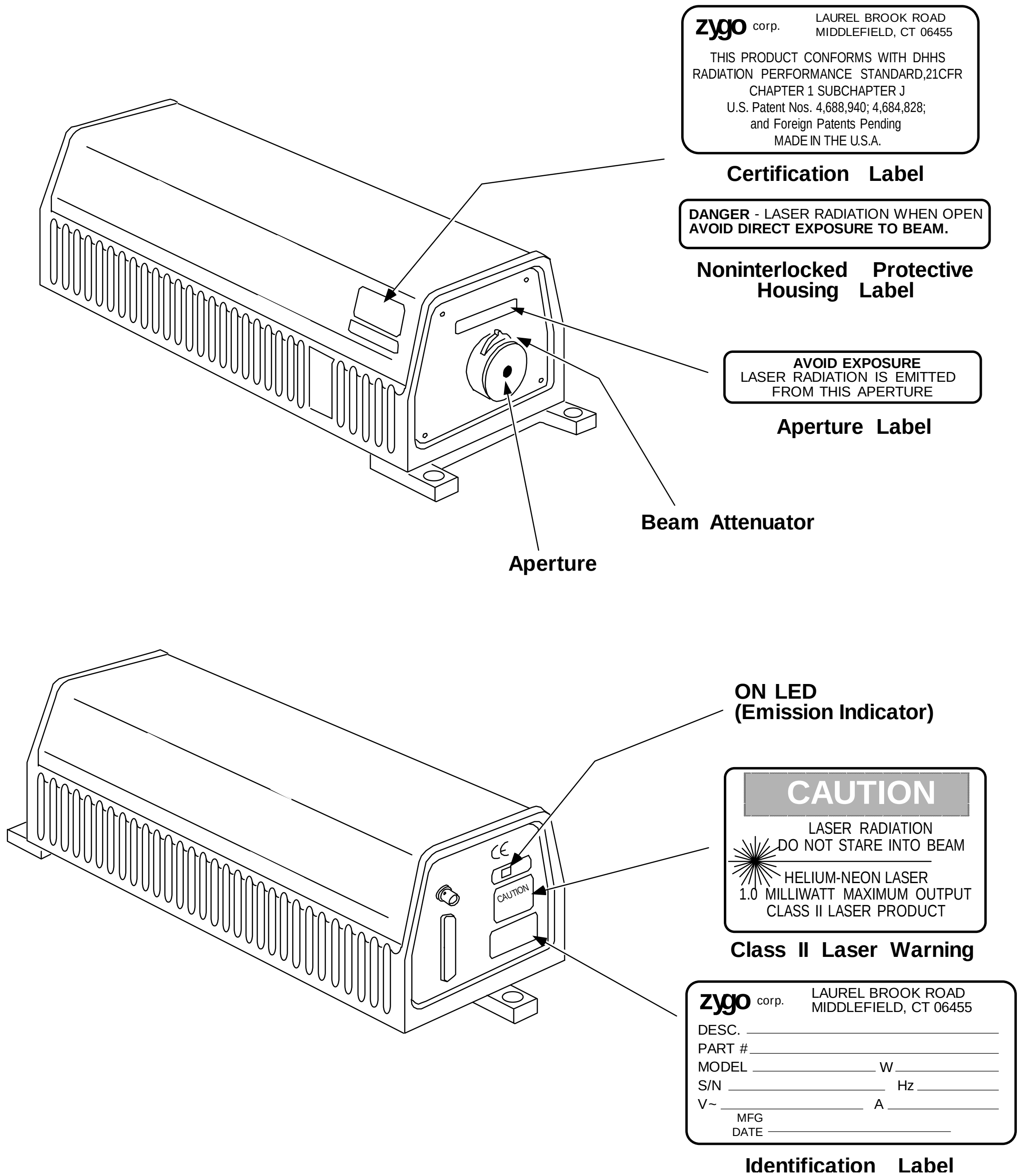
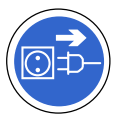
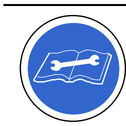
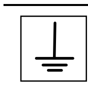
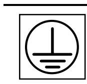


Figure 1-3 Laser Head Safety Controls and Labels

Safety Labels

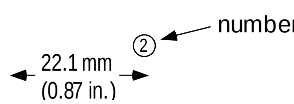
The following table describes the general meaning of safety labels found on the equipment. Specific warnings are covered in the applicable section within this manual. Failure to follow the safety labels and the recommendations in this manual could result in damage to personnel and the instrument, and may void the warranty.

Label	*Meaning*
	General hazard. Proceed with caution. Refer to the manual for instructions.
	Electrical shock hazard. Proceed with caution, there is a risk of electrical shock.
	Laser hazard. Avoid exposure to beam.
	Disconnect power.
	Refer to the manual for instructions.
	Earth ground.
	Protective conductor terminal.

Specifications

The general specifications of the Laser Head are shown on the next two pages. For specifications on cables refer to the *ZMI Cable Guide*, OMP-0333.

Dimensions are tagged with numbers as shown here:



The numbers denote the tolerance of the dimension as follows:

Number	*Millimeters*	*Inches*
1	± 0.13	± 0.005
2	± 0.25	± 0.010
3	± 0.38	± 0.015
4	± 0.51	± 0.020
5	± 0.64	± 0.025
6	± 0.79	± 0.031
7	± 1.27	± 0.050
8	± 2.16	± 0.085

ZMI Laser Head P/N 8070-0102-XX

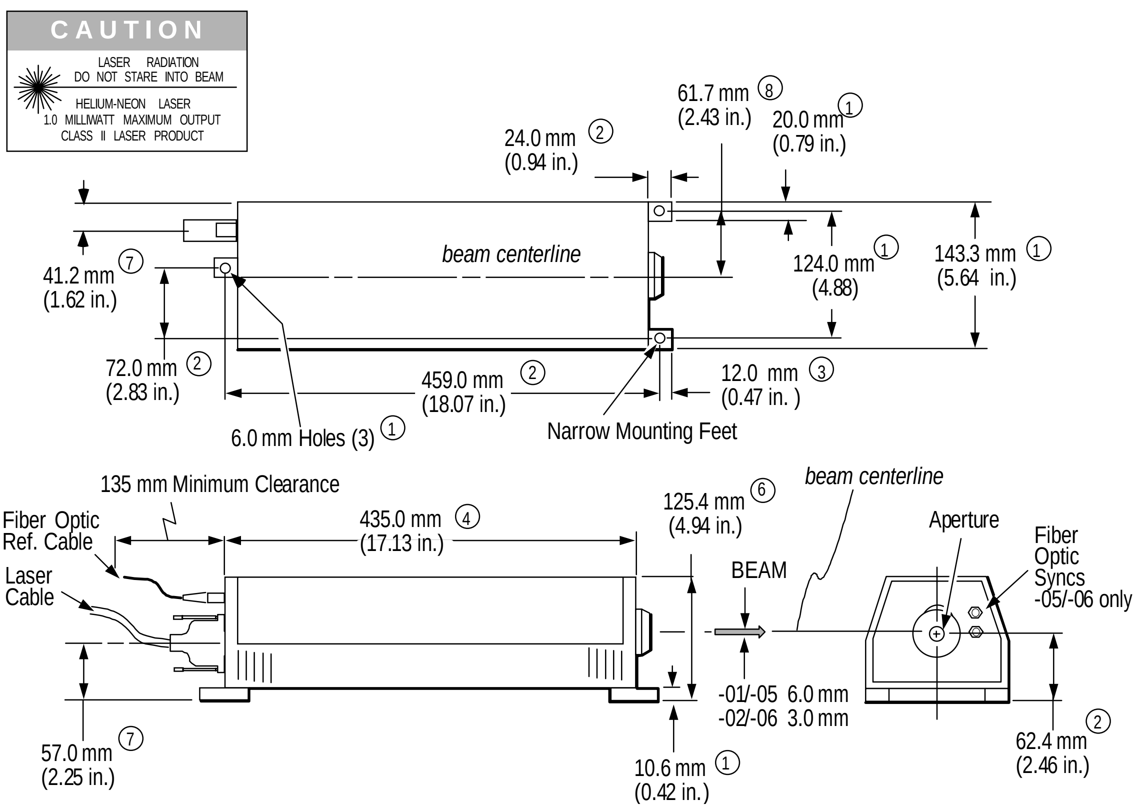
Physical Characteristics:
Dimensions: See Figure
Weight: 5.5 Kilograms (12.0 lb)
Nominal Cable Clearance: 135 mm (5.3 in.)
(a right-angle laser cable is available)
Materials: Laser Head Casting - Aluminum
Narrow Mounting Feet - Ultem 2400

Electrical:
Power Requirements (max.):
+ 15 VDC ±0.5V @ 2.1 A
- 15 VDC ±0.5V @ 1.2 A
Power Dissipation (max.):
39 watts during operation
50 watts peak during warm-up
Wavelength Stability Time: <10 minutes

Laser Beam Characteristics:
Type: Helium-Neon, Continuous Wave, Two-Frequency
Maximum Beam Power Output: < 1 milliwatt
Minimum Beam Power Output:
>400 microwatts -01/-02/-03/-04
>525 microwatts -05/-06
Frequency Difference: 20 MHz ±1600 Hz
Maximum Power Difference Between Two Frequency Components: 5% of total power
Time from turn-on to laser light:
<10 sec typical, 70 sec. maximum

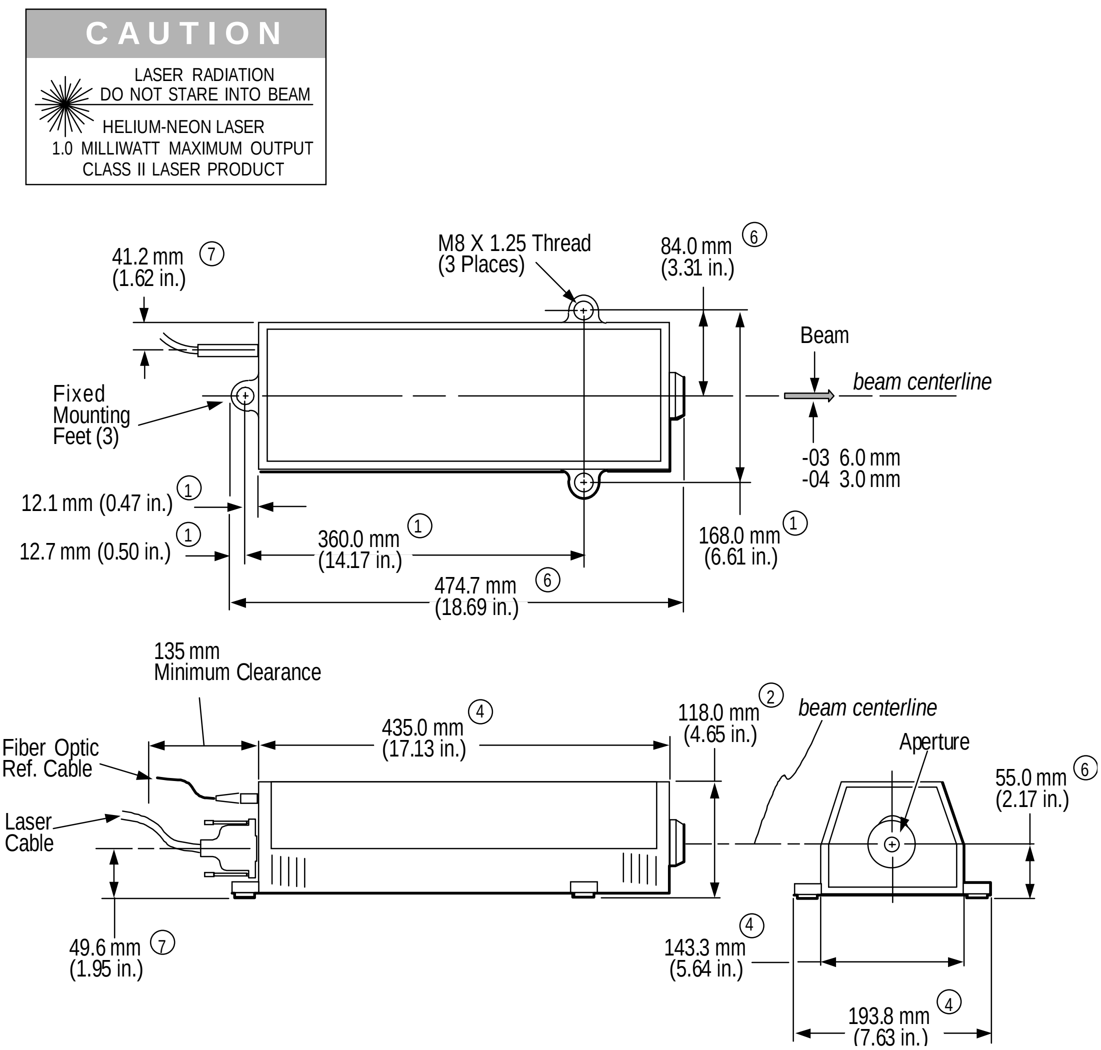
Laser Beam Characteristics (continued):
Beam Diameter:
6 millimeters (0.24 in.) -01/-03/-05
3 millimeters (0.12 in.) -02/-04/-06
Usable Beam Length:
25 meters (82 ft) -01/-03/-05
2 meters (6.6 ft) -02/-04/-06
Beam Pointing Stability: < 0.1 arc sec/°C ambient temperature change after wavelength is stable
Polarization Orthogonality: 90° ±0.5°
(Horizontal polarization is parallel to the Laser Head mounting surface.)
Nominal Vacuum Wavelength:
F1: 632.991501 nm (vertical polarization)
F2: 632.991528 nm (horizontal polarization)
Vacuum Wavelength Lifetime Accuracy: ± 0.1 ppm
Vacuum Wavelength Stability: ± 0.01 ppm/24 hours
DHHS Laser Safety Classification: Class II laser product conforming to NCDRH regulations

Environmental:
Operating Temperature: 10 to 30°C
Non-operating Temperature: -40 to 75°C
Operating Humidity: 0 to 90% (non-condensing)
Non-operating Humidity:
0 to 90% (non-condensing)
Shock: (non-operating) 11 milliseconds 40 G shock on each of three orthogonal axes.



Dimensions shown above pertain to -01/-02/-05/ -06 configurations with Narrow Mounting Pattern

ZMI Laser Head P/N 8070-0102-XX (continued)



Dimensions shown above pertain to -03/-04 confi gurations with Wide Mounting Pattern (Cast Feet)

ZMI Laser Head Power Supply P/N 8010-0104-XX

Description:
Universal switching power supply provides ± 15 VDC for ZMI laser heads (models 7702 and 7705). Available as an accessory.
For ZMI 2000 systems, use with ZMI Laser Head Cable P/N 1115-801-346 (not included). For ZMI 510 systems, a user-made cable is required.

Part Numbers:

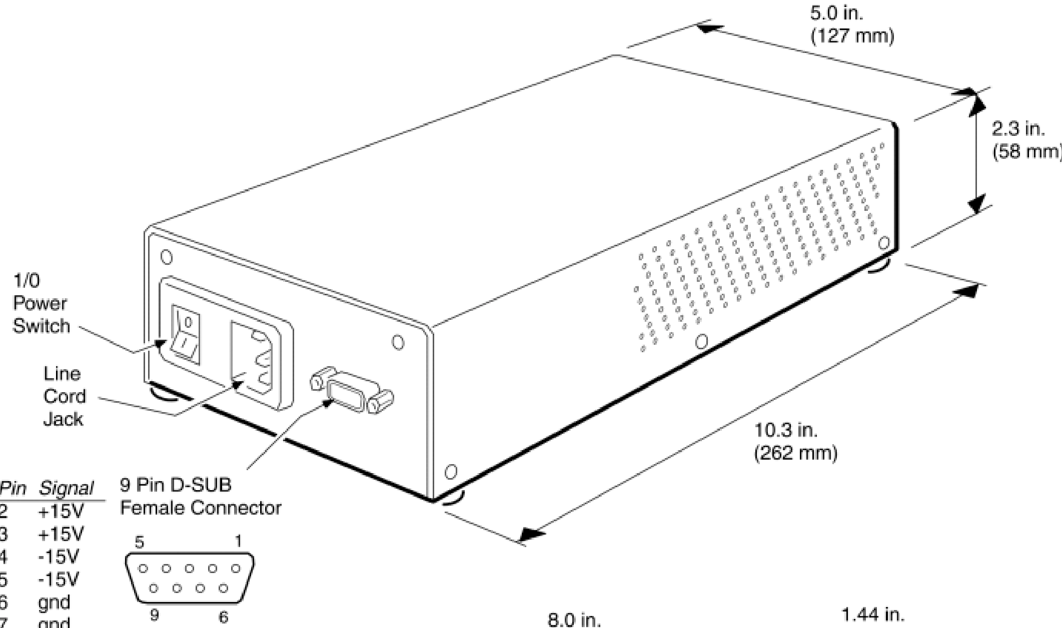
8010-0104-01	Domestic 110V
8010-0104-02	German/French 220V
8010-0104-03	Japan 100V
8010-0104-04	United Kingdom 240V

Physical Characteristics:
Dimensions: See Figure
Weight: 40.2 oz (1.1 kg)
Cable Clearance: 5 in. (127 mm)

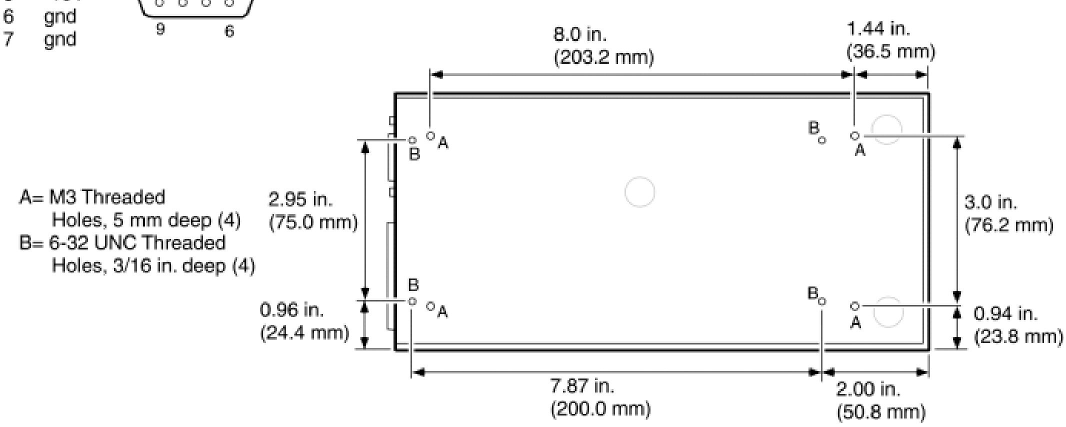
Mounting:
Self adhesive feet included, or may be attached with 4 screws (not included) into the threaded holes in the base.
Note: Provide clearance for air flow. Do not mount near measurement axes due to heat dissipation.

Electrical:
Input (nominal): 100 to 240 VAC, 50/60 Hz
Output: +15 VDC @ 2.5 A, -15VDC @ 2.0 A
Heat Dissipation: 12.8 watts maximum
Fuse Rating (power module): 250V 2A

Environmental:
Operating Temperature: 0 to 40°C
Operating Humidity: 0 to 85% (non-condensing)



Pin	Signal
2	+15V
3	+15V
4	-15V
5	-15V
6	gnd
7	gnd



Chapter 2 Installation

In This Chapter

- CE Note Regarding the Power Supply
- Checklist
- Unpacking
- Installing the Laser Head
- Aligning the Laser Head

CE Note Regarding the Power Supply

The optional power supply is intended for Category 2 Installation per EN 61010-1, Clause 5.4.1, of the Low Voltage Directive of the European Union.

Checklist

The following checklist is provided to assist you in installing your Laser Head. Use the checklist as a summary of the installation procedures.

- ❑ Inspect all packages for signs of shipping damage. Report any damage to the carrier and to the Zygo Service Department.
- ❑ Verify that the mounting location for the Laser Head is true, solid, and that the beam height is located properly.
- ❑ Secure the Laser Head in position using kinematic mounting techniques.
- ❑ Connect the cables to the Laser Head. Verify that the Laser Head is properly grounded.
- ❑ For customized applications using the RS232 port, review the connector pin assignments.
- ❑ Align the Laser Head to the measurement axes.

Unpacking

Inspect all packages for signs of shipping damage. Report any damage to the carrier and notify your Zygo representative. If necessary, retain the shipping material for the carrier’ s inspection.

> **Note:** Save your packing material, in case it is necessary to transport the Laser Head at a future date.

Verify that the order is complete. The following parts are included with the Laser Head:

Part	*Laser Head 8070-0102-01/02/06*	*Laser Head 8070-0102-03/04*	*Laser Head 8070-0102-05*
Alignment Card	X	X	
Mounting Kit		X	

Cabling is supplied separately. Refer to the ZMI Cable Guide, OMP-0333, for a sample of the cable options available from Zygo.

Installing the Laser Head

The Laser Head can be mounted in any orientation as long as it is positioned to direct the beam into the optics parallel or perpendicular to the application' s measurement axes. The Laser Head is attached to the mounting surface with bolts through its three mounting holes.

Due to Gaussian characteristics of the laser beam, the beam diameter varies as a function of distance from the Laser Head; see the following drawing. This phenomenon does not impact most applications; however, it may cause a signal efficiency loss when there are unequal test and measurement paths in the interferometer.

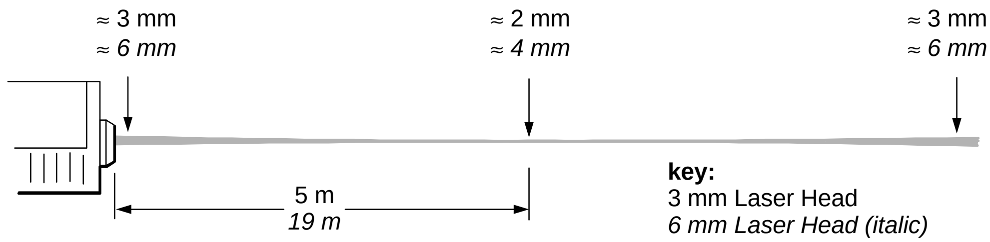


Figure 2-1 Output Beam Diameter

The Laser Head should be mounted such that the output beam is centered in the optical component(s) aperture, as the mounting holes do not allow for height adjustment. Allow 50 millimeters clearance around the Laser Head for access and 135 millimeters at the back for cable access. Interferometers should not be positioned too close to the Laser Head because the Laser Head dissipates heat.

1. If necessary, drill and tap holes in the mounting surface, spaced for the Laser Head mounting holes, as shown on the specification pages in Chapter 1.
2. Remove the Laser Head from the shipping container and place it in position on the mounting surface.

   ⚠ **Warning!**
   Incorrectly mounting the Laser Head can cause degradation of the laser beam. Ensure that the mounting technique used for the Laser Head does not introduce stresses. This caution especially applies to the Laser Head configurations with wide pattern (cast) feet.

3. For Laser Head configurations with the narrow mounting feet, insert M5 or 10-32 bolts through each mounting hole and tighten the bolts.

4. For Laser Head configurations with wide mounting feet, use the mounting kit included with the Laser Head, as shown in Figure 2-2. To secure the Laser Head:
   a. Place the insulating washers and spherical washers around each foot of the Laser Head.
   b. At the rear foot, stack the Belleville washers on top of the spherical washers.
   c. Insert the 10-32 mounting screws through each washer stack.
   d. Tighten the rear foot mounting screw 1/4-turn past the point when the screw contacts the Belleville washers.
   e. Torque the two side screws to 40 in-lb (5 N• m).

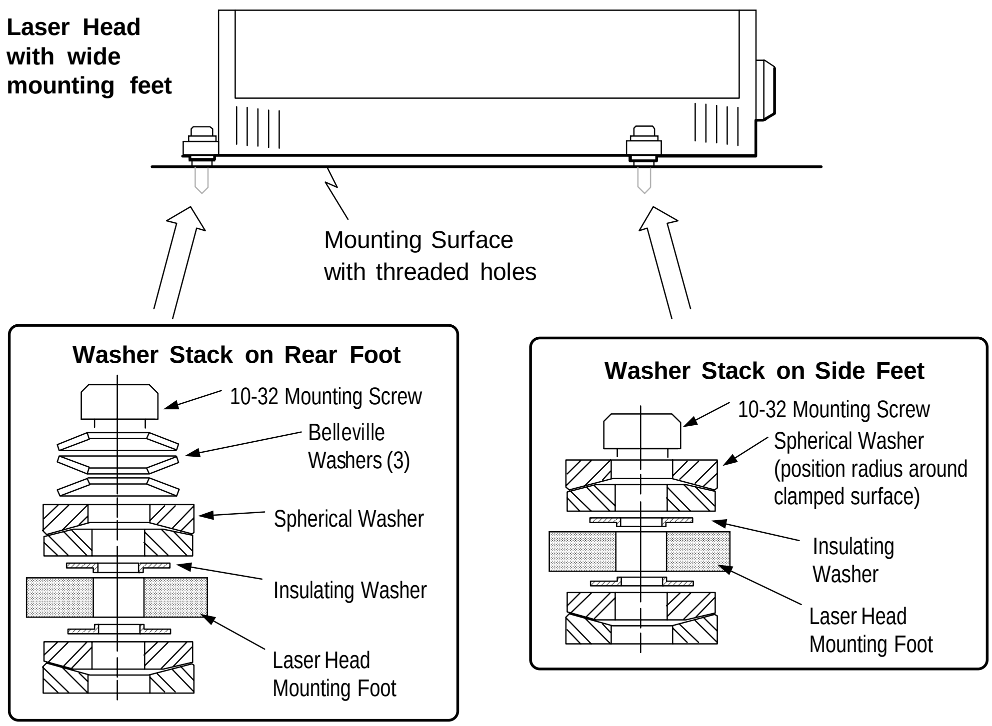


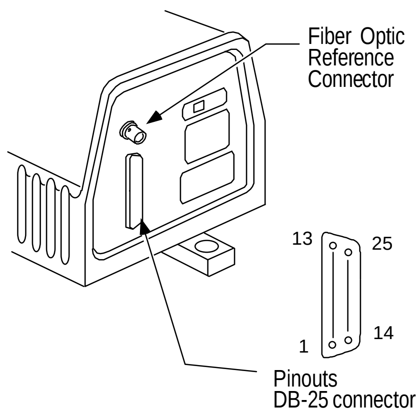
Figure 2-2 Mounting Kit Detail

⚠ **Warning!**
The Laser Head feet and enclosure should be isolated from earth ground. The ZMI Laser Head, configurations 01, 02, 05, and 06, have nonconductive feet. Laser Head configurations 03 and 04 have conductive feet; ensure that the feet are not grounded.

5. Verify that the Laser Head is grounded through the cable connection and not the Laser Head enclosure or feet.

6. Connect the laser cable to the Laser Head to supply the head with ± 15 volts. For use with ZMI-764 and ZMI-1000 Measurement boards, this same cable carries the reference signal to the Measurement board. For use with the ZMI-2000 Measurement board family, connect a fiber optic cable (Zygo P/N 8020-0410-XX) from the Laser Head to the Measurement board for the reference signal. The pinout of the Laser Head connector is shown in Figure 2-3.

   Note: Tighten the screws on the connector that mates to the laser head DB-25 connector to: 44 in-oz (0.3 Nm).



19	LTO*	Reference Signal to ZMI-764 and ZMI-1000 Measurement Boards
20	LTO	
22	ECL REF	
23	ECL REF*	
10	ECL REF SHLD	
24	REF SHLD	
14	+15V	Incoming Power
21	+15V	
12	-15V	
13	-15V	
7	GND	
8	GND	
17	SERVICE*	Discrete Status Indicators
18	UNSTABLE*	
9	GND	RS232 Communication
6	RXD	
5	TXD	
25	MAIN SHLD	

Figure 2-3 Laser Head Connector Pinout

7. *This step only applies to 8020-0102-05/-06 Laser Heads.* To synchronize the reference output of multiple Laser Heads, connect the fiber optic output (on the front panel) of one Laser Head to the fiber optic input on the other Laser Head. Standard Zygo fiber optic cable (P/N 8020-0410-XX) may be used. The fiber optic reference signal on the back panel from the transmitting Laser Head should be used to provide the reference signal to the Measurement boards. See Figures 2-4 and 2-5.

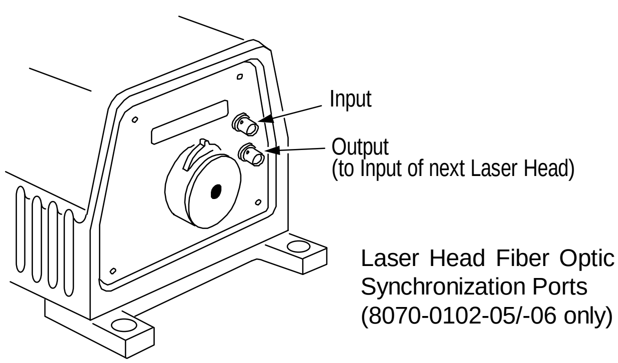


Figure 2-4 Laser Head Sync Ports

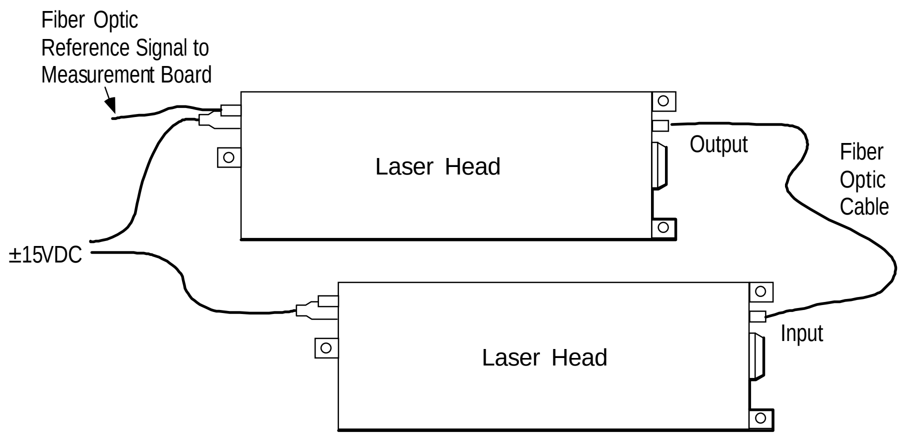


Figure 2-5 Synchronizing Multiple Laser Heads

Aligning the Laser Head

The following steps cover the alignment of the output laser beam. All components in a distance measuring interferometer system must be properly aligned. For information on alignment, see the *ZMI Optics Guide*, OMP-0326.

1. Mount the Laser Head. Turn on the Laser Head and allow it to stabilize.
2. Select the small aperture on the Laser Head. Place the Alignment Card in front of the Laser Head so the beam goes through the center of the pinhole in the card.
3. To align the output beam parallel to the reference surface:
   a. Move the Alignment Card along the reference surface. Adjust the tilt of the Laser Head so the beam goes through the center of the pinhole in the card. Ensure that the beam is centered in the Alignment Card pinhole as the card is moved along the full length of the reference surface.
   b. If necessary, adjust the height of the Laser Head so the beam is centered in the components' apertures.

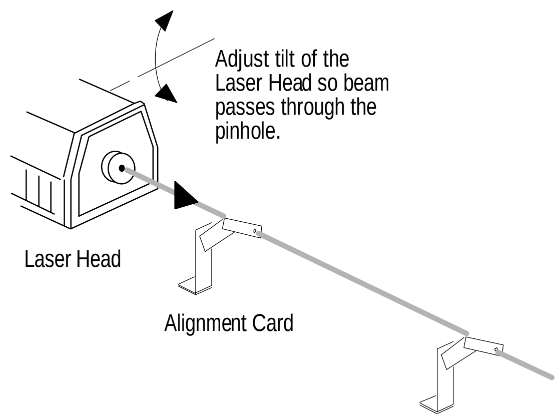


Figure 2-6 Aligning Beam to Surface

continued

4. To align the output laser beam parallel to the measurement axis: (This step assumes that the target mirror is mounted on a movable component and is properly aligned.)

   a. Move the target mirror as close as possible to the Laser Head.

   b. Adjust the alignment of the Laser Head (in pitch and yaw) so that the beam goes through the center of the pinhole in the card and reflects back from the target mirror to the center of the same hole.

c. Translate the target mirror to its farthest position from the Laser Head. If necessary, readjust the position of the Laser Head to get the reflected beam back through the center of the pinhole. Ensure that the reflected beam is centered in the pinhole throughout the complete range of travel.

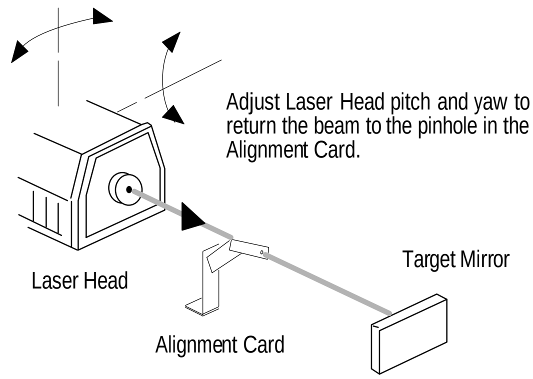


Figure 2-7 Aligning Beam to Axis

Chapter 3 Operation

In This Chapter

- Typical Operation
- Using the RS232 Communications
- Laser Head Commands
- Laser Head Maintenance

Typical Operation

A typical installation includes a Laser Head, power supply, one or more measurement boards, and a host computer. The ±15 volt DC power supply is connected to the Laser Head. The Laser Head reference signal is connected to a measurement board. An optional RS232 connection can be made between the Laser Head and the host computer to monitor Laser Head operations and status.

An internal microcontroller controls the Laser Head operations. It sequences the Laser Head through various operating modes using a firmware based state machine. It changes the Laser Head from one state to another based on the previous state and the status of the various inputs, such as laser tube temperature and wavelength stability error level.

When power is first applied to a Laser Head, it typically goes through a series of pre-warm-up states, performing self-tests and determining the current tube temperature. It then sequences through a series of warm-up states, after which it enters the stable state and outputs the reference signals. The laser wavelength is stabilized in less than 10 minutes and reaches full accuracy stabilization(1) 30 to 70 minutes later. At this point, the Laser Head is now ready for use.

The Laser Head leaves the stable state only if it detects mode slewing. This is typically caused by optical feedback into the Laser Head. See Table 3-3 for a complete listing of Laser Head states.

---

(1) Full accuracy stabilization is defined as the point at which the phase shift of the Laser Head is less than or equal to one least significant bit (LSB) of measurement resolution. One LSB equals 1.24 nm in a ZMI 1000 system and 0.31 nm in a ZMI 2000 system. For a ZMI 1000 system, the Laser Head reaches full accuracy stabilization approximately 30 minutes after the laser is wavelength stabilized. For a ZMI 2000 system, the Laser Head reaches full accuracy stabilization approximately 70 minutes after the laser is wavelength stabilized.

Using the RS232 Communications

The Laser Head uses a 3-wire connection to communicate with a host computer or terminal. Typical connections are shown in figure 3-1. The Laser Head RS-232 communication parameters and protocol are listed in table 3-1.

RS-232 diagnostics can be established using the 8020-0411-XX series of laser cables in VME backplane applications or via the laser head diagnostic connector on the back panel of the Zygo VME Chassis (Zygo part numbers 8010-0100-02/-03 revision J or later, and 8010-0100-04/-05).

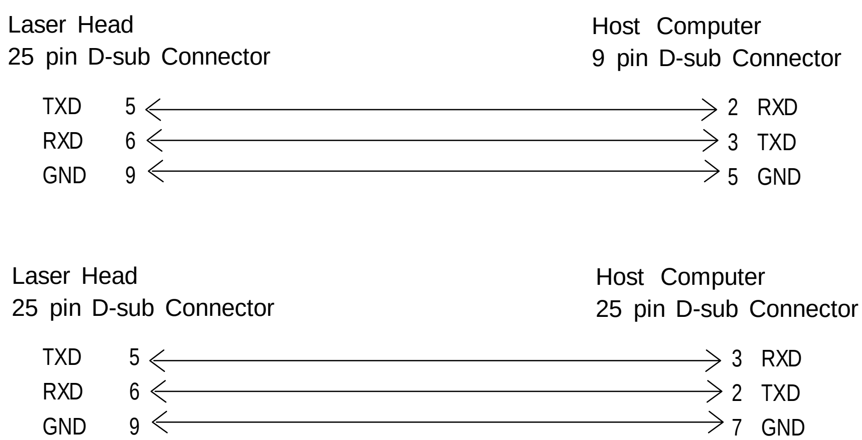


Figure 3-1 Typical RS232 Laser Head Connections

Parameter	*Value*
Number of start bits	1
Number of data bits	8
Number of stop bits	1
Parity check	none
Baud rate	9600
Handshake protocol	XON/XOFF

Table 3-1 Communications Protocol

Laser Head Commands

Communications with the Laser Head are performed using ASCII character based commands. Each command must be terminated with a carriage return character. The Laser Head ignores all other control characters, such as linefeed and escape characters. It does backup the communications input buffer one character for each backspace character received. Table 3-2 summarizes the Laser Head command set.

All commands output a response. Most output the requested value. Some output a "G" indicating the command was successfully processed. An "Enn" response indicates an error where "nn" is the error number. All Laser Head responses are terminated with linefeed and carriage return characters <LF><CR>.

Throughout the command descriptions a <CR> denotes a carriage return character and a <LF> denotes a linefeed character.

Each command description includes an example. The user entered command is shown after the word "command"; the laser head response is shown after the word "response".

Command	*Description*
100	Report laser head state.
101	Report all recorded errors.
102	Report laser head serial number.
103	Report firmware version.
104	Report laser tube hour meter value.
105	Report heater control status.
112	Report laser head output power.

Table 3-2 Summary of Commands

100<CR>

This command reports the state of the Laser Head. All valid numeric responses are shown in table 3-3.

State Number	*Description*
0	Manual control. The Laser Head enters this state if a hardware failure is detected. It is also used during factory setup and tuning.
1	Wait for laser tube to turn on.
2	Power-on start up.
4	Wait for initial A/D values to be read.
5	First heater wire resistance reading.
10	15 second delay after first heater wire resistance reading.
15	Second heater wire resistance reading.
20	15 second delay after second heater wire resistance reading.
25	Third heater wire resistance reading.
30	Delay two minutes while the heater wire temperature cools to the laser tube temperature.
35	Warm-up state. The heater is on full and the microcontroller is tracking mode slews.
40	Heater control switched to analog mode. Wait one minute until analog controller locks.
45	Laser head is stable. Reference signals enabled.
50	Instability detected after state 45. Reference signals disabled. 10 msec pause to permit the error signal to propagate through the user’ s system.
55	Monitoring checking. Wait for up to 2 minutes for mode slewing. If mode slewing stops then go back to state 45. If mode slewing continues then go to state 60.
60	Instability condition exists. Turn off the heater. Wait for tube temperature to cool to 95°C then go to state 65. If mode slewing stops go to state 45.
65	Instability condition exists. Turn on the heater. Wait for tube temperature to rise to 105°C then go to state 60. If mode slewing stops go to state 45.

Table 3-3 Laser Head States

Example:

command 100<CR>

response 5<LF><CR>

101<CR>

This command reports the contents of the error log.

As errors are encountered, the firmware enters them into an error log. Table 3-4 shows the errors that could be contained in the error log. Command syntax errors are not maintained in the log because they are immediately reported.

The errors in table 3-5 are not reported in the error log. These errors are communications type errors and are immediately transmitted as they are detected.

Each error number response includes linefeed and carriage return characters. When the response is complete, a "G" is sent. The error buffer is cleared after the "G" command is executed. Duplicate, consecutive errors are recorded only once.

Error Number	*Description*
E00	Unknown error.
E05	EEPROM failed to verify.
E07	Unknown heater override command type.
E08	A/D too large for calibration.
E09	A/D too small for calibration.
E10	EEPROM clock error.
E11	A/D Failed to convert in time.
E12	Heater wire resistance too high.
E13	Heater wire resistance too low.
E14	Mode slewing not fast enough.
E15	Mode slewing too fast.
E16	Heater is stuck on.
E17	Heater is stuck off.
E18	D/A read back did not verify.
E19	Data EEPROM checksum failed at startup.
E20	Laser output power too low.
E21	Wavelength unstable.
E22	Laser tube did not turn on after 70 seconds.
E23	Program checksum failed to verify.

Table 3-4 Recorded Laser Head Errors

Error Number	*Description*
E01	Command not recognized.
E02	Privileged mode not enabled.
E03	Incorrect number of parameters entered.
E04	Parameter out of range.
E06	Incorrect password for privileged mode.

Table 3-5 Laser Head Errors Not Recorded

Examples:

command 101<CR>
response E05<LF><CR>
E08<LF><CR>
G<LF><CR>

command 101<CR>
response G<LF><CR>

102<CR>

This command reports the Laser Head serial number. The command responds with a text string. This is the same serial number printed on the product identification label.

Example:

command 102<CR>
response 96-23-342<LF><CR>

103<CR>

This command reports the firmware version number. The Laser Head control firmware is given a new version number each time it is changed.

Example:

command 103<CR>
response V01.00<LF><CR>

104<CR>

This command reports the Laser Head hour meter value. The Laser Head firmware records the number of hours power has been applied to the laser head since final inspection at Zygo.

Examples:

command 104<CR>
response 2<LF><CR>

command 104<CR>
response 12352<LF><CR>

105<CR>

This command reports the heater control status. During warm-up, the heater is under control of the microcontroller. The values reported are shown in Table 3-6.

Value	*Description*
0	Unknown heater control.
1	Heater is on full.
2	Heater is off.
3	Heater is controlled by the analog controller.

Table 3-6 Laser Head Heater Control Status

Example:

command 105<CR>
response 3<LF><CR>

112<CR>

This command reports the laser head output power in microwatts.

The response from this command is an integer decimal number indicating the relative optical power output by the laser head. This value may be used to track the relative optical power of the laser head over time. It should not be used to determine or measure the absolute optical power output by the laser head. If the laser head is in an unstable condition so that a power measurement has no meaning, the value -1 is returned.

Example:

command 112<CR>
response 132<LF><CR>

command 112<CR>
response -1<LF><CR>

Laser Head Certification

The frequency stabilization of Zygo laser heads is calibrated against a NIST traceable standard. (Frequency is equal to the speed of light in a vacuum divided by the wavelength.) Laser head certification is available through the Zygo Service Department.

Laser Head Maintenance

The Laser Head does not require any day-to-day maintenance.

⚠ **Warning!**
Do not remove the Laser Head cover; all the internal components are non-serviceable and may be easily damaged if tampered with. Removing the cover voids the warranty.

The laser tube inside the Laser Head has an estimated lifetime of greater than 50,000 hours. Actual laser head output power should be monitored using the RS-232 communications or the optical power feature on the ZMI 2000 family of Measurement boards. When the laser power level drops to a value less than the specified minimum output power, the laser tube should be replaced. Contact Zygo for factory replacement of the laser tube.

ZMI 1000A
Measurement Board
P/N's 8020-0100-XX and 8020-0206-01
Operation Manual
OMP-0358F

Zygo Corporation
Laurel Brook Road
P.O. Box 448
Middlefield, Connecticut 06455-0448

Telephone: (860) 347-8506
Fax: (860) 346-4188
E-mail: inquire@zygo.com
Website: www.zygo.com

ZYGO CUSTOMER SUPPORT

For help within North America, 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	Monday - Friday, 8 a.m. - 5 p.m. (Eastern Standard Time) (800) ZYGO NOW (800) 994-6669 *or* (860) 704-5191
FAX	(860) 346-4188
INTERNET	www.zygo.com support@zygo.com
WRITE	Zygo Corporation Laurel Brook Road P.O. Box 448 Middlefield, CT 06455-0448 Attn: Customer Support

MANUAL REVISION INFORMATION

The document (OMP) number and the applicable revision letter for this manual appear on the title page. The publication date appears below.

Revision	***Publication Date***	Revision	***Publication Date***
A	January 1996	F	August 2001
B	February 1996		
C	July 1996		
D	November 1997		
E	November 1998		

MANUAL NOTATIONS

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

Note: Provides helpful information.

NOTICE: The descriptions, drawings, and specifications contained herein are subject to change. Zygo is not responsible for errors or omissions herein or for incidental damages in connection with the furnishing or use of this information. This document shall not be reproduced, photocopied, or duplicated, in whole or in part, without prior written approval of Zygo Corp.

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.

01/96

CONTENTS

CONTENTS

page intentionally blank

Introduction

Chapter 1

In This Chapter

What This Manual Covers

This manual describes the installation and use of the ZMI 1000A Measurement Board. It is part of a complete Zygo Motion Interferometer (ZMI) system. Refer to Figure 1-1.

The manual makes the assumption that you are familiar with the VMEbus specification and interferometry principles. It is arranged as follows:

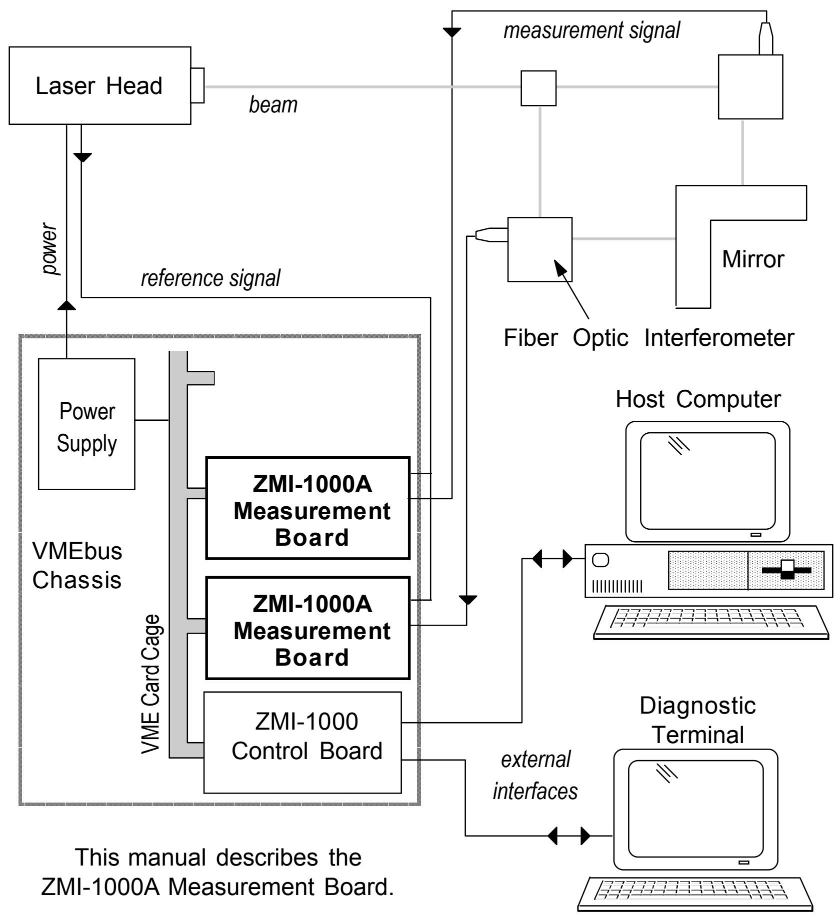
Chapter 1	Describes the board's features and specifications.
Chapter 2	Describes installing the board.
Chapter 3	Describes using the board in a *customized* VME backplane.
Chapter 4	Provides a detailed theory of operation.
Chapter 5	Describes typical applications and uses of the board.
Chapter 6	Contacting Zygo for technical support.

A copy of the VMEbus specification can be obtained from:

IEEE Service Center
Publications Sales Department
445 Hoes Lane
Piscataway, New Jersey, USA 08854-4150
Telephone: 201-981-0060
Internet: http://www.ieee.org

Note: Throughout this manual, a $ in front of a number indicates that the number is hexadecimal, and an * (asterisk) used after a signal name indicates a negative true signal.

Figure 1-1 Typical ZMI System

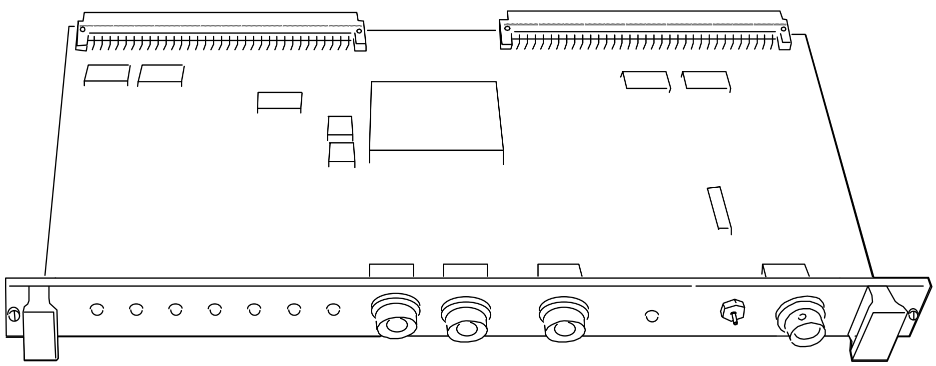


If the Measurement Board is used in the Zygo Chassis, see the ZMI-1000 Chassis and Control Board Manual, OMP-0328.

Overview

The ZMI 1000A Measurement Board, shown in Figure 1-2, is a register based VME slave card used with Zygo motion measuring interferometers. Its circuitry converts the light output signal of the interferometer to position data, using either an external, remote receiver or its own built-in fiber optic detector. The Measurement Board complies electrically and mechanically with Revision C.1 of the VMEbus specification.

Figure 1-2 ZMI 1000A Measurement Board

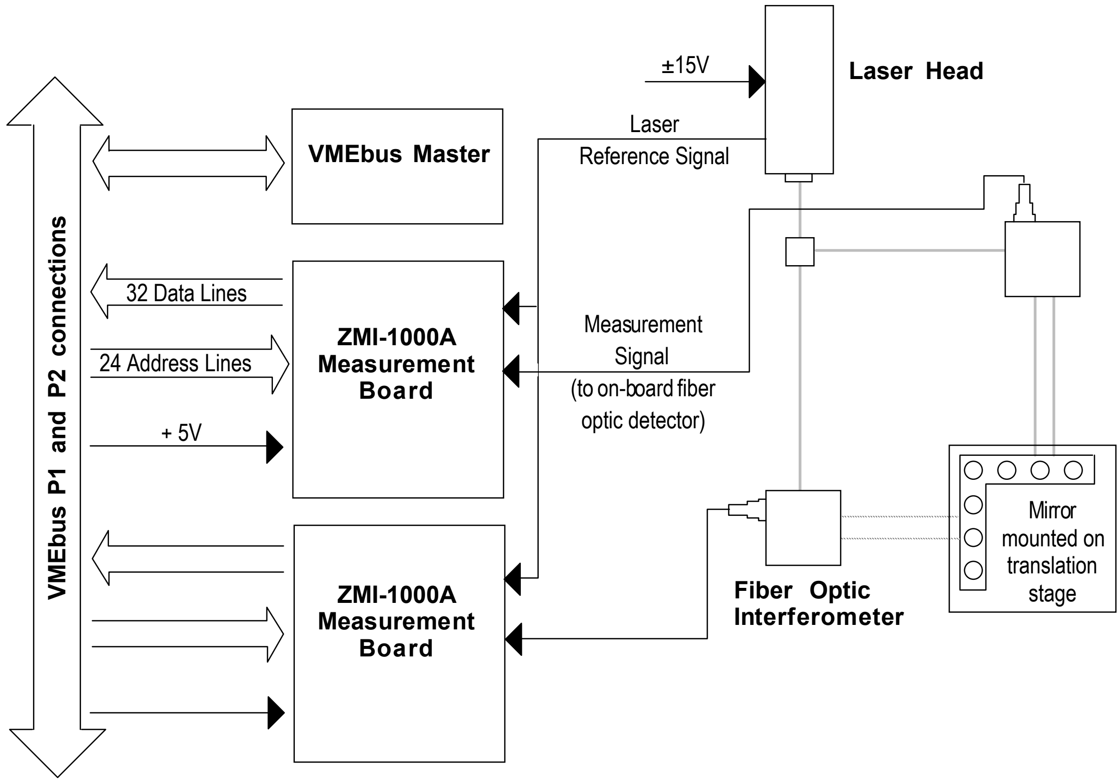


The Measurement Board is part of a total solution for an interferometry based motion measurement system. It can be used in Zygo's VME based interferometer system or incorporated into your own VME backplane. Minimally, a distance measuring interferometer system consists of a laser head, optics, and a Measurement Board.

The function of the Measurement Board is to convert an electrical measurement signal from an interferometer and a reference signal from the laser head to measurement data in the form of a 32-bit 2's complement word.

The ZMI 1000A Measurement Board is compatible with the ZMI Laser Head, P/N 8070-0102-XX (or 6191-0460-XX), and the fiber optic pickup, P/N 8040-0103-XX or the ZMI Receiver, P/N 6191-0420-01. The on-board fiber optic detector eliminates the need for a separate receiver. A typical VME system configuration is shown in Figure 1-3.

Figure 1-3 VME System Configuration

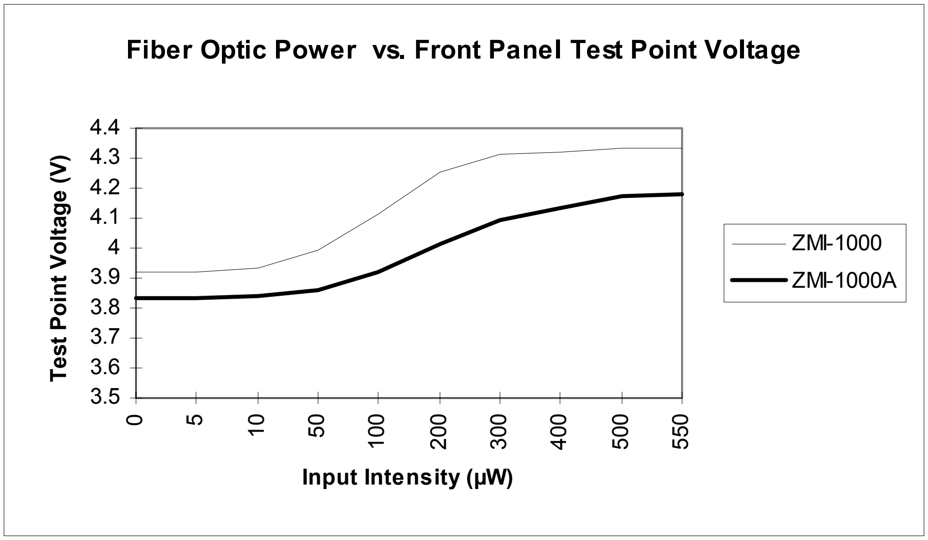


The ZMI 1000A Measurement Boards can be installed in your VME backplane or pre-installed in the Zygo ZMI-1000 Chassis. The Chassis has seven slots, one slot for the Zygo ZMI-1000 Control Board, and six slots for Measurement Boards or other VME compatible boards. The ZMI-1000 Chassis is *not* fully VME compatible as it does not provide 12 volts to the backplane. The ZMI-1000 Control Board is used for connection to a host computer through a GPIB or RS-232 interface. This manual describes using the ZMI 1000A Measurement Board in any VME backplane.

Difference Between the ZMI-1000 and ZMI 1000A Measurement Boards

The ZMI 1000A Measurement Board is an improved version of the ZMI-1000 Measurement Board; it is backward compatible with the ZMI-1000. The ZMI 1000A board has improved reliability and test point voltage characteristics. The chart below highlights the typical test point characteristics between the old board and the new.

Input intensity is measured versus optical power into a fiber optic pickup. Test point voltage may vary by 25% from board to board due to component tolerances. Fiber optic pickup alignment and fiber optic connections directly impact the input intensity versus the test point voltage transfer function.



Physically, the ZMI 1000A Measurement Board looks different from the ZMI-1000 board, but the functionality remains the same. Changes to the switches and jumpers used when setting up the board are highlighted below.

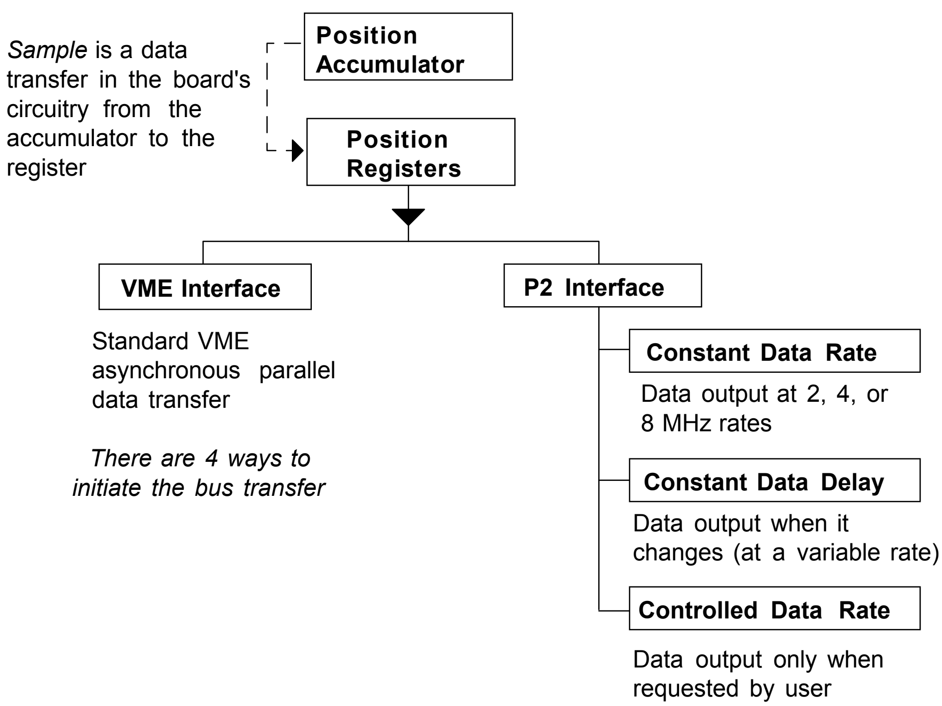
Change	*Reference*
Location of JN1, JN2, JN4, SW1, SW2 is changed.	See Figure 2-1
JN3 was deleted. JN3 functionality was incorporated into JN2.	See Figure 2-4
JN5 was deleted. There is no longer a 16 MHz clock to the VMEbus SYSCLK connection.	
JN7 and JN8 are now reserved for factory use only.	
JN14 was added to select power-on reset options.	See Figure 2-4

ZMI 1000A Measurement Board Description

The function of the ZMI 1000A Measurement Board is to output measurement data that represents the position or movement of the object being measured. The Measurement Board converts optical phase information to 32-bit 2's complement format. The data is in uncompensated wavelength units.

The position data is accumulated by an Application Specific Integrated Circuit (ASIC) on the board. There are two ways to read position data: through the VME interface or through the P2 connector interface. These two main interfaces also have user-selectable modes; they are highlighted in Figure 1-4 and explained over the next few pages. Chapter 2 shows the location of the P2 connector and the pinouts.

Figure 1-4 Interface Options



VME Interface

VME data transfer requires only a standard VME data transfer read cycle. No previous sample command or signal is required. Data transfers of this type are accomplished by reading the *Sampled Position Register* location. Position can be read using 8, 16, or 32 bit data transfer cycles.

The *position data* is accumulated asynchronously with respect to any VME access of the data, except in the DTACK hold-off mode. A VME read access of *Sampled Position Register* causes the current position to be transferred from the accumulator. This transfer is called the internal sample operation. The contents of the Sampled Position Register are then supplied to the VME data bus to complete the VME read cycle.

The time when the position accumulator data is sampled can also be controlled independent of the VME data transfer read cycle. Data is transferred in this way by reading position data from the *Position Register* location. For example, sample timing can be controlled by the External Sample* signal on P2.

In addition to position data, *time data* is transferred into a *Time Register* whenever the position accumulator is sampled; time data is available through a VMEbus read as a 32-bit positive number. Time data is equal to the time that the position accumulator was sampled relative to the time when the time accumulator was reset. The resolution is approximately 16 nanoseconds.

VME functions include *Status Registers*, from which a VME master board can determine the status of the measurement and the board. *Control Registers* are provided for setting board configuration. A *Command Register* is provided for resetting error conditions and data accumulators.

The Measurement Board can generate VME *interrupts* on all seven levels. All of the Measurement Board error conditions can be individually enabled to cause interrupts. An *Interrupt Vector Register* is also provided.

The VME interface supports various *reset* functions. The position data and time data can be reset simultaneously or the time data can be reset independently. The reset function is synchronized. Any reset signal which resets the time accumulator will generate the output signal Time Reset Out* on the P2 connector. This signal can be used to synchronize user circuits external to the board for some applications.

The reset function also resets all error flags on the Measurement Board. If the Preset Mode is enabled, the reset function presets the position accumulator with the contents of the *Offset Register*. The reset function can be initiated external to the board through the P2 connector or reset can be initiated under software control through the *Command Register*.

The VME interface supports various *sample* functions. The position and time registers are updated after a sample operation. This is accomplished under software control through the Command Register or by reading the Sampled Position Register.

There are provisions for an external sample signal via the P2 connector. The falling edge of this signal initiates the transfer of the current position and time data to their respective VME data registers. The position data and time data may be accessed through a VME data transfer bus read cycle.

There are provisions for common sample and reset of multiple Measurement Boards. The user should connect the appropriate External Sample*, Position Reset*, and Time Reset* signals on the P2 connectors together. The stated signal function for all boards can be accomplished by issuing the appropriate command to the Command Register of any one Measurement Board.

P2 Interface

A hardware interface is provided on the P2 connector. There are three software selectable position data transfer modes:

- Constant Data Rate, data is a 32-bit, 2's complement number.
- Constant Data Delay, data is a 32-bit, 2's complement number.
- Controlled Data Rate, data is one 32-bit or two 16-bit, 2's complement numbers.

Constant Data Rate Mode

The constant data rate mode provides a fixed or constant output clock frequency which is used to clock the position data into the user's hardware. This option provides a constant output data rate, but a variable data delay. On power-up the Measurement Board defaults to the constant data rate option of the 32-bit parallel interface. The constant data rate option of the 32-bit parallel interface is compatible with the HP 10895A Laser Axis Board. The P2 interface data is supplied at a fixed rate without a sample input signal or handshake signal. P2 interface functions also include position and error reset, output drive enable and output update hold-off.

Constant Data Delay Mode

The constant data delay mode provides for minimum position data output delay time uncertainty. A high to low transition of the transfer signal is used to clock the position data into the user's hardware. The transfer signal has a variable frequency, dependent on the axis velocity (thus making it a variable output data rate of 0.5 to 7.5 MHz). When using a plane mirror interferometer, the update rate is expressed in megahertz (MHz) and equals $[4 + (6.32 \times 10^{-3} \times V)]$, where velocity (V) is expressed in millimeters per second (mm/sec). The constant data delay is an advantage in some applications. This option provides the lowest data delay dispersion (15.6 ns @ constant velocity) and does not require a sample input signal or handshake signal. Since the frequency of the transfer signal is a function of velocity, it can be used to measure velocity and for position extrapolation. P2 interface functions also include position and error reset and output drive enable.

Controlled Data Rate Mode

The controlled data rate mode is compatible with the ZYGO 2/20 multiplexed servo interface. P2 interface data is accessed by a sample signal and handshaking is provided by a transfer signal. P2 interface options also include position and error reset and three address lines for selecting up to eight Measurement Boards.

All P2 interface options can have their position data modified by having a constant value subtracted from the position data. The value is stored in the *Offset Register* by a VMEbus write access. The 32-bit 2's complement number is subtracted from the position data.

The position accumulator can be preset with the contents of the *Offset Register* by a Reset Axis command or by an active Position Reset* signal if the Preset Accumulator Enable bit is active in *Control Register 1*.

Interface Comparison

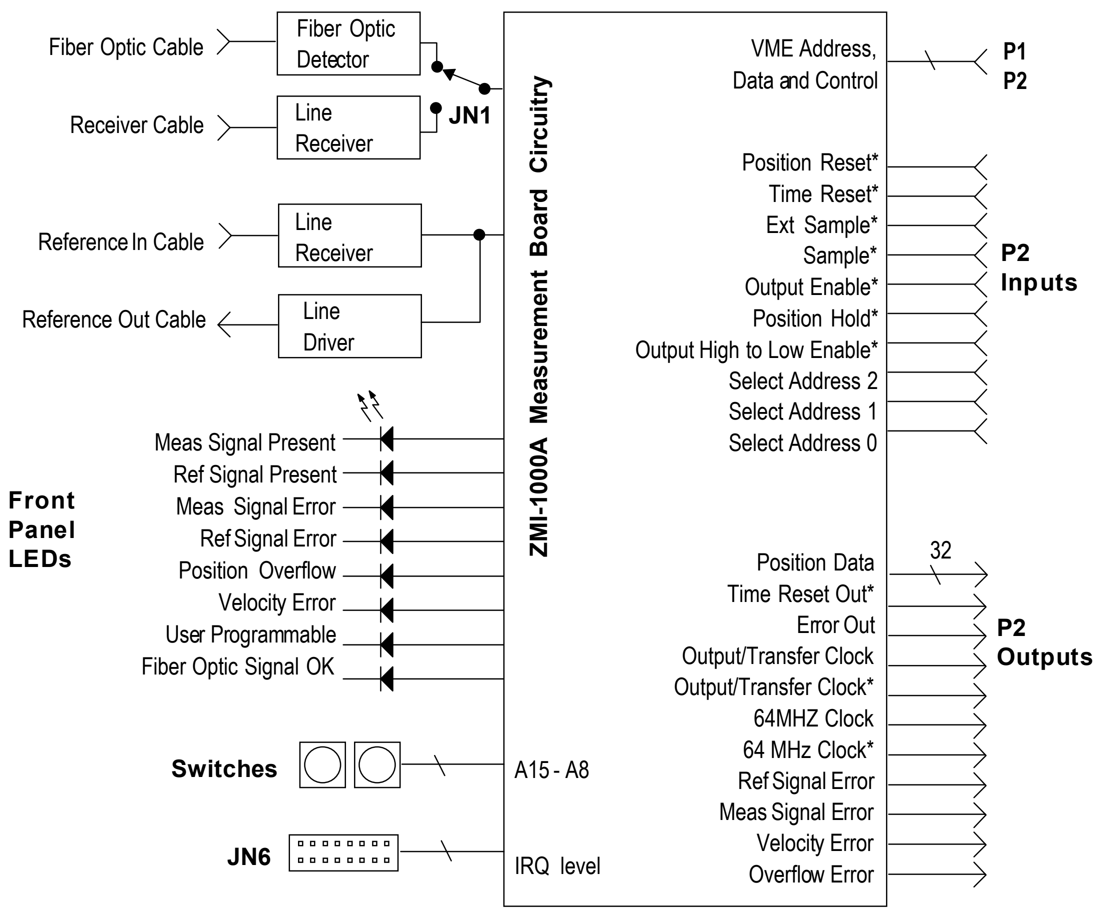
A summary of the interface options of the Measurement Board are shown in Table 1-1. A ✓ indicates the feature is available with the interface.

Table 1-1 Interface Options

Features	*VME*	*P2 Constant Data Rate*	*P2 Constant Data Delay*	*P2 Controlled Data Rate*
8-bit data	✓	-	-	-
16-bit data	✓	-	-	✓
32-bit data	✓	✓	✓	✓
read data	✓	✓	✓	✓
time data	✓	-	-	-
error detection	✓	✓	✓	✓
common sample	✓	-	-	✓
common reset	✓	-	-	✓
Max transfer rate	3 MHz	8 MHz	7.5 MHz	2 MHz

A block diagram of the ZMI 1000A Measurement Board is shown in Figure 1-5.

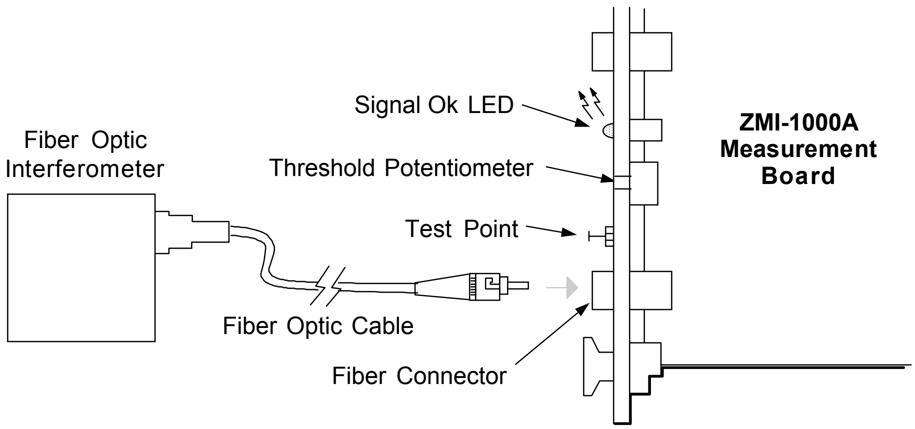
Figure 1-5 ZMI 1000A Measurement Board Block Diagram



On-board Fiber Optic Detector

The ZMI 1000A Measurement Board includes an on-board fiber optic detector, shown in Figure 1-6. This feature eliminates the need for a separate receiver. The Measurement Board on-board detector connects directly to a fiber optic cable, from either a fiber optic interferometer or a nonfiber optic interferometer with a fiber optic pickup. In both cases, the fiber optic cable directs the light from the interferometer to a photodetector on the Measurement Board.

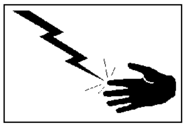
Figure 1-6 On-board Fiber Optic Detector



The on-board fiber optic detector has a Signal Ok LED, a threshold or sensitivity adjustment potentiometer, and a test point. The threshold potentiometer is used to adjust the optical signal threshold level. The LED turns on when the threshold is exceeded. The threshold should be adjusted after interferometer alignment to ensure that the Signal Ok LED turns off when the beam is blocked.

The test point is used when aligning the interferometer to ensure the best possible alignment. The interferometer position is adjusted to maximize the output voltage at the test point. The higher the voltage the greater the detected signal intensity. The specific output voltage varies depending upon the interferometer efficiency, the optical alignment, and other system tolerances.

Electrical Safety



Failure to follow the recommendations in this manual could result to damage to the Measurement Board and may void the warranty.

Warning!
To prevent the board from being damaged by electrostatic discharge (ESD) it should be stored in a static shield bag and handled only if you are using a static control wrist grounding strap.

Remove power from the VME card cage before installing the board or when connecting and disconnecting cables.

The Measurement Board must be connected to earth ground through the VME card cage.

Specifications

The general specifications of the ZMI 1000A Measurement Board are shown on the following page. P2 hardware interface timing diagrams are provided in Chapter 3. For cable specifications refer to the ZMI Cable Guide, OMP-0333.

ZMI-1000A Measurement Board
P/N 8020-0206-01

Number of Axes per Board: 1
Power Requirement: + 5 VDC, +0.25V/ -0.125V @ 2.5A

Specification	**4-pass PMI**	**2-pass PMI**
Position Resolution	λ/1024 (0.62 nm)	λ/512 (1.24 nm)
Position Range	± 1.328 m	± 2.655 m
Maximum Velocity	275 mm/sec	550 mm/sec
Max. Acceleration	7.5 g	15 g
Error, 3s (1)	0.78 nm	1.6 nm

(1) Electronic measurement error including resolution.

Position Format: 32 bit - 2's complement
Time Resolution: 15.625 ns
Time Range: 67.1 sec
Time Format: 32 bit positive integer
On-board Fiber Optic Detector
Recommended input intensity: 10 microwatts

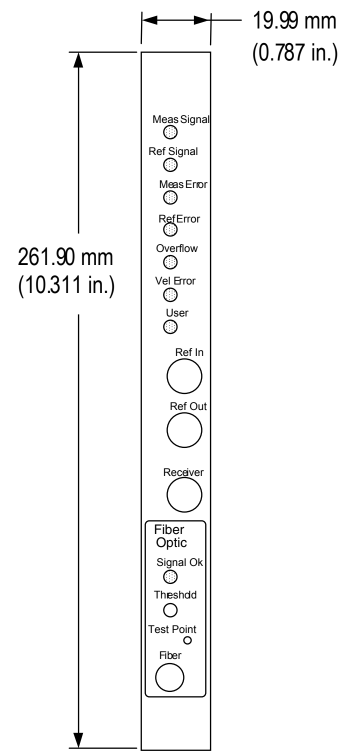
Compliance: UL94VO, UL796
VME Compliance:
VMEbus Specification Rev. C.1
6U Size
A16 or A24 Addressing
D08 (EO) or D16 or D32 Data Transfer
D08 (O) Interrupt Acknowledge Cycle
Environmental:
Operating Temperature: 0 to 55° C
Non-operating Temperature: -40 to 75° C
Operating Humidity: 0 to 90% (non-condensing)
Non-operating Humidity: 0 to 90% (non-condensing)
Cooling Requirements:
60 linear fpm minimum for 0 to 40° C
250 linear fpm minimum for 0 to 55°C

Position Data Rates:

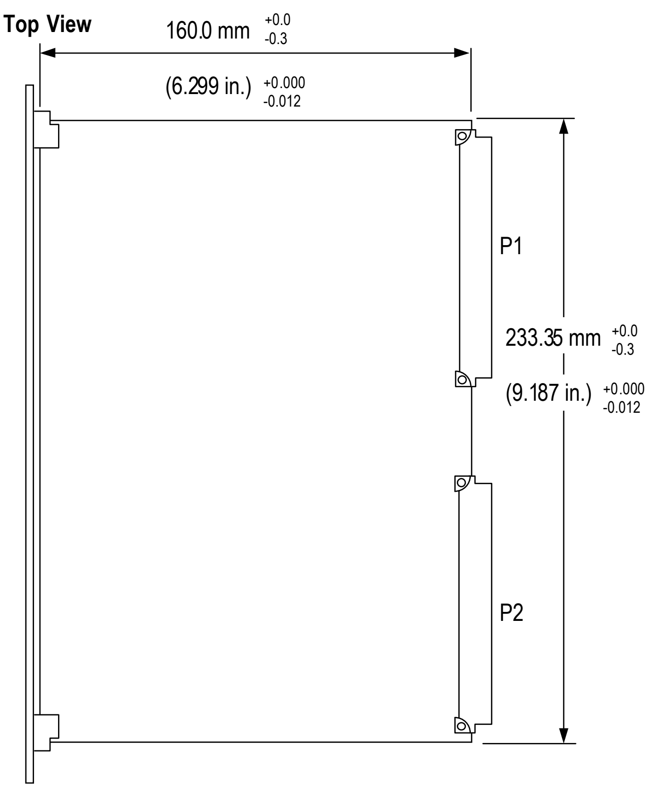
Interface	*Rate*
VME Data Transfer Bus [1] (DTACK Hold-off disabled)	3 MHz
Constant Data Rate, P2	2, 4, or 8 MHz
Constant Data Delay, P2	Same as measurement update rate: 4 MHz +/- (6.32 x 10^{-3} * V) MHz [2]
Controlled Data Rate, P2	2 MHz

[1] Data is valid when the Measurement Board sends a high to low transition on DTACK* during a data transfer cycle, according to VME protocol. See DTACK at the end of Chapter 3.
[2] Units of velocity (V) are mm/sec.

Front Panel



Top View



Installation

Chapter 2

In This Chapter

- Checklist
- Unpacking
- Installing the Board
  - Base Address Selection
  - Receiver Selection
  - Selecting Interrupts
  - P1 and P2 Pin Assignments
  - P2 Signal Termination
  - Jumper Summary
- Installing the Board in a User-supplied Chassis
  - Noise and Interference
- Standalone Operation
- Front Panel Connectors
- Recommended System Grounding
- On-board Fiber Optic Detector
  - Installing Fiber Optic Cables
  - Cleaning Fiber Optic Cables
  - Detector Threshold Adjustment

Checklist

The following list is provided as a summary of the installation procedures.

☐ Inspect all packages for signs of shipping damage. Report any damage to the carrier and to the Zygo Service Department, as described in Chapter 5.

☐ Check that the shipment is complete.

☐ Select the base address, receiver input, and the desired interrupt level.

☐ Install the board in the chassis and connect the cables. If necessary, review the connector pin assignments.

☐ If installing the board in a user-supplied chassis, ensure that the chassis meets the requirements described in the section “Installing the Board in a User-supplied Chassis”. You must also program your VME master board to access and control the ZMI 1000A Measurement Board; see Chapter 3.

☐ Follow the guidelines in the section “Recommended System Grounding”.

☐ Install the fiber optic cables and adjust the On-board Fiber Optic Detector.

Unpacking

Inspect all packages for signs of shipping damage. Report any damage to the carrier and notify your Zygo representative. If necessary, retain the shipping material for the carrier's inspection.

Ensure that your order is complete. The following parts are included with the ZMI 1000A Measurement Board:

8020-0206-01	ZMI 1000A Measurement Board
1618-600-001	Static Wrist Strap

Cabling is supplied separately. Refer to the ZMI Cable Guide, OMP-0333 for a sampling of the cable options available from Zygo.

Installing the Board

The Measurement Board is factory installed if you purchased a Zygo Chassis at the same time. However, to install the Measurement Board in the VME chassis, proceed as follows. Refer to Figures 2-1 and 2-2.

Warning!
Use proper handling techniques when touching the Measurement Board to prevent the board from being damaged by electrostatic discharge (ESD). The board should be stored in a static shield bag and handled only by individuals using a static control wrist grounding strap.

Steps 2 through 4 are described in greater detail in succeeding sections.

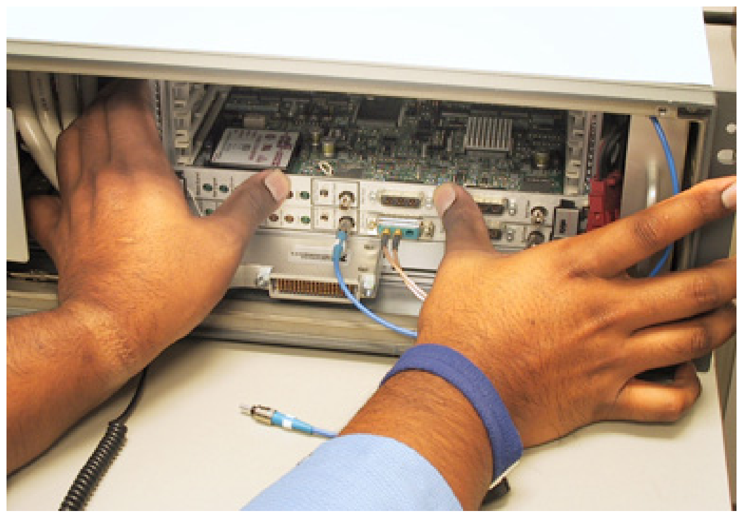
1. Using a static control wrist strap, remove the board from the static shield bag.
2. Using a small screwdriver, set SW1 and SW2 of each board to a unique address setting.
3. Set the JN1 jumper to 1-2 for normal receiver input or to 2-3 for fiber optic cable input when using the on-board fiber optic detector.
4. Set the JN6 jumper to the desired interrupt level for each board.
5. Set jumper JN4 for the desired output state. See the section on the Output Enable* signal in Chapter 3 for information.
6. Set jumper JN14 for the desired reset mode. Jump pins 1-2 to reset board using VMEbus SYSRESET* signal; jump pins 2-3 for board reset at power-on.

Warning!
Disconnect the VME chassis from power before installing the board and when connecting (or disconnecting) cables.

7. Insert the measurement board into the card cage by pressing on blank areas of the board's front panel with your thumbs to seat the board into the P1 and P2 connectors.

Figure 2-1 Correct Method of Inserting the Measurement Board in a Card Cage

Warning!
Do not install the board with the ejector handles. Pushing on the ejector handles may damage the board.



Actual board may vary from that shown above.

8. Screw the captive front panel screws into the card cage frame.
9. Connect the cables as shown in Figure 2-2. Optional receiver connections are shown in Figure 2-3.

Figure 2-2 Installing the Measurement Board

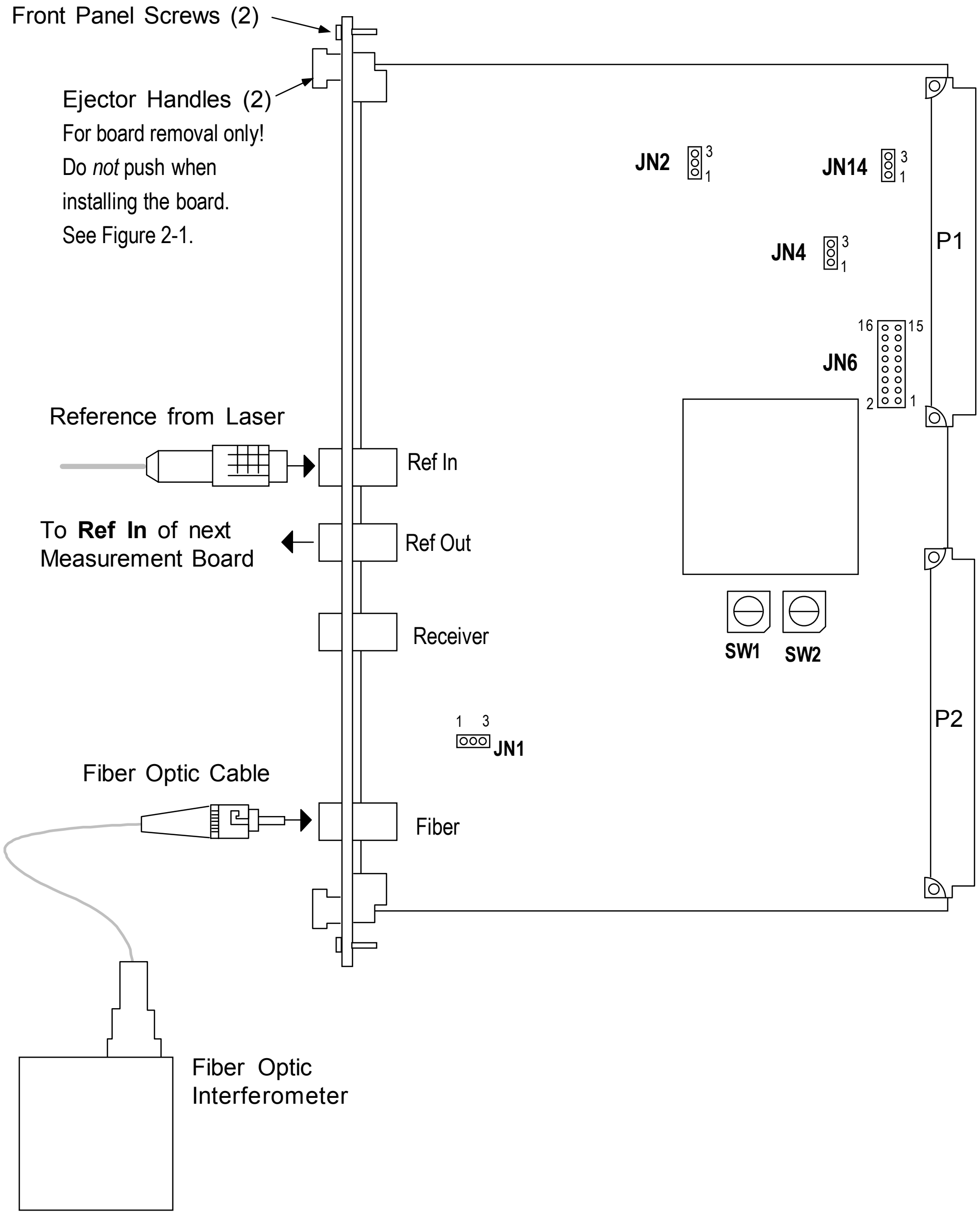
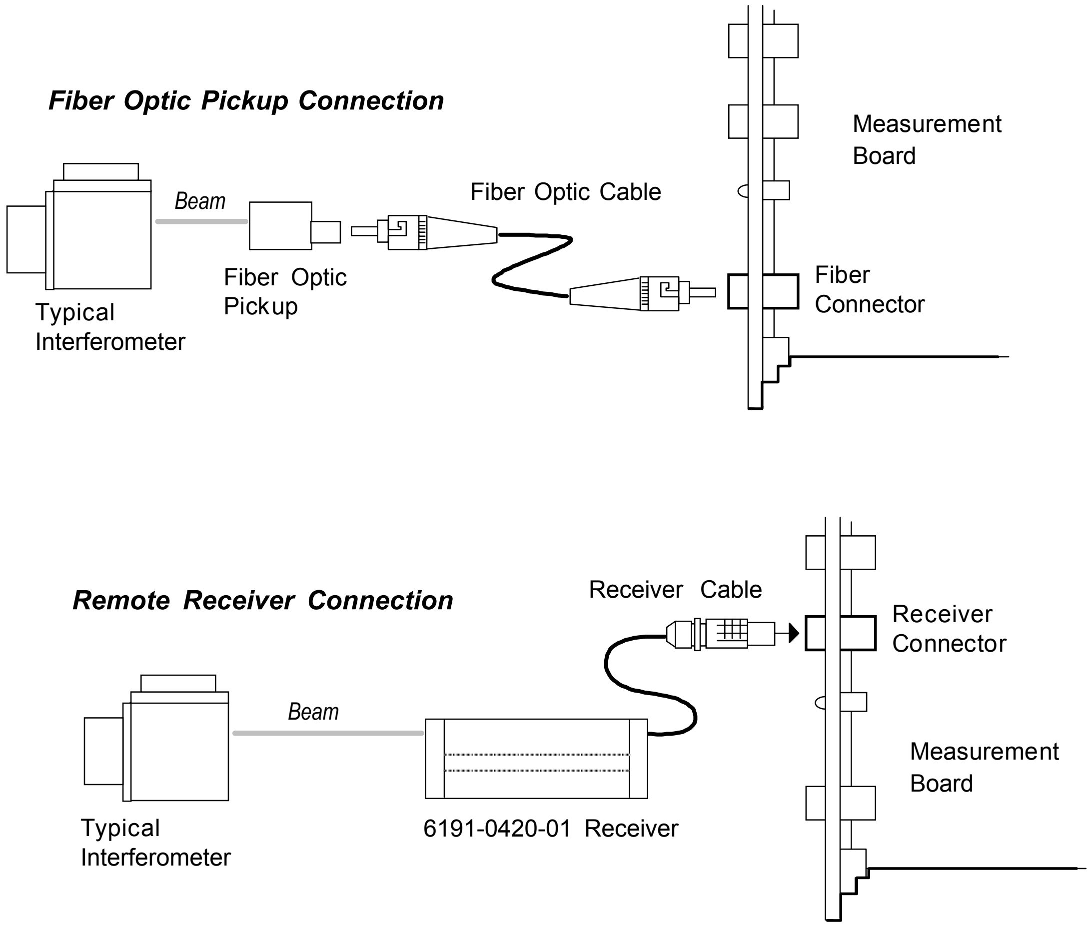


Figure 2-3 Optional Receiver Connection



Base Address Selection

The Measurement Board always powers-up in the A16 address mode, using address lines A01 through A15. The base address of A15 to A08 is determined by two 4-bit rotary switches; denoted as SW1 and SW2.

SW1 and SW2 can be set to any of 256 addresses, starting at $0000 through $FF00 in $100 byte intervals. The 8-bits on the switches correspond to A8 through A15 on the backplane. SW2 is the most significant, it determines A15 to A12; SW1 determines A11 to A08.

For A16 addressing, ensure the setting of SW1 and SW2 is unique for each Measurement Board and does not conflict with any existing VME board in the system.

For A24 addressing, using address lines A01 through A23, the base address is determined by the settings stored in the Base Address Register. This corresponds to address bits A23 to A8. A24 addressing is enabled only when the A24 Enable bit is set in Control Register 1.

For A24 addressing, ensure that the address stored in the Base Address Register is unique for each Measurement Board and does not conflict with any existing VME board in the system. The A24 Enable bit must also be set. See Chapter 3 for the write address of the register; the A24 Enable is bit 14.

Note: When A24 addressing is used, each board in the VME system must have a unique A16 base address and a unique A24 base address.

The Measurement Board base address is calculated according to the equations in the table below.

Address Mode	*Base Address (decimal)*	
A16	Sx256	where S is the decimal value of SW1 and SW2.
A24	Rx256	where R is the decimal value of the A24 Base Address Register.

Address Mode	*Base Address (hexadecimal)*	
A16	A_3A_2	where A_3 is the hex value of SW2 and A_2 is the hex value of SW1.
A24	$B_5B_4B_3B_2$	where $B_5B_4B_3B_2$ is the hex value of the A24 Base Address Register.

Receiver Selection

The Measurement Board can accept a receiver cable from a remote receiver or a fiber optic cable from an interferometer. Set the jumper JN1 as shown below.

JN1 Jumper Setting	*Selects…*
1-2	Remote receiver input.
2-3	On-board fiber optic detector (default).

Interrupt Selection

The Measurement Board can be set for any of the seven VME interrupt levels. Jumper block JN6 sets the interrupt request level and the decimal setting written to Control Register 2, bits 7, 8, and 9 sets the interrupt response level. Both levels must be set equal for proper operation.

Set the jumper in JN6 and the interrupt response level of Control Register 2, bits 7, 8, and 9. The write address of Control Register 2 is $18.

Interrupt Request Level	*JN6 Jumper Setting*	*Control Register 2 Setting of Bit… 9*	*8*	*7*
off	15-16	0	0	0
1	1-2	0	0	1
2	3-4	0	1	0
3	5-6	0	1	1
4	7-8	1	0	0
5	9-10	1	0	1
6	11-12	1	1	0
7	13-14	1	1	1

P1 Pin Assignments

VME signal pins on the P1 connector are shown in Table 2-1. VME signal pins that are not used by the Measurement Board are not connected and are indicated by a dash (–).

⚠ **Warning!**
P1 inputs and outputs can be damaged by electrostatic discharge and short circuits in user connections.

Note: The P1 connector supplies position data to the VMEbus as 16-bit or 8-bit accesses. For 32-bit data accesses use the P2 connector.

P1 Connector Pin Out - Pin View

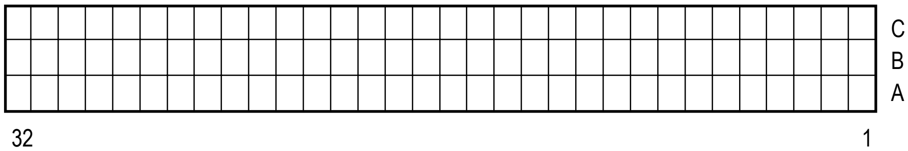


Table 2-1 P1 Pin Assignment

	P1 Connector		
Pin	*Row A*	*Row B*	*Row C*
1	D0	-	D8
2	D1	-	D9
3	D2	-	D10
4	D3	-	D11
5	D4	-	D12
6	D5	-	D13
7	D6	-	D14
8	D7	-	D15
9	GND	-	GND
10	-	-	-
11	GND	-	-
12	DS1*	-	SYSRESET*
13	DS0*	-	LWORD*
14	WRITE*	-	AM5
15	GND	-	A23
16	DTACK*	AM0	A22
17	GND	AM1	A21
18	AS*	AM2	A20
19	GND	AM3	A19
20	IACK*	GND	A18
21	IACKIN*	-	A17
22	IACKOUT*	-	A16
23	AM4	GND	A15
24	A7	IRQ7*	A14
25	A6	IRQ6*	A13
26	A5	IRQ5*	A12
27	A4	IRQ4*	A11
28	A3	IRQ3*	A10
29	A2	IRQ2*	A9
30	A1	IRQ1*	A8
31	-	-	-
32	+5V	+5V	+5V

P2 Pin Assignments

The outer rows of the P2 connector are used for the P2 hardware interface. The pin assignments are shown in Table 2-2.

Warning!
Unprotected 26LS31 and 74ABT16245 devices drive P2 output signals. Use recommended termination as shown in the next section.

P2 inputs and outputs can be damaged by electrostatic discharge and short circuits in user connections.

Take the following precautions to ensure valid P2 input logic levels:

- The worst case low level input voltage for a logic zero must be less than 0.46 volts.
- Use a common AC ground between the Measurement Board and the source of the external input signal(s).
- Use a signal ground for each external input signal.
- Minimize the length of the interconnecting cable.

P2 Connector Pin Out - Pin View

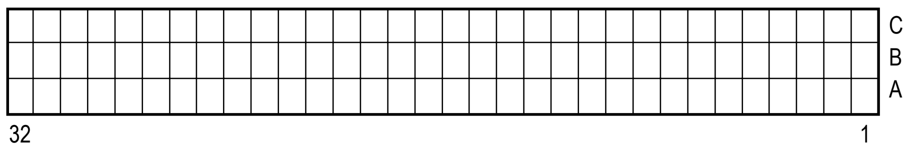


Table 2-2 P2 Pin Assignment

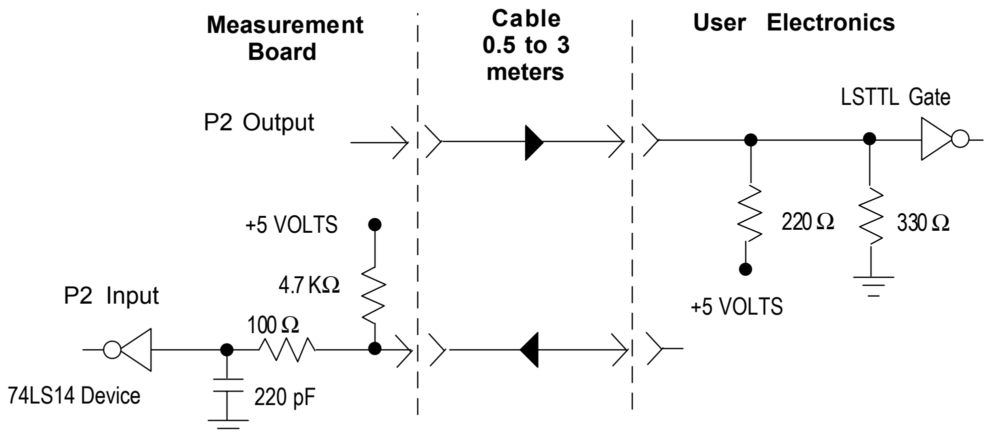
Pin	*P2 Connector* Row A	Row B	Row C
1	64 MHz	+5V	GND
2	64 MHz*	GND	GND
3	Error Out	RESERVED	GND
4	Measurement Signal Error	RESERVED	Ref Signal Error
5	Window*	RESERVED	Overflow Error
6	Output High to Low Enable*	RESERVED	GND
7	Position Reset*	RESERVED	External Sample*
8	Output Enable*	RESERVED	Position Hold*
9	Output/Transfer Clock	RESERVED	GND
10	Output/Transfer Clock*	RESERVED	GND
11	Velocity Error	RESERVED	Time Reset Out*
12	P1	GND	P0
13	P3	+5V	P2
14	GND	D16	P4
15	P6	D17	P5
16	P8	D18	P7
17	P10	D19	P9
18	P12	D20	P11
19	P13	D21	GND
20	P15	D22	P14
21	P17	D23	P16
22	P19	GND	P18
23	GND	D24	P20
24	P22	D25	P21
25	P24	D26	P23
26	P26	D27	P25
27	P28	D28	P27
28	P29	D29	GND
29	P31	D30	P30
30	Time Reset*	D31	Select Address 2
31	Sample*	GND	Select Address 1
32	GND	+5V	Select Address 0

P2 Signal Termination

Both P2 input and output termination is represented on the following figure. All P2 inputs are one TTL load with a 4.7 kΩ pull-up resistor, 100 kΩ series resistor, and a 220 pF capacitor to ground.

All P2 outputs are TTL compatible and drive up to 3 meters of shielded flat cable. Terminating resistors may not be required for cable lengths less than 0.5 meter.

Figure 2-4 P2 Input and Output Termination

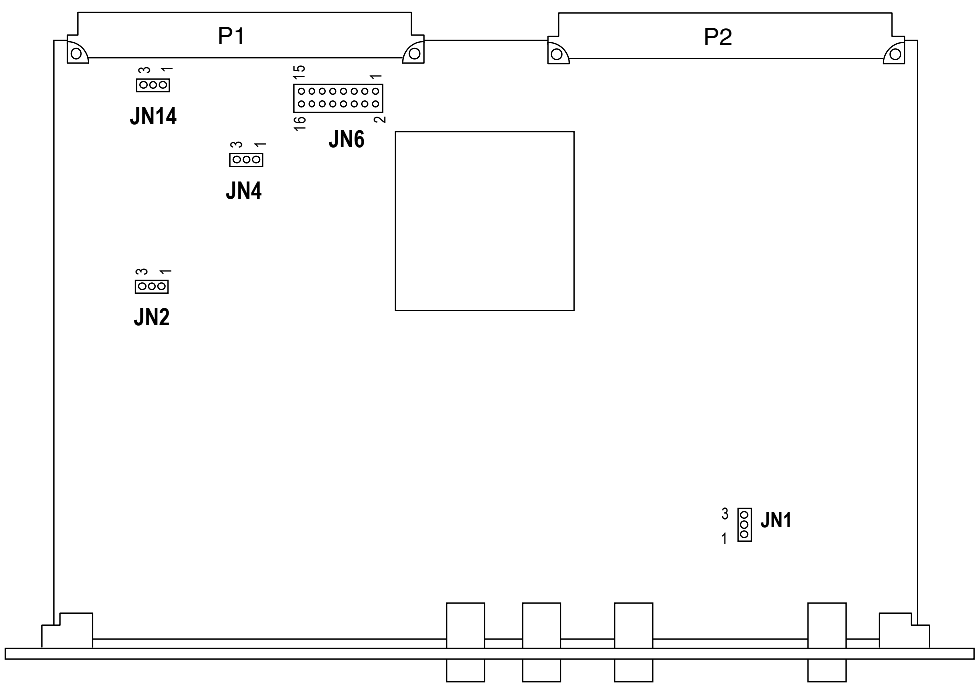


Jumper Summary

The Measurement Board jumpers are shown in Figure 2-5.

Jumper	*Function*		*Position*	*Factory*
JN1	Enable remote receiver.		1-2	
	Enable on-board fiber optic detector.		2-3	2-3
JN2	Enable 64 MHz clock signals (P2 -A1 & A2).		1-2	1-2
	Disable 64 MHz clock signals (P2 -A1 & A2).		2-3	
JN4	See descriptions of Output Enable* and Output High to Low Enable* signals in Chapter 3.			2-3
JN6	Selects VME interrupt level:	IRQ1	1-2	
		IRQ2	3-4	
		IRQ3	5-6	
		IRQ4	7-8	
		IRQ5	9-10	
		IRQ6	11-12	
		IRQ7	13-14	
		Disabled	15-16	15-16
JN14	Board reset at power-on and by the VMEbus SYSRESET* signal.		1-2	1-2
	Board reset only at power-on.		2-3	

Figure 2-5 Measurement Board Jumpers



Installing the Board in a User-supplied Chassis

The Zygo Measurement Board may be installed in a user-supplied VME chassis. If this is the case, the set-up procedure for the board is identical to what was described in the previous sections. In addition, ensure that your VME chassis meets the following basic requirements:

- Supplies an incoming voltage of 5 VDC, +0.25V/-0.125V, at 2.5 amps.
- Provides a cooling air flow of 60 linear feet per minute for operation in a temperature range from 0 to 40 degrees Celsius, or 250 linear feet per minute for 0 to 55 degrees Celsius.
- Supplies a level of noise and interference immunity, as detailed below.

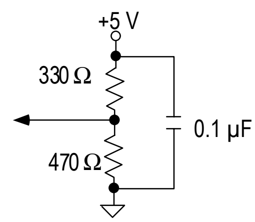
Noise and Interference

Noise and interference caused by other system components, such as switching power supplies and fans, can degrade the accuracy of the Measurement Board. The possible symptoms are: apparent noise in the position data output, Meas Error LED on, Ref Error LED on, or Vel Error LED on.

A performance check should be made to confirm operation when installing the Measurement Board in a user-supplied chassis. To perform the check, install the Measurement Board, a 6191-0460-XX Laser Head, and a 6191-0420-01 Receiver, according to their installation instructions. Position the Receiver directly in the Laser Head output beam with no interferometer. In this configuration, the position data should be stable to ±1 count and no error LEDS on. If the data is not stable or there are error LEDS on, interference is indicated.

Some of the potential noise sources are listed in the Table 2-3.

Table 2-3 Possible Noise Sources in User-supplied Chassis

Noise/Interference Source	*Guidelines*
Switching Power Supplies	Switching power supplies can cause transients on the power supply conductors at harmonics of the switching frequency. Follow the installation and noise suppression recommendations of your power supply manufacturer.
DC Brushless Fans	DC brushless fans can also cause transients on the power supply conductors. Follow the installation and noise suppression recommendations of your fan manufacturer.
VME Backplane	Use passive termination not active termination. The recommended termination circuit is shown here. 
Improper Component Grounding	Improper grounding of the laser head, receiver, cables, or Measurement Board, may cause measurement data noise. To eliminate this possibility, conform to the guidelines in the section entitled “Recommended System Grounding”, later in this chapter.

Standalone Operation

The Measurement Board can be used without a VMEbus controller or “standalone”. To operate in this mode, you must supply a power-up reset signal to pin C12 (SYSRESET*) on the P1 connector. This initializes the board to output 32-bit data in the constant data rate mode. All unused input signals on the P1 connector must be pulled up to +5 volts through 4.7 kΩ resistors.

Input and output signals are interfaced through the P2 connector. See Chapter 3 for a detailed description of P2 signals.

Front Panel Connectors

The Measurement Board has four front panel connectors. These are described in Figure 2-6. The pin view diagrams are described in Figure 2-7.

Figure 2-6 Front Panel Connectors

Panel Label	*Description*
Ref In	Input reference signal from the Laser Head.
Ref Out	Output reference signal to next Measurement Board.
Receiver	Input measurement signal from external receiver.
Fiber	Input optical signal from a fiber optic cable.

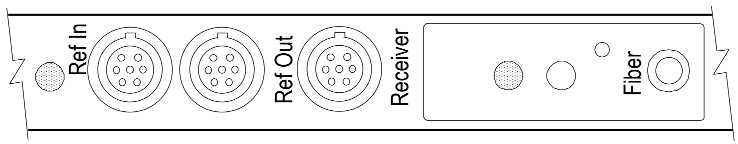
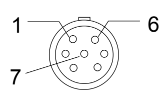


Figure 2-7 Front Panel Signal Assignments

Pin	*Ref In*	*Ref Out*	*Receiver*
1	Status signal from laser	Status signal from laser	Circuit ground
2	Chassis ground	Chassis ground	Chassis ground
3	compliment of 1	compliment of 1	+5V to receiver
4	unused	NC	+5V to receiver
5	Reference Signal	Reference Signal	Measurement Signal
6	Reference Signal*	Reference Signal*	Measurement Signal*
7	Circuit ground	Circuit ground	Circuit ground



Ref In, Ref Out, and Receiver Connectors Pin View

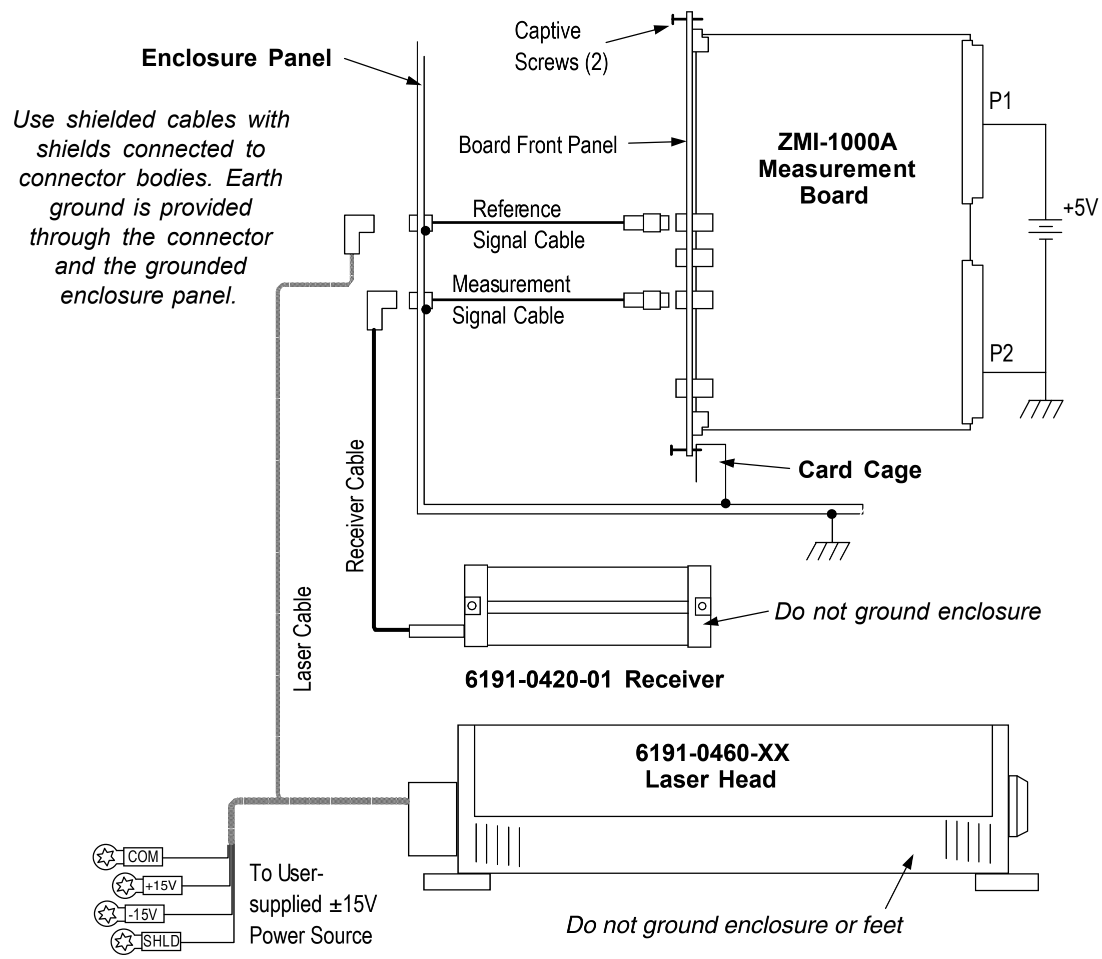
Recommended System Grounding

Improper grounding of the laser head, receiver, cables, or Measurement Board, may introduce noise in the measurement data. Adhere to the recommendations in Figure 2-8 to prevent electromagnetic interference from causing measurement problems.

The ZMI-1000 Chassis and cables available from Zygo provide a convenient way to implement these recommendations.

Figure 2-8 System Grounding Recommendations

Component	*Recommendation*
Measurement Board	The front panel of the board should be in contact with earth ground through its captive screws. The captive screws secure the board to the card cage, which in turn should be connected to earth ground.
Laser Head	The laser head feet and enclosure should be isolated from earth ground. Grounding is provided through the cable. The Zygo 6191-0460 Laser Head, configurations 01 and 02, have non-conductive feet. Laser Head configurations 03 and 04 have conductive feet; ensure that the feet are not grounded.
Receiver	If using a Zygo 6191-0420-01 Receiver, its enclosure should be isolated from earth ground. Grounding is provided through the cable. Disregard this recommendation if using the Measurement Board's on-board fiber optic receiver.
Cables	All cables should be shielded and connected to earth ground through their connectors and the electronic enclosure panel.



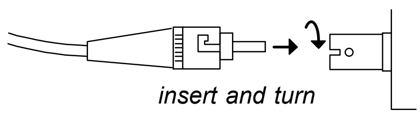
On-board Fiber Optic Detector

Installing Fiber Optic Cables

One or more fiber optic cables can be used to connect the interferometer to the Measurement Board Fiber Optic Detector. The Zygo Fiber Optic Feed-Thru, P/N 1189-857-076, connects two cables together for extending cable length or for passing through a sheet metal enclosure. The efficiency of each Feed-Thru is typically from 80 to 90%.

> **Note:** Clearance and bending specifications for fiber optic cables and Fiber Optic Feed-Thru dimensional specifications are located in the ZMI Cable Guide, OMP-0333.

1. Remove the protective end cap from the cable.
2. Insert the cable end into the connector.
3. Align the pin to the slot in the cable's collar. Press and turn the cable clockwise to secure the pin into the cable's detent.



insert and turn

Cleaning Fiber Optic Cables

Dirty or damaged fiber optic cable ends greatly reduce fiber optic efficiency.

> ⚠ **Warning!**
> Protective cups should be installed when the cable is not in use.

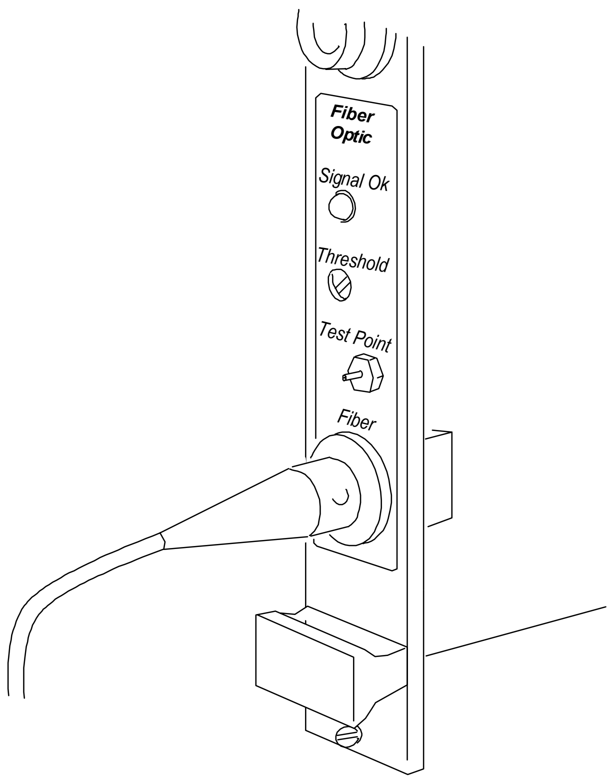
1. Remove protective caps from both ends of fiber optic cable. If the cable is connected to an interferometer or board, disconnect the cable.
2. Wet a lint free wipe with Methanol or Isopropyl.
3. Gently wipe both cable ends.
4. Examine the end to ensure no contaminants or reside are present. Repeat steps 2 and 3 if necessary.

Detector Threshold Adjustment

After the interferometer system is installed and aligned, you should optimize the alignment of each interferometer and adjust the detector threshold. The Test Point, Signal Ok LED, and the Threshold adjustment screw are all located on the front panel of the Measurement Board. To adjust the On-board Fiber Optic Detector complete the following procedure. Refer to Figure 2-9.

1. Connect the positive lead from a voltmeter to the **Test Point** and connect the negative lead to ground on the VME chassis.
2. Carefully adjust the position of the interferometer to obtain the maximum voltage reading. See the appropriate Zygo manual included with the interferometer for detailed alignment instructions. Disconnect the voltmeter when complete.
3. Verify that the **Signal Ok** LED goes off when the beam is blocked from reaching the measurement reflector.
4. If the LED does not go off, block the measurement beam and turn the **Threshold** adjustment screw clockwise until the LED goes off. Unblock the beam and confirm that the LED goes back on.
5. Turn the **Threshold** adjustment screw a quarter-turn counter-clockwise.

Figure 2-9 On-board Fiber Optic Detector



Operation

Chapter 3

In This Chapter

- Overview
- Board LED's
- Data Transfer Modes
- P1 Signals
- P2 Signals
- P2 Timing Diagrams
- Address Map
- Registers
- VME Functions

Overview

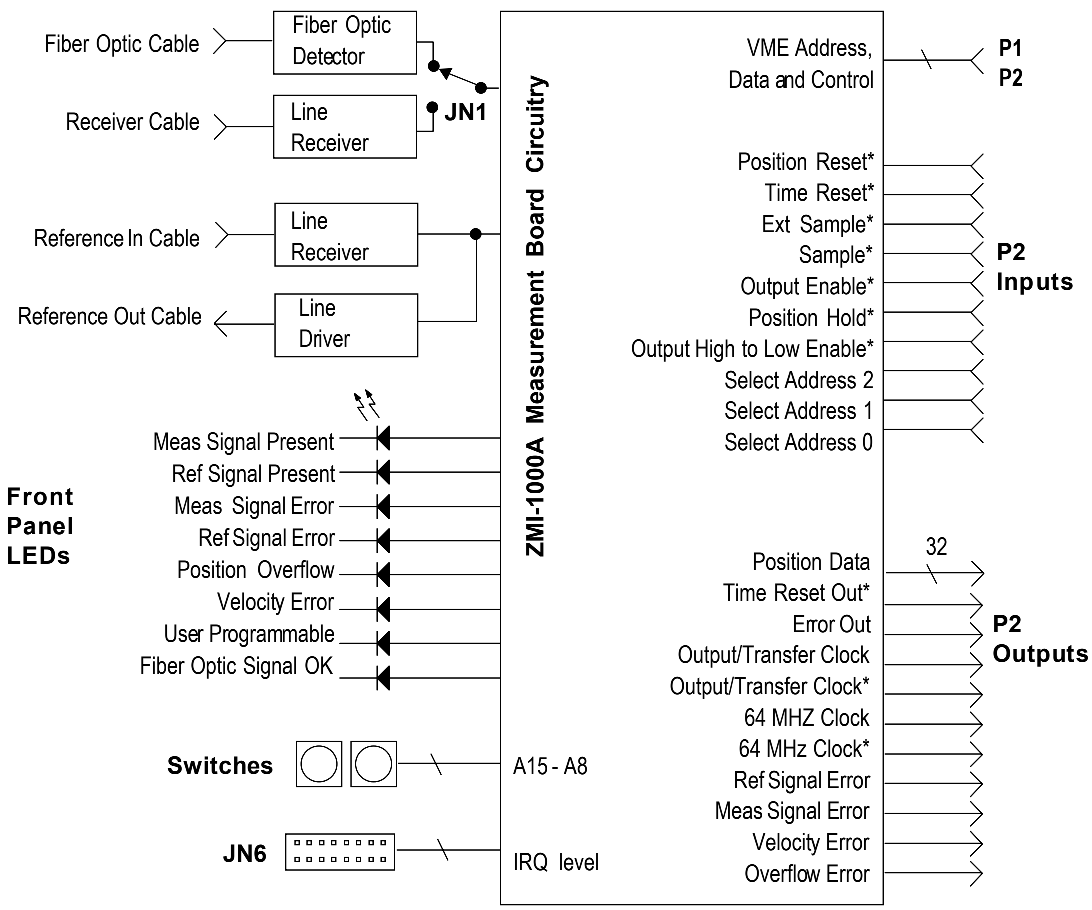
The Zygo Measurement Board is a register-based VME card. As a review, a block diagram of the ZMI 1000A Measurement Board is shown in Figure 3-1.

The board is initialized and all bits in the control registers are cleared when the board receives an active SYSRESET* signal from the VMEbus or when power is turned off and then back on. After the system is reset, the board responds only to A16 bus cycles. To use A24 addressing, the A24 Base Register must be loaded with the desired address and bit 14 set in Control Register 1.

When powered up, the laser head takes a number of minutes to stabilize. The Status Register's Ref Present bit indicates when the system is ready to make a measurement. It will go high after the laser head stabilizes. The Reset Axis bit in the Command Register should be asserted at this point to clear any error generated during warm-up.

Making measurements with the board consists of accessing the appropriate registers to control interrupts, setting the offset position, sampling and reading the position and time, and setting the Clip and Window Masks. Each register is described in detail later in this chapter.

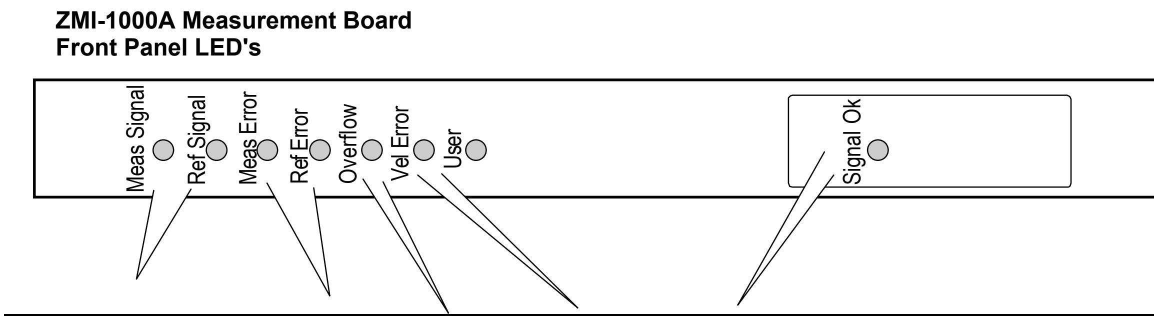
Figure 3-1 ZMI 1000A Measurement Board Block Diagram



Board LED’s

The Measurement Board front panel LED’s are described in Figure 3-2.

Figure 3-2 Board LED’s



Meas Signal	Ref Signal	Meas Error	Ref Error	Overflow	Vel Error	Signal Ok	Status
ON	ON	OFF	OFF	OFF	OFF	ON	Normal (with fiber optic detector).
ON	ON	OFF	OFF	OFF	OFF	OFF	Normal (with remote receiver).
X	OFF	X	X	X	X	X	Laser Head NOT stable.
X	OFF	X	ON	X	X	X	Reference signal NOT present.
X	ON	X	ON	X	X	X	Reference signal error.
OFF	X	ON	X	X	X	OFF	Measurement signal NOT present.
ON	X	ON	X	X	X	X	Measurement signal error; excessive acceleration.
ON	ON	OFF	OFF	X	ON	X	Excessive velocity.
ON	ON	OFF	OFF	ON	X	X	Position accumulator overflow.
OFF	ON	ON	OFF	X	X	OFF	Insufficient optical power.

VMEBUS Data Transfer Modes

The Measurement Board is compatible with the following VME data transfer modes:

- A16 or A24 addressing.
- D08(EO) or D16 or D32 data transfer.
- D08(O) interrupt acknowledge cycle (RORA).

The Measurement Board also has the following specialized P2 data transfer modes:

- Constant Data Rate (at 2, 4, or 8 MHz).
- Constant Data Delay.
- Controlled Data Rate.
  (similar to the ZYGO 2/20 Multiplexed servo interface).

The board accepts the following Address Modifier codes:

- $29 Short Non-Privileged Access.
- $2D Short Supervisory Access.
- $39 Standard Non-Privileged Access.
- $3D Standard Supervisory Access.

P1 Signals

The P1 connector and signals comply with the VMEbus specification, revision C.1. P1 can supply data as a VME read of 8-bits or 16-bits. For 32-bit VME data, the P2 connector, row B, must also be used. This arrangement also conforms to the aforementioned specification.

P2 Signals

Refer to Table 3-1 for a summary of the P2 signals. An asterisk (*) following a signal name indicates a true negative signal. P2 pin assignments are listed in Table 2-2. The signals listed below are described in greater detail over the next few pages.

Table 3-1 P2 Interface Signals

Signal Name	*Signal Type*		*Description*
P2 Position Data P0-P31	output	TTL	32-bit measurement data.
Error Out	output	TTL	Indicates an error has occurred.
Meas Signal Error (1)	output	TTL	Indicates a measurement phase locked loop loss of lock.
Window*	output	TTL	Indicates magnitude of data is less than window mask.
Output/Transfer Clock	output	TTL	Data clock for P2 interface modes.
Output/Transfer Clock*	output	TTL	Complementary data clock.
Velocity Error (1)	output	TTL	Indicates excess velocity.
Ref Signal Error (1)	output	TTL	Indicates a reference phase locked loop loss of lock.
Overflow Error (1)	output	TTL	Indicates position accumulator overflow.
Time Reset Out*	output	TTL	Indicates time data has been reset to zero.
64 MHz	output	ECL	Used for external synchronous timing.
64 MHz*	output	ECL	Used for external synchronous timing.
Output High to Low Enable*	input	TTL	Used in combination with Output Enable* for controlled mode.
Output Enable*	input	TTL	Enables output from the board.
Position Reset*	input	TTL	Resets position and time data to zero.
Time Reset*	input	TTL	Resets time data to zero.
Sample*	input	TTL	Initiates a sample of the data for controlled mode.
External Sample*	input	TTL	Initiates a data sample.
Position Hold*	input	TTL	Holds the current position data.
Select Address 2-0	input	TTL	Selects board for controlled mode.

(1) Reset of these signals depends on the position of JN14. When set to 1-2 these signals are reset at power-on and by a VME SYSRESET* signal; when set to 2-3 these signals are reset only at power-on.

P2 Position Data P0-P31

There are 32 output lines through which the contents of the position data register can be read. P31 is the most significant bit and P0 is the least. Data is output in 32-bits, 2's complement form.

Error Out

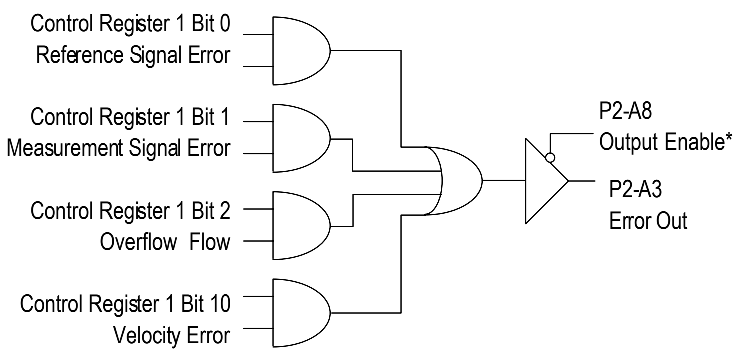
Error Out indicates an error has occurred. Error Out is a tri-state output signal enabled by the P2 Output Enable* signal and Control Register 1.

Error Out will go high for any of the following conditions, if the corresponding enable bit is set high in Control Register 1:

Reference Signal Error	Velocity Error
Measurement Signal Error	Overflow Error

Note: The reference signal error, measurement signal error, velocity error, and overflow error are output individually on the P2 connector. These outputs can be tri-state or always enabled; refer to Output Enable*. Errors are latched until reset by the Position Reset* signal.

The Error Out signal can drive up to eight LSTTL loads. An equivalent logic diagram for error indication is shown below.



Meas Signal Error

The Meas Signal Error output indicates the measurement signal is noisy, intermittent, or missing, or that the acceleration limit is exceeded. This output is latched until reset. Output can be reset by the Position Reset* signal, a system power-on, or the VME SYSRESET* signal (depends on the setting of JN14).

Window*

The Window* output signal is active low indicating that the magnitude of the P2 Position Data outputs are within the range specified by the Window Mask Register. This output can be tri-state or always enabled; refer to Output Enable*.

Output/Transfer Clock and Output/Transfer Clock*

The Output/Transfer Clock output signals are used to synchronize external hardware to the P2 interface. The high to low transition of the Output/Transfer Clock can be used to clock in the P2 position data on the user's hardware for all P2 interface modes using a 32-bit interface. The Output/Transfer Clock* is a complementary signal.

The Output/Transfer Clock and Output/Transfer Clock* signals can drive up to 10 LSTTL loads. These outputs can be tri-state or always enabled; refer to Output Enable*.

In the constant data rate mode and the constant data delay mode the duty cycle of the Output/Transfer Clock signal is 50%.

In the controlled data rate mode, using a 16-bit data interface, the Output/Transfer Clock* signal is used as a handshaking signal in conjunction with the Sample* signal. The high to low transition of this input signal indicates the Position Accumulator has been sampled.

Velocity Error

The Velocity Error output indicates that the velocity of the object being measured is higher than the system allows. This output is latched until reset. Output can be reset by the Position Reset* signal, a system power-on, or the VME SYSRESET* signal (depends on the setting of JN14).

Ref Signal Error

The Ref Signal Error output indicates the reference signal from the laser head is noisy, intermittent, or missing. This output is latched until reset. Output can be reset by the Position Reset* signal, a system power-on, or the VME SYSRESET* signal (depends on the setting of JN14).

Overflow Error

The Overflow Error output indicates that the position data accumulator has exceeded 2^{32}. This corresponds to a linear displacement greater than ± 5.2 meters with a plane mirror interferometer. This output is latched until reset. Output can be reset by the Position Reset* signal, a system power-on, or the VME SYSRESET* signal (depends on the setting of JN14).

Time Reset Out*

The Time Reset Out* signal is a TTL level output signal whose high-to-low transition indicates the instant at which the time accumulator has been reset to zero.

If the Time Reset Out* signal is to be used with external logic requiring the 64 MHz reference clock output, the Time Reset Out* signal should be re-synchronized with the 64 MHz clock.

The Time Reset Out* signal is generated by the following signals or functions:

Reset Axis command	Reset Position* signal (P2)
Reset Time command	Reset Time* signal (P2)

64 MHz and 64 MHz*

A 64 MHz internal reference signal is a jumper enabled output on P2 pins A1 and A2. This complementary ECL reference signal output can be useful in specialized applications using synchronous high speed logic.

Output Enable* and Output High to Low Enable*

The Output Enable* and Output High to Low Enable* signals are used to control the state of output as either enabled or high impedance. The Output High to Low Enable* is used only for the controlled data rate mode. In the controlled data rate mode, Output High to Low Enable* is used to multiplex the most significant 16 bits of the position data onto P15-P0. See the controlled data rate timing diagrams in the next major section.

Jumper JN4 on the Measurement Board controls the function of the Output High to Low Enable* and Output Enable* signals. The factory setting of jumper JN4 is 2-3. In this position, either one of the signals, Output High to Low Enable* or Output Enable*, activates the following outputs:

Position Data	Error Out
Meas Signal Error	Window*
Ref Signal Error	Output/Transfer Clock
Overflow Error	Output/Transfer Clock*
Velocity Error	Time Reset Out*

The truth table below summarizes the P2 output enable options when jumper JN4 is set to 2-3.

Table 3-2 Output Enable Options (JN4 set to 2-3)

P2 Mode(1)	*Output Enable**	*Output High to Low Enable**	*P2 Data Output*		*P2 Output*	
			P31-P16	*P15-P0*	*Error Out*	*Misc.*(2)
A, B	1	1	Z	Z	Z	Z
A, B	0	1	MSW	LSW	Enabled	Enabled
C	1	1	Z	Z	Z	Z
C	0	1	MSW	LSW	Enabled	Enabled
C	1	0	Z	MSW	Enabled	Enabled

(1) A = constant data rate mode, B = constant data delay mode, and C = controlled data rate mode.

(2) Miscellaneous refers to the following output signals: Meas Signal Error, Ref Signal Error, Overflow Error, Velocity Error, Window*, Output/Transfer Clock, Output/Transfer Clock*, and Time Reset Out*.

Z = high impedance.

MSW = most significant word (bits 31 to 16).

LSW = least significant word (bits 15 to 0).

JN4 is set to the 1-2 position for multiplexing the following signals of more than one Measurement Board onto one P2 data cable:

Meas Signal Error	Window*
Ref Signal Error	Output/Transfer Clock
Overflow Error	Output/Transfer Clock*
Velocity Error	Time Reset Out*

Note: The P2 Position Data and Error Out Signals can be multiplexed on one P2 data cable without setting JN4 to 1-2. The P2 Position Data and Error Out Signals are independent of JN4.

Position Reset*

The Position Reset* input signal resets (zeroes) the position and time data accumulators and also clears all errors on the Measurement Board. The reset function is synchronized to the next position update. It also presets the position accumulator with the contents of the Offset Register if the Preset Accumulator Enable bit is set in Control Register 1.

Use an open-collector driver to activate the Position Reset* signal.

For the controlled data rate mode, the Position Reset* signal is qualified by the Select Address inputs if the Disable Common Reset bit in Control Register 3 is set high.

Time Reset*

The Time Reset* input signal zeroes the time data accumulator. The reset function is synchronized to the next position update. Time Reset Out* identifies the instant at which the accumulator equals zero.

Use an open-collector driver to activate the Time Reset* signal.

Sample*

The Sample* signal only applies to the controlled data rate mode. The high to low transition of the Sample* input signal initiates the transfer of the contents of the position accumulator into the P2 data register if the controlled data rate mode is enabled in Control Register 2.

External Sample*

The External Sample* input signal is a VME function not related to the P2 interface. See page 3-36.

Position Hold*

The Position Hold input signal prevents position updating of the P2 Position Register after the next position update.

Select Address 2-0

These input signals only apply to the controlled data rate transfer mode. They are used for multiplexing more than one board on the same P2 data cable. The combination of TTL signals input on these lines determine what board is addressed. The address and high/low input signals are shown below. SA refers to select address, L refers to low, and H refers to high.

Address	*SA2*	*SA1*	*SA0*
0	L	L	L
1	L	L	H
2	L	H	L
3	L	H	H
4	H	L	L
5	H	L	H
6	H	H	L
7	H	H	H

If either Disable Common Sample or Disable Common Reset bits in Control Register 3 are set high, the Select Address further qualifies the Sample* or Reset* signals.

P2 Output Enable Options

The table that appears on the following page is a detailed listing of the effect of the Output Enable* and Output High to Low Enable* signals on the output signals in each of the three P2 transfer modes. The state of the output signals is determined by the interaction of jumper JN4 settings, P2 input signals, and Control Register 2.

Table 3-3 P2 Output Enable Options

P2 Mode	P1 SYSRESET* Input (1)	Output Enable* Input	Output High to Low Enable* Input	Select Address SA2, SA1, SA0 Input	Control Register 2 Bits 6-4 (Select Address)	Jumper JN4 Position	Position Output P31-P16	Position Output P15-P0	Error Out*	Output/Transfer Clock Output/Transfer Clock* Meas Signal Error Ref Signal Error Velocity Error Overflow Error Time Reset Out* Window*
A,B,C	0	X	X	X	X	2-3	Z	Z	Z	Enabled
A,B,C	0	X	X	X	X	1-2	Z	Z	Z	Z
A,B	1	1	1	X	X	2-3	Z	Z	Z	Enabled
A,B	1	1	1	X	X	1-2	Z	Z	Z	Z
A,B	1	0	1	X	X	-	MSW	LSW	Enabled	Enabled
C	1	1	1	X	X	2-3	Z	Z	Z	Enabled
C	1	1	1	X	X	1-2	Z	Z	Z	Z
C	1	X	X	SA≠CR	CR≠SA	2-3	Z	Z	Z	Enabled
C	1	X	X	SA≠CR	CR≠SA	1-2	Z	Z	Z	Z
C	1	0	1	SA=CR	CR=SA	-	MSW	LSW	Enabled	Enabled
C	1	1	0	SA=CR	CR=SA	-	Z	MSW	Enabled	Enabled
C	1	0	0	SA=CR	CR=SA	2-3	Z	Z	Z	Enabled
C	1	0	0	SA=CR	CR=SA	1-2	Z	Z	Z	Z

Key:

(1) The reset is determined by JN14. Outputs are reset by a power-on and by the VME SYSRESET* signal if pins 1-2 are jumpered.

A = constant data rate, B = constant data delay, C = controlled data rate.

X = 0 or 1, 0 = (low) voltage level £ 0.6 volts, 1 = (high) voltage level ³ 2.0 volts.

SA = Select Address inputs, CR = Control Register 2 select address bits.

Z = high impedance, MSW = most significant word (bits 31 to 16), LSW = least significant word (bits 15 to 0).

P2 Timing Diagrams

Timing specifications for the three P2 interface transfer modes are located as follows:

Transfer Mode	*Figure Reference*	*Table Reference*
Constant Data Rate	3-3	3-4
Constant Data Delay	3-4	3-5
Controlled Data Rate, 16 bit multiplexed	3-5	3-6
Controlled Data Rate, 32 bit	3-6	3-6

For each mode, reference numbers on the diagrams refer to the information in the applicable timing table. All timing specifications are in nanoseconds (ns).

Constant Data Rate Timing

This interface provides direct access to measurement data without use of the VME bus. It has a default data rate of 2 MHz. The data rate is selected for values of 2, 4, and 8 MHz with Control Register 2.

Figure 3-3 Constant Data Rate Timing Diagram

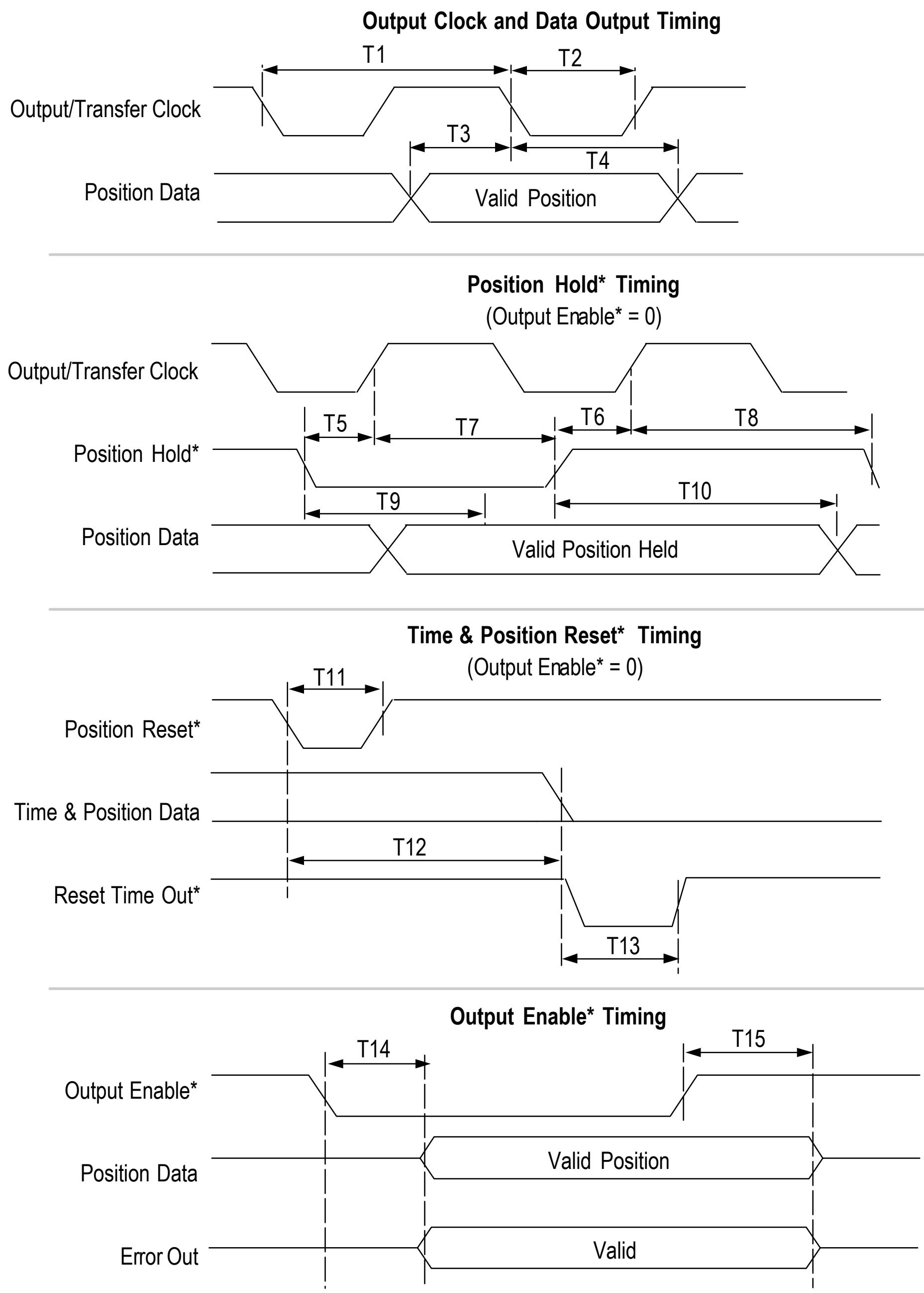


Table 3-4 Constant Data Rate Timing

Ref	*Description*		*Timing in ns for update rate…* 2 MHz	4 MHz	8 MHz
T1	Position Clock Period	Typ(1)	500	250	125
T2	Position Clock Low	Typ	250	125	62.5
T3	Data Valid to Clock ↓	Min	200	100	40
T4	Clock ↓ to Data Invalid	Min	200	90	35
T5	Position Hold* True Setup Time to Clock ↑	Min	100	-	-
T6	Position Hold* False Setup Time to Clock ↑	Min	100	-	-
T7	Clock ↑ to Position Hold* True Hold Time	Min	0	-	-
T8	Clock ↑ to Position Hold* False Hold Time	Min	0	-	-
T9	Position Hold* True to Position Held	Min	200	-	-
T10	Position Hold* False to Position Register Update	Min/ Max	300/ 750	175/ 375	-
T11	Position Reset* Pulse Width	Min	150	150	150
T12A	Position Reset* True to Accumulator Data = 0 (@ velocity = 0)	Max	250	250	250
T12B	Position Reset* True to Position Data = 0	Max	750	750	750
T13	Reset Time Out* Pulse Width	Typ	90	90	90
T14	Out Enable* True to Data Enabled	Max	200	200	200
T15	Out Enable* False to High Z Out	Max	200	200	200

(1) The clock is derived from a crystal oscillator.

Constant Data Delay Timing

This interface provides direct access to measurement data without use of the VME bus (except for initialization). The data rate is variable, dependent on axis velocity.

Figure 3-4 Constant Data Delay Timing Diagram

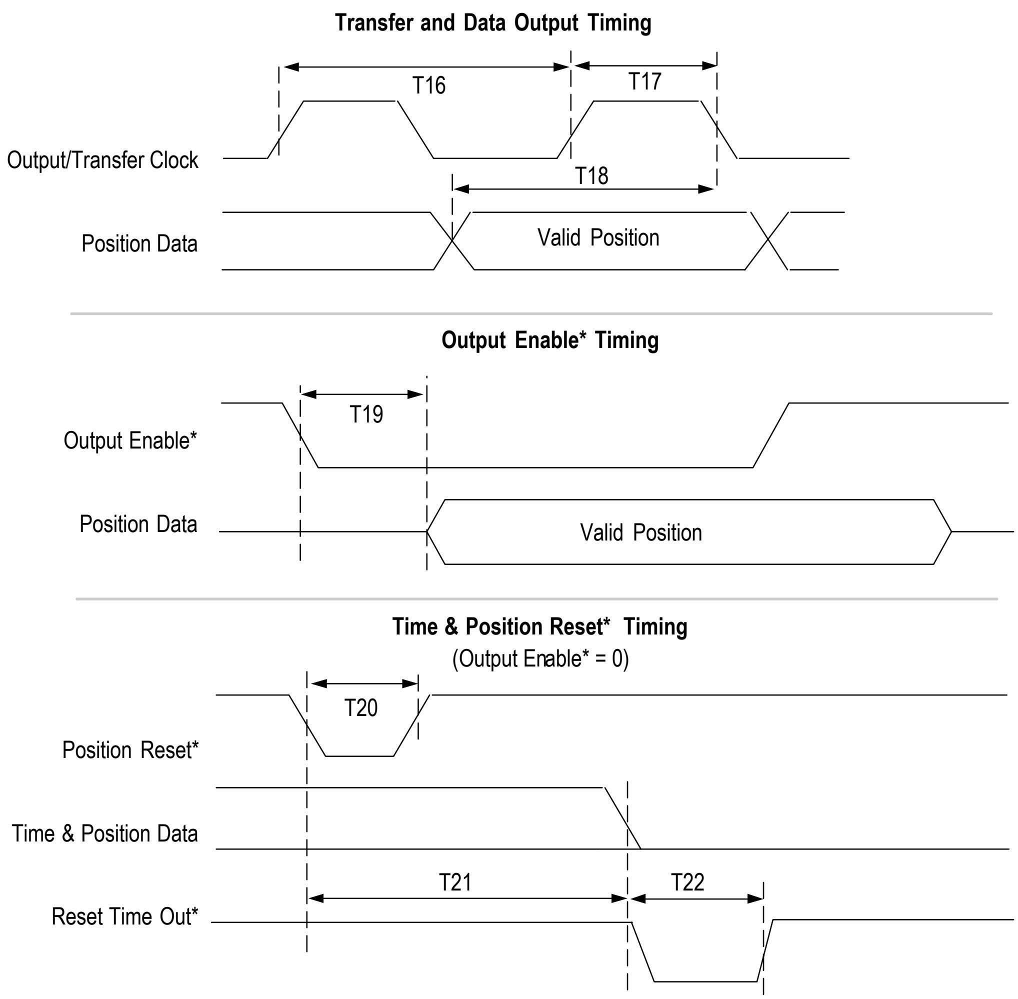


Table 3-5 Constant Data Delay Timing

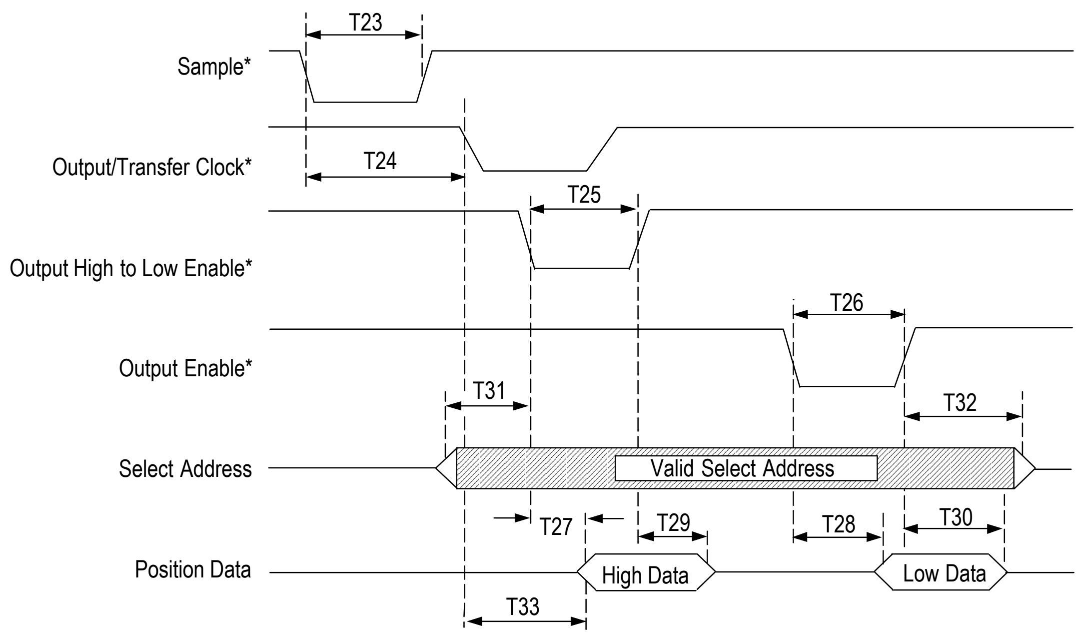
Ref	*Description*	*Timing in ns* *Min*	*Typ*	*Max*
T16	Out Transfer Period (1)	130	-	1910
T17	Out Transfer High	90	-	-
T18	Data Valid to Output/Transfer ↓	50	-	-
T19	Out Enable* True to Data Enabled		-	200
T20	Position Reset* Pulse Width	150	-	-
T21A	Position Reset* True to Accumulator Data = 0 (@ velocity =0)	-	-	250
T21B	Position Reset* True to Position Data = 0 (@ velocity = 0)	-	-	500
T22	Reset Time Out* Pulse Width	-	90	-

(1) Function of velocity, see P2 interface description, page 1-9.

Controlled Data Rate Timing - 16 Bit Multiplexed

This interface provides direct access to measurement data without use of the VME bus (except for initialization) and is ZYGO 2/20 compatible. Use of the ZC transition board changes timing parameters T27, T28, T29, and T30. See Table 3-6.

Figure 3-5 Controlled Data Rate Timing Diagram (common sample)



The following signal descriptions apply only to the controlled data rate mode:

Sample* A high to low transition on this input signal initiates sampling the position accumulator.

Output/Transfer Clock* A high to low transition on this output signal indicates the time when the position accumulator is sampled.

Output High to Low Enable* This input signal enables position data bits 31 to 16 onto P2 connector pins P15 to P0.

Output Enable* This input signal enables position data bits 15 to 0 on to P2 connector signals P15 to P0.

Position Data The 32-bit Position Register is output as two 16-bit words (MSB and LSB). The data can be read at a rate up to 2 MHz.

Table 3-6 Controlled Data Rate Timing

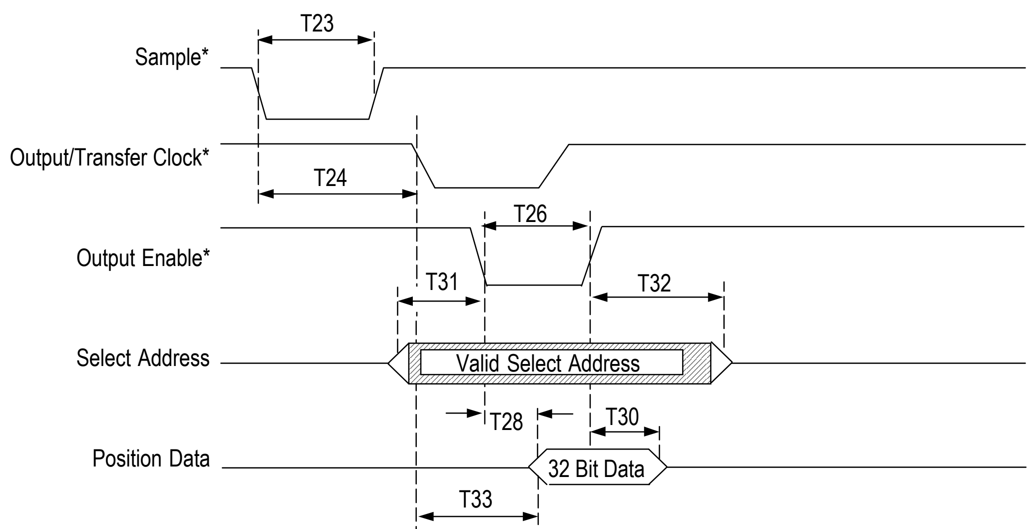
Ref	*Description*	*Timing in ns* *Min*	*Typ*	*Max*	*ZC Max*
T23	Sample* Pulse Width	150			
T24	Sample* True to Data Sampled	120		2000	
T25	Out High to Low Enable* Pulse Width	200			
T26	Out Enable* Pulse Width	200			
T27	Out High to Low Enable* to Data Enabled			150	175
T28	Out Enable* to Data Enabled			150	175
T29	Out High to Low Enable* to Data Disabled			150	175
T30	Out Enable* to Data Disabled			150	175
T31	Select Address Setup Time	150			
T32	Select Address Hold Time	50			
T33	Transfer Clock* low to Data Valid				

(1) Maximum timing when using the ZC transition board (8020-0301-01) with the Measurement Board.

Controlled Data Rate Timing - 32 Bit

Position data bits 31 to 16 are provided on the P2 connector signals P31 to P16 for interface applications requiring 32-bits simultaneously.

Figure 3-6 Controlled Data Rate Timing Diagram

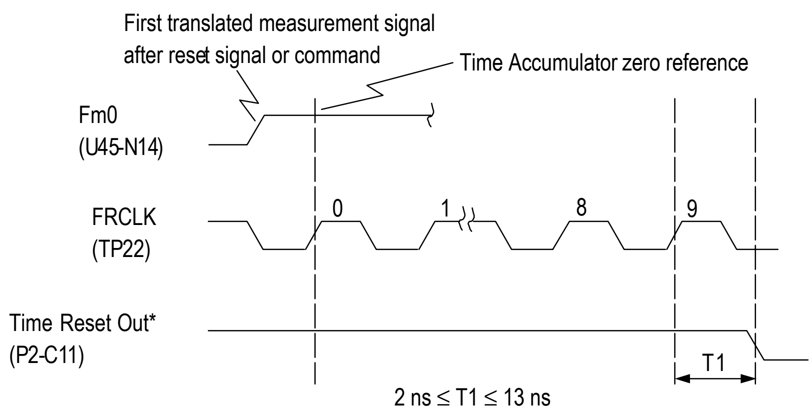


Time Reset Out* Timing

Time Reset Out* is provided so that user-supplied counters can be preset consistent with the Time Accumulator on the Measurement Board. The timing diagram below shows the relationship between the FRCLK edge that defines the Time Accumulator reset and the Time Reset Out* signal.

The purpose of the Time Accumulator is to record the elapsed time between axis reset and subsequent position measurements. Time Accumulator reset and subsequent updates occur on rising edges of the synchronized translated measurement signal, Fm0. Fm0 is synchronized to FRCLK inside U45.

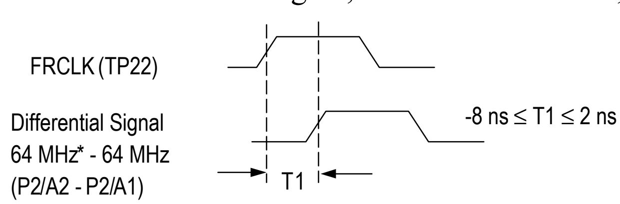
Time Reset Out* Timing



For example - assuming equal signal delays and zero clock skew between FRCLK and the user clock signal (derived from the Measurement Board 64 MHz and 64 MHz* output signals) the correct preset value for the user-supplied counter is 10.

64 MHz and 64 MHz* Clock Skew

64 MHz (P2-A1) and 64 MHz* (P2-A2) are time base output signals on the P2 connector. They are derived from the same signal as FRCLK, the time base used by the Measurement Board for position and time measurements. The diagram below shows the worst case skew between the differential signal, 64 MHz* - 64 MHz, and FRCLK.



Address Map

The address map for the Measurement Board registers is shown in the table below. The offset addresses, shown in hexadecimal, are relative to the base address selected by the user. The exact address for these registers is determined by adding the base address (A16 or A24) to the register location.

Base address is selected using two 4-bit rotary switches for the A16 mode and the A24 Base Address Register for the A24 mode. See Base Address Selection in Chapter 2.

Table 3-7 Register Address

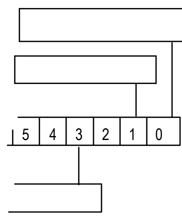
Offset	*Read Register*	*Write Register*	*Comments*
1E	Window Mask Reg.	-	
1C	Clip Mask Register	-	
1A	Status Register 3	Control Register 3	
18	Status Register 2	Control Register 2	
16	Offset Register Low	-	Offset data is a 2's complement number which is subtracted from P2 position data.
14	Offset Register High	-	See above comment.
12	Time Low	-	Timing data is a 32-bit positive number (1 bit @ 15.625 ns).
10	Time High	-	See above comment.
0E	Sampled Position Low	Window Mask Register	Position data is a 2's complement number. Reading location C causes sample to be taken (1 bit @ 1.25 nm).
0C	Sampled Position High	Clip Mask Register	See above comment.
0A	Position Low	Offset Register Low	Position updated by Sample Command or External Sample. Reading Position High clears External Sample Flag.
08	Position High	Offset Register High	See above comment.
06	Interrupt Vector	Interrupt Vector	Only offset location 7 has valid data.
04	Command Register	Command Register	
02	A24 Base Register	A24 Base Register	
00	Status Register 1	Control Register 1	

Registers

Each register is described in greater detail in the sections that follow. In each case, information is presented in the following format:

Status Register 1 is read only. The functionof each bit in the register is given in the table below. All errors are reset by Reset Axis command, Reset Errors command, P2 Position Reset* signal and VME SYSRESET* signal.

Written overview of the register's function.



Drawing showing the function of each bit in the register.

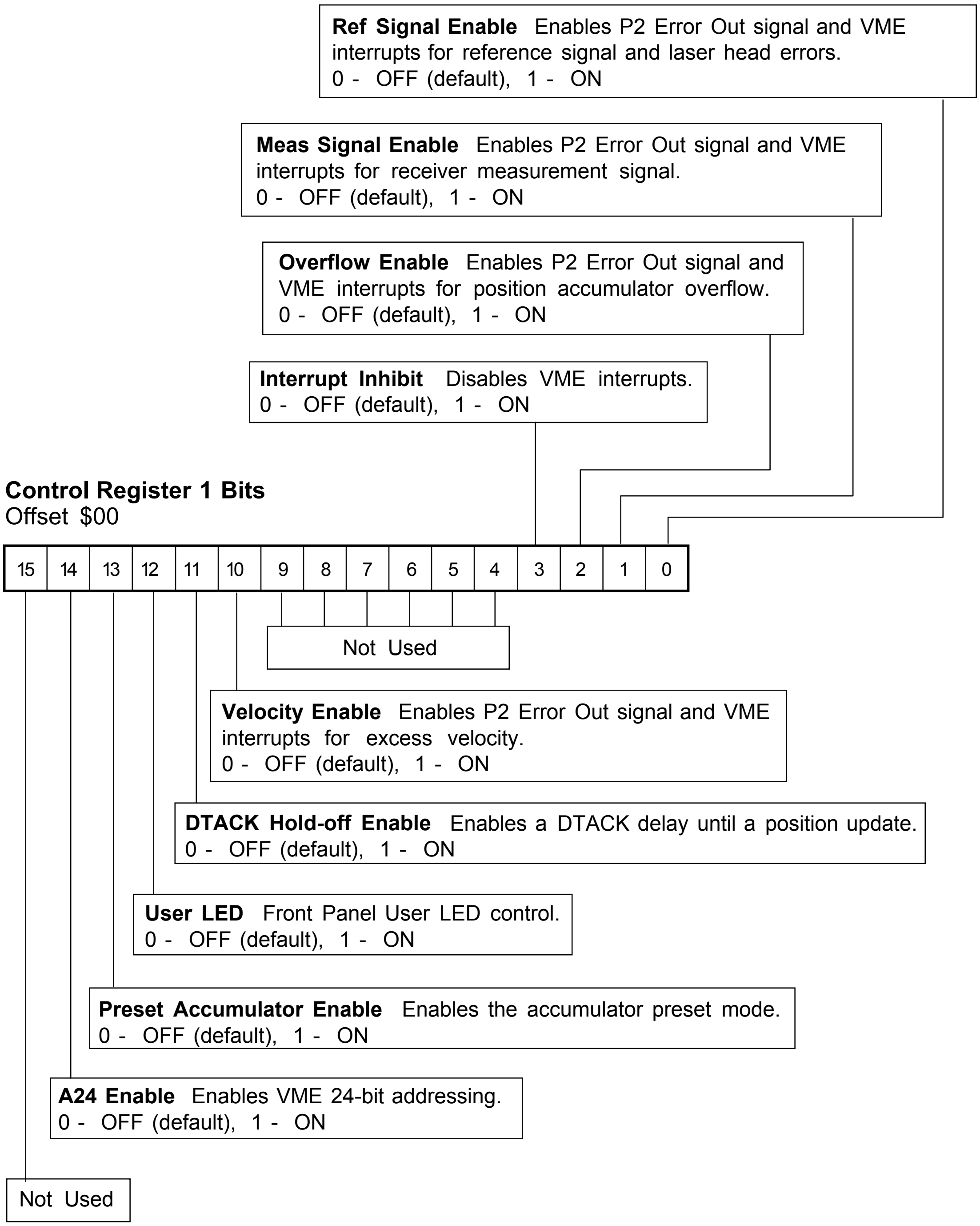
User LED
This bit is a copy of the User LED bit in control register 1.

DTACK Hold-off Enable
This bit is a copy of the DTACK Hold-off Enable bit in control register 1.

If necessary, additional information pertaining to a specific bit.

Control Register 1

The Control Register 1 is write only; it is used for control functions. The function of each bit is given in the following drawing. The register offset location is 00 hex. All bits are cleared at power-on and by the VME SYSRESET* signal if JN14 is set to pins 1-2.



Preset Accumulator Enable, bit 13 This bit enables the position accumulator to be preset with the contents of the Offset Register during a Reset Axis command or when Position Reset* goes low.

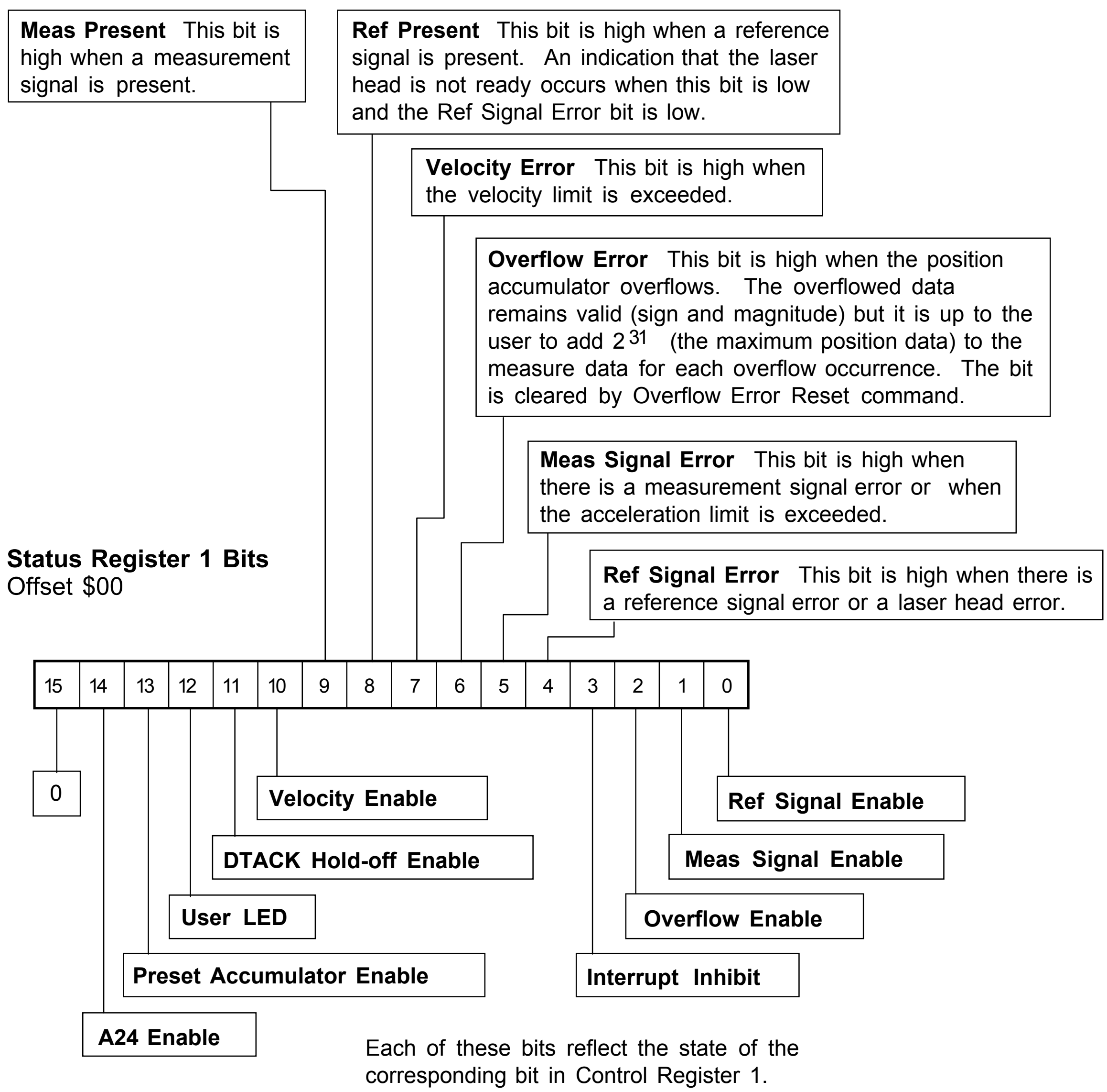
User LED, bit 12 This bit controls the user LED on the front panel. When it is high the LED will be on.

DTACK Hold-off Enable, bit 11 This bit causes DTACK* hold-off for a sampled position data read access until after a position update occurs. This data transfer mode reduces measurement delay uncertainty for VME position read operations. The DTACK* signal is generated to indicate that valid position data is available on the VME data bus.

Interrupt Inhibit, bit 3 This bit controls VME interrupts. When Interrupt Inhibit is cleared, an error condition will cause a VME interrupt if the corresponding Enable Bit is high.

Status Register 1

Status Register 1 is read only; it is used to determine the status of the Measurement Board. The register offset location is 00 hex. The function of each bit in the register is given in the following drawing; many of the bits reflect the state of bits in Control Register 1. All errors are reset by the Reset Axis command, the Reset Errors command, the P2 Position Reset* signal, at power-on, and by the VME SYSRESET* signal if JN14 is set to pins 1-2.



Control Register 2

Control Register 2 is write only; it is used for control functions.. The register offset location is 18 hex. The function of each bit is given in the following drawing. All bits are cleared at power-on and by the VME SYSRESET* signal if JN14 is set to pins 1-2.

Constant Data Rate Select 1-0 These two bits correspond to the clock frequency used for the P2 Constant Data Rate interface.

Output Clock MHz	Bit 1	Bit 0
2 default	0	0
4	0	1
8	1	x

P2 Interface Select 1-0 Selects the P2 interface transfer mode.

Interface	Bit 3	Bit 2
Constant Data Rate	0	0
Fixed Data Delay	0	1
Controlled Data Rate	1	x

Control Register 2 Bits
Offset $18

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Not Used (bits 15-11)

Select Address 2-0 These three bits correspond to the board address when using the P2 Controlled Data Rate mode. These bits are compared with P2 Select Address 2-0 signals.

Address	Bit 6	Bit 5	Bit 4
0	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5	1	0	1
6	1	1	0
7	1	1	1

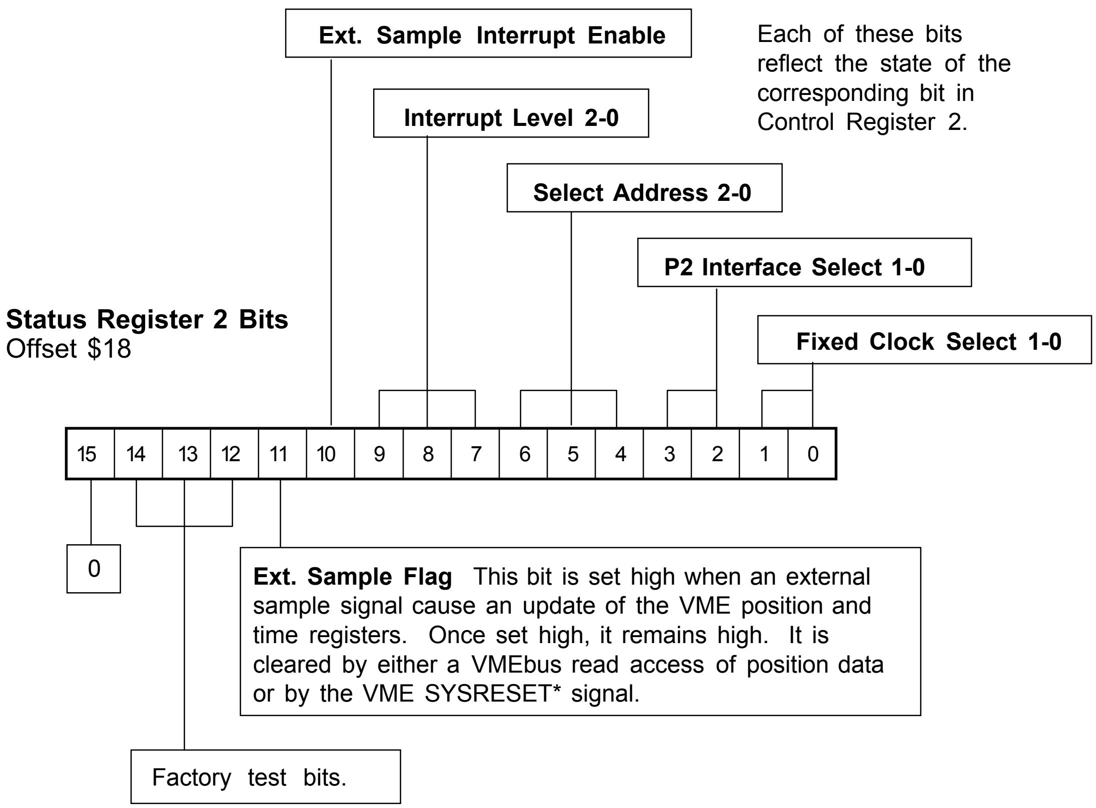
Interrupt Level 2-0 These three bits correspond to the interrupt signal which is generated when interrupts are enabled. See Chapter 2 - Interrupt Selection.

IRQ	Bit 9	Bit 8	Bit 7
off	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5	1	0	1
6	1	1	0
7	1	1	1

Ext. Sample Interrupt Enable Enables VME interrupts for external sample signal falling edge transitions.
0 - OFF (default), 1 - ON

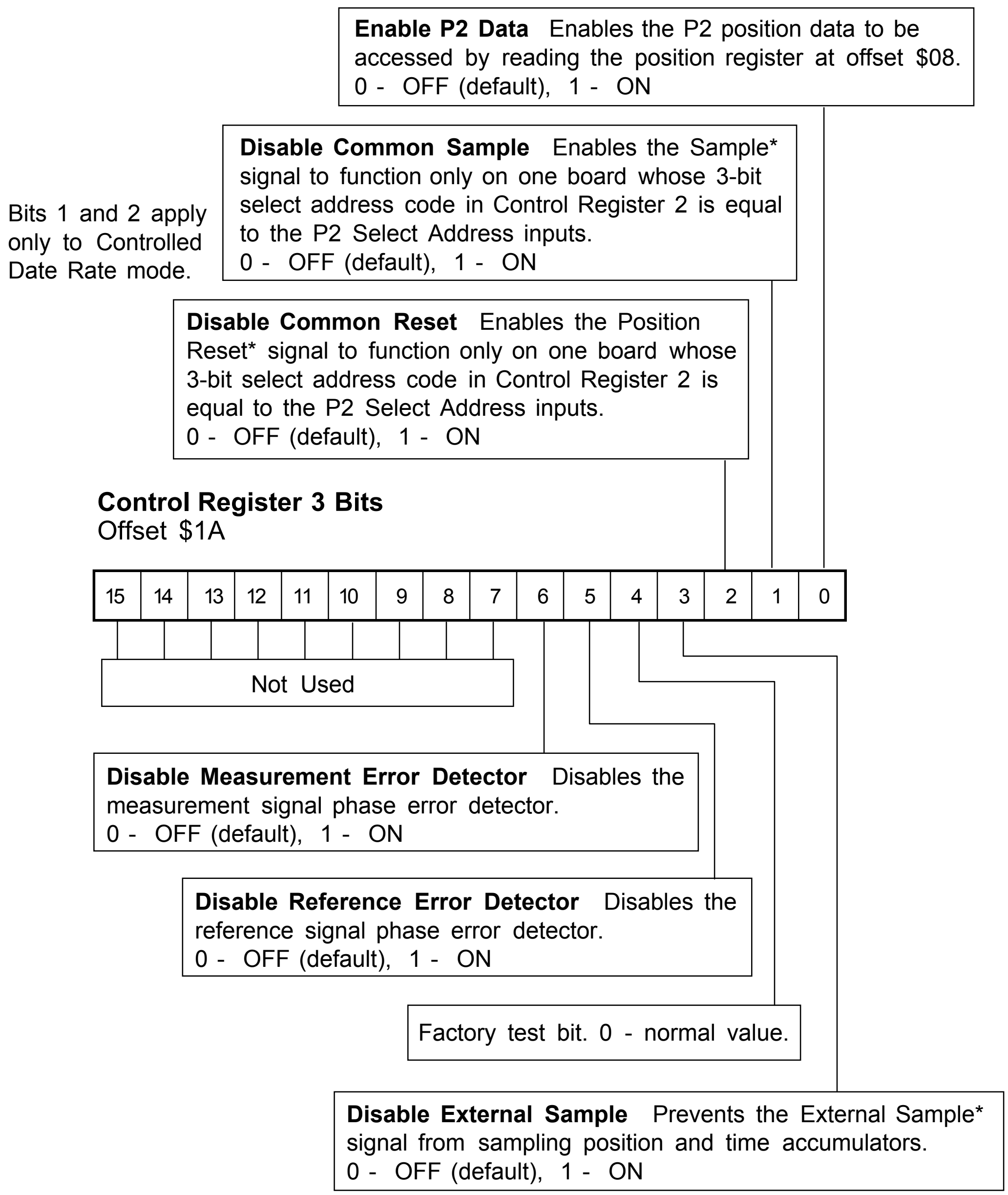
Status Register 2

Status Register 2 is read only. The register offset location is 18 hex. The function of each bit in the register is given in the following drawing; many of the bits reflect the state of bits in Control Register 2. All errors are reset by the Reset Axis command, the Reset Errors command, the P2 Position Reset* signal, at power-on, and by the VME SYSRESET* signal if JN14 is set to pins 1-2.



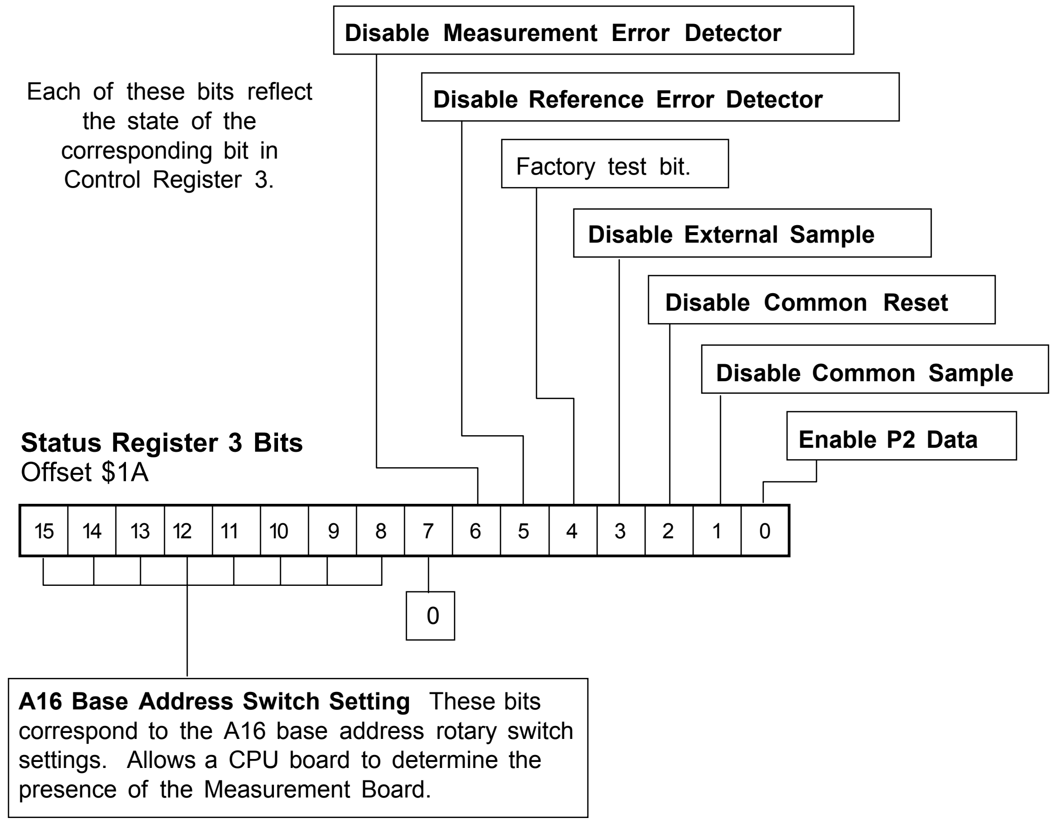
Control Register 3

Control Register 3 is write only; it is used for control functions.. The register offset location is 1A hex. The function of each bit is given in the table below. All bits are cleared at power-on and by the VME SYSRESET* signal if JN14 is set to pins 1-2.



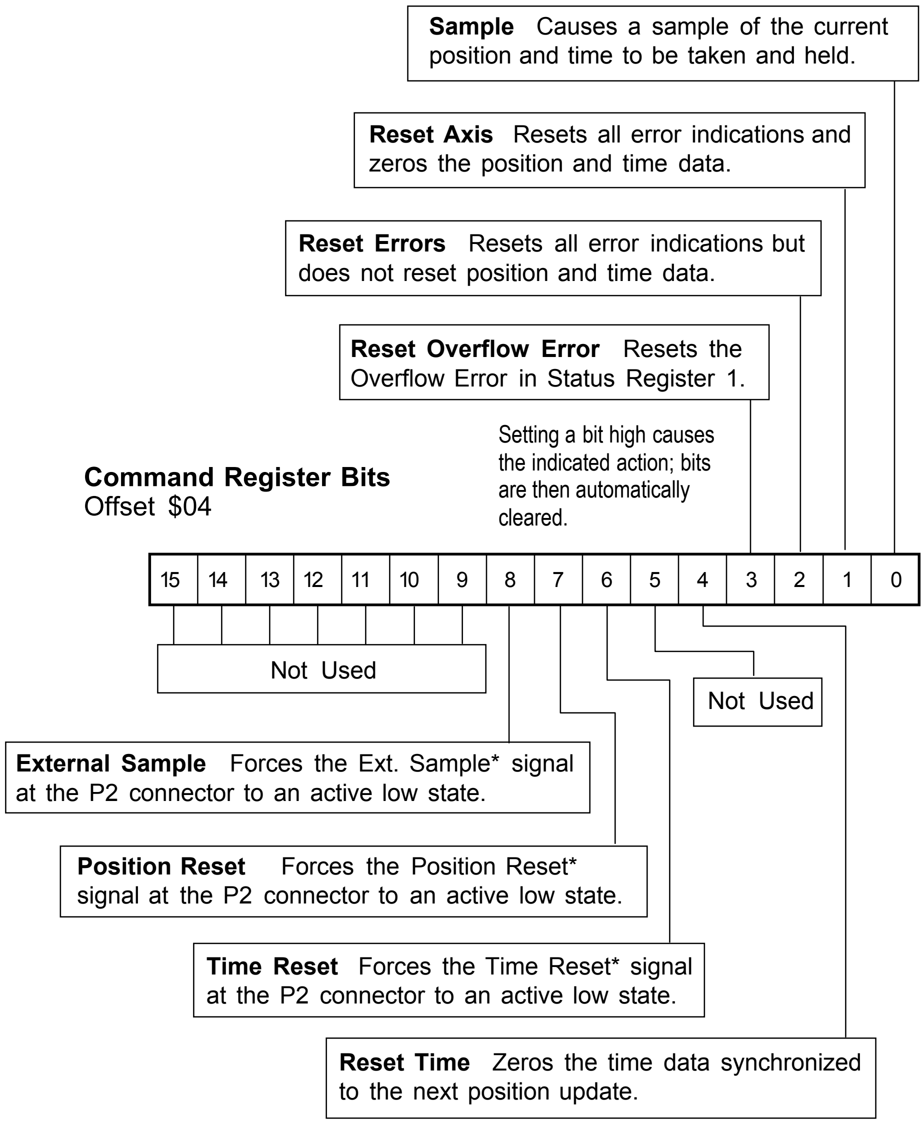
Status Register 3

Status Register 3 is read only. The register offset location is 1A hex. The function of each bit in the register is given in the following drawing; many of the bits reflect the state of bits in Control Register 3.



Command Register

The Command Register is a read/write register; it is used for general system operation. Setting a command bit high causes the indicated action. The bits are cleared (re-enabled) after the indicated action is taken by the board. The register offset location is 04 hex.



Reset Axis, bit 1 This command resets all error indications and zeroes the position data and the time data. It also presets the position accumulator with the contents of the Offset Register if the Preset Accumulator Enable bit is set.

> **Note:** Bits 6, 7, or 8 activate an open collector driver which forces P2 connector pins A30, A7, or C7, respectively, active low. For proper operation, all external devices connected to these pins must be open collector.

Time Reset, bit 6 This command forces the Time Reset* signal at the P2 connector to the active low state for approximately 500 nanoseconds.

Position Reset, bit 7 This command forces the Position Reset* signal at the P2 connector to the active low state for approximately 500 nanoseconds.

External Sample, bit 8 This command forces the External Sample* signal at the P2 connector to the active low state for approximately 500 nanoseconds.

A24 Base Register

The A24 Base Register is a read/write register; it contains the base address for VME A24 mode accesses. The contents of this register can only be changed during an A16 Mode access. The register offset location is 02 hex.

Interrupt Vector Register

The Interrupt Vector Register is a read/write register which is loaded with an 8-bit value that is read during an interrupt acknowledge cycle. Note that since it is an 8-bit register and data cycles are D16 or D32, that the upper eight bits of data during a data read cycle are invalid. The register offset location is 06 hex.

Position Register

The Position Register is a 32-bit read only register containing a 32-bit signed position value. The contents of this register are updated by the External Sample* signal or by Command Register bit 0. The Position Register offset location is 08 hex.

The position value is in uncompensated lambda units.

Sampled Position Register

The Sampled Position Register is identical to the Position Register except that an internal sample operation is performed before the position data is read. If DTACK Hold-off is enabled, the internal sample operation will be synchronized to the next position update. The Sampled Position Register offset location is 0C hex.

> **Note:** Any read access which includes byte offset location 0C hex will cause an internal sample to be taken.

Offset Register

The Offset Register is a read/write register (different addresses) whose value is subtracted from the contents of the position accumulator to obtain the 32-bit position data for the various P2 interfaces.

If the Preset Accumulator Enable bit is set in Control Register 1, the Offset Registers' contents will be preset into the position accumulator during a Reset Axis command or if an active Position Reset* signal is detected.

The Offset Register offset location for a write operation is 08 hex and the offset location for a read operation is 14 hex.

Time Register

The Time Register is read only. It contains the time at which the position sample was taken, 1 LSB equals 15.625 nanoseconds. The Time Register offset location is 10 hex.

Clip Mask Register

The Clip Mask Register is a read/write register (different addresses) whose value is used to clip the magnitude of the P2 position data bits to a power of two. This is useful when connecting the P2 position data bits to a digital-to-analog converter (DAC). The following table shows the clip mask value which matches the P2 outs to the number of DAC in bits. Bit 0 of the Clip Mask Register enables the clipping function when set to 1 and disables the function when set to 0.

Clip Mask Register (HEX value)	*Use Bit 31 plus the following P2 data bits*
$0001	0 through 7
$0003	0 through 8
$0007	0 through 9
$000F	0 through 10
$001F	0 through 11
$003F	0 through 12
$007F	0 through 13
$00FF	0 through 14
$01FF	0 through 15
$03FF	0 through 16
$07FF	0 through 17
$0FFF	0 through 18
$1FFF	0 through 19

When clipping is enabled, the specified P2 position data bits will become one (1) for positive numbers and will become zero (0) for negative numbers when the magnitude of the P2 position data bits exceeds the maximum value that can be represented by that number of bits.

The register offset location for a write operation is 0C hex and the offset location for a read operation is 1C hex.

Window Mask Register

The Window Mask Register is a read/write register (different addresses) whose value is used to determine the magnitude of the P2 Position Data that will cause the Window* out to be active. The following table shows the window mask value and the corresponding out values that will cause an active Window* signal.

The register offset location for a write operation is 0E hex and the offset location for a read operation is 1E hex.

Window Mask Register (HEX value)		*Window* Out Low When ...*
0	($0000)	-2 < Out Value < 1
1	($0001)	-3 < Out Value < 2
3	($0003)	-5 < Out Value < 4
7	($0007)	-9 < Out Value < 8
15	($000F)	-17 < Out Value < 16
31	($001F)	-33 < Out Value < 32
63	($003F)	-65 < Out Value < 64
127	($007F)	-129 < Out Value < 128
255	($00FF)	-257 < Out Value < 256
511	($01FF)	-513 < Out Value < 512
1023	($03FF)	-1025 < Out Value < 1024
2047	($07FF)	-2049 < Out Value < 2048
4095	($0FFF)	-4097 < Out Value < 4096
8191	($1FFF)	-8193 < Out Value < 8192
16383	($3FFF)	-16385 < Out Value < 16384
32767	($7FFF)	-32769 < Out Value < 32768
65535	($FFFF)	-65537 < Out Value < 65536

VME Functions

Interrupt Cycle Operation

The Measurement Board can generate interrupts to a VME CPU board in the event of measurement errors and the occurrence of an external sample signal. All causes of interrupts have individual interrupt enable bits in the Control Registers 1 and 2, individual interrupt status bits in the Status Registers 1 and 2 and various resetting functions in the Command Register which removes the cause of the interrupt. There is also an overriding Interrupt Inhibit bit in Control Register 1.

As an example, suppose interrupts are enabled for a position accumulator overflow. When an overflow occurs an interrupt is generated. The Overflow Error bit in Status Register 1 is set high. The interrupt signal will remain active until the overflow condition is reset. For this example, there are three commands which will reset the overflow error:

1. Reset Overflow Error
2. Reset Errors
3. Reset Axis

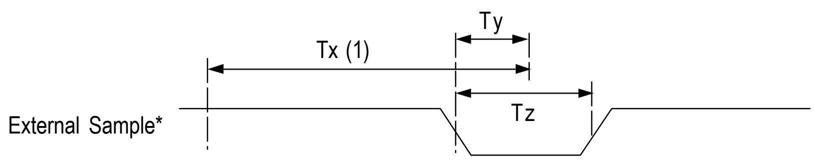
Note: Clearing the overflow enable bit removes the interrupt but not the cause of the interrupt. Re-setting the overflow enable bit to a high will regenerate the interrupt if one of the above three reset commands is not issued first.

External Sample*

This signal causes a sample to be taken and held. The External Sample Flag bit in Status Register 2 is set high by the sample operation. If the External Sample Enable bit is set in Control Register 2, an interrupt will be generated to indicate that an external sample operation has occurred. Until the Position Register is read, subsequent External Sample* signal high to low transitions will be ignored. The sample data is accessed by a VME Data Transfer Bus read cycle of the Position Register (offset location 08 hex) for the axis. The timing uncertainty (timing window) of the sample is from 0 to 2 microseconds. The sample operation does not affect the P2 position data.

The timing for an External Sample* signal is shown below.

External Sample* Timing



(1) Position update occurred within this timing window.

Ref	Description	Min	Typ	Max
		Timing in ns		
Ty	Sample Time Delay	-	-	135
Tz	External Sample* Pulse Width	150	-	-
Tx	Data Age at Time of Sample (1)	0	-	2400

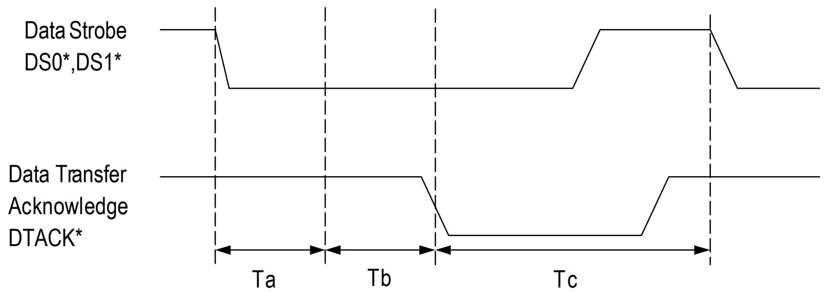
(1) Includes all delays in the interferometer system.

Note: When using D08(EO) or D16 VMEbus data transfer cycles and the External Sample* signal, momentarily disable External Sample* by setting bit 3 to 1 in Control Register 3 before reading the Position Register. Clear Control Register 3, bit 0, after reading all 32 Position Register bits to re-enable the External Sample* signal. Momentarily disabling the External Sample* signal is not necessary when using D32 VMEbus data transfer cycles.

DTACK Hold-off Function

Position data can be sampled by reading the Sampled Position Register through a VMEbus read access. A sample operation is defined as the transfer of position data from the position accumulator to the VME Position Register. The figure below shows a read of the Sampled Position Register. A read access is initiated by a high to low transition of the VMEbus data strobe. The position data is valid on the VMEbus when data transfer acknowledge makes a high to low transition.

Sample Operation Timing



With the DTACK hold-off function disabled, the three timing parameters shown in the diagram are fixed; but the accumulator sample operation has no fixed timing relationship to the position data output on the VMEbus. With the DTACK hold-off function enabled, two timing parameters are fixed and one is variable; but the accumulator sample operation has a fixed timing relationship to the position data output on the VMEbus. The advantage of the DTACK Hold-off function is low data delay time uncertainty (16 nanoseconds). The disadvantage of the DTACK Hold-off function is the position data rate is decreased.

The following table specifies the three timing parameters for the DTACK Hold-off function enabled and the function disabled. Velocity (V) is in mm/sec.

Interferometer Type	*Function*	*Data Strobe: to Sample Taken (Ta) max*	*Sample Taken to DTACK* : (Tb) max*	*DTACK* to next Data Strobe: (Tc) min*
N/A	Disabled	200 ns	90 ns	30 ns
double pass	Enabled	120 + {1/[4 MHz + (6.32 x 10^3 * V)]}	90 ns	30 ns
single pass	Enabled	120 + {1/[4 MHz + (3.16 x 10^3 * V)]}	90 ns	30 ns

Theory of Operation

Chapter

4

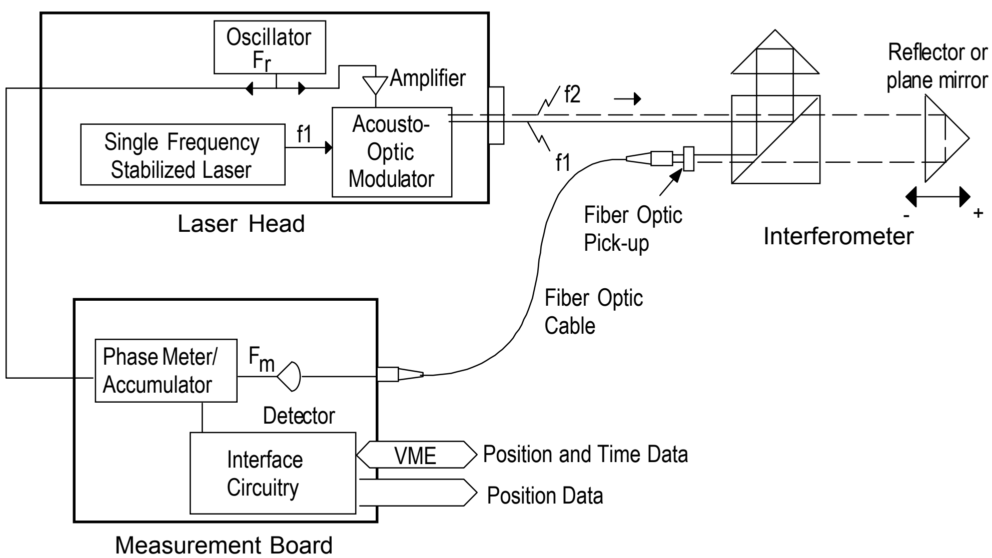
In This Chapter

- System Operation
- Measurement Board Operation

System Operation

A typical single axis ZMI system is shown in Figure 4-1. The main components are: a Laser Head, an interferometer, and a ZMI 1000A Measurement Board.

Figure 4-1 ZMI System Block Diagram



The Laser Head consists of stabilized laser, an acousto-optic modulator and a 20 MHz oscillator. The Laser Head provides a beam with two orthogonal linear polarizations having different frequencies. One frequency, f1, is vertically polarized and is 20 MHz higher in frequency than f2. The second frequency, f2, is horizontally polarized. Also, the Laser Head provides an electrical reference signal (f_r), equal to the difference f1 - f2.

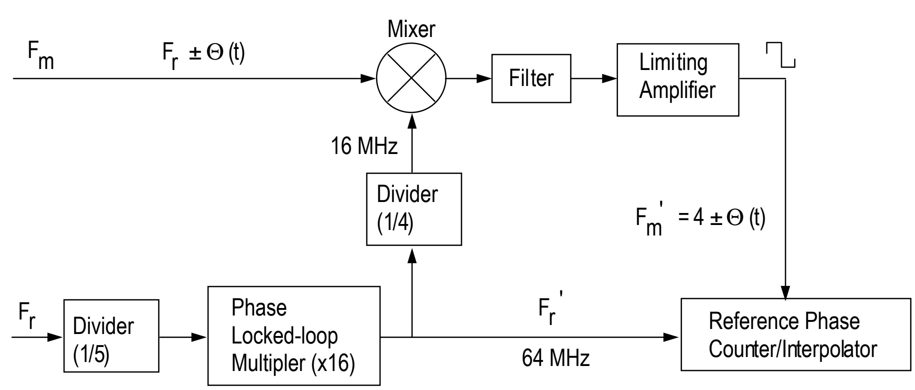
The interferometer can be a single-pass, double-pass, or four-pass design. (Resolution requirements determine which interferometer configuration to use.) A single pass interferometer consists of a polarizing beamsplitter and two reflectors. The polarizing beamsplitter divides the laser beam into its two frequency components and directs one component to a stationary reflector and the other to a moving reflector. Optical path changes in the interferometer phase modulate the difference frequency f1 - f2. The optical measurement signal is directed to the Measurement Board by a fiber optic cable.

At the ZMI 1000A Measurement Board, a photoelectric detector converts the optical signal into an electrical measurement signal (F_m). The phase meter/ accumulator measures and accumulates phase changes between the electrical reference signal, F_r, and the electrical measurement signal, F_m. The accumulator indicates total phase change since the last accumulator reset. Interface circuitry converts the phase information into measurement data.

Measurement Board Operation

Figure 4-2 shows a block diagram of the phase measuring electronics on the Measurement Board. The reference frequency of 20 MHz, F_r, is divided by 5 and multiplied by 16 to generate a new reference frequency, F_r’, which is 64 MHz. An intermediate reference frequency of 16 MHz is generated by dividing F_r’ by 4. This signal is used to mix the measurement signal frequency, F_m, to an intermediate frequency, F_m’. The filter output, F_m’, is a constant frequency (4 MHz) plus or minus the Doppler shifted frequency. The Doppler shift is caused by a change in optical path length between the measurement and reference legs of the interferometer.

Figure 4-2 Phase Measuring Circuits



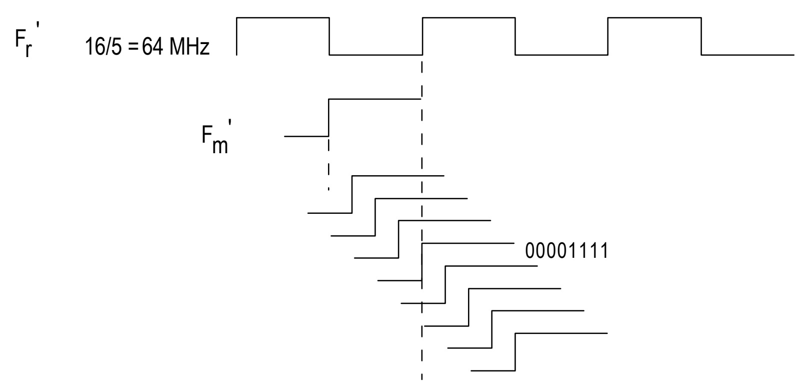
The reference phase counter/interpolator is the phase meter. It uses the 64 MHz signal as a clock. It subdivides the translated measurement signal into 16 parts by counting the number of 64 MHz cycles that occur between successive rising edges of the translated measurement signal, F_m'. This is visualized easiest at rest - there are 16 cycles of the 64 MHz clock for every one cycle of the 4 MHz translated measurement signal.

When motion occurs, the phase of F_m' changes. The reference phase counter/interpolator detects phase change by counting the number of F_r' cycles between positive going zero crossings of F_m' and adding any difference between the count and 16 to an accumulator.

The reference phase counter/interpolator extends the resolution further by interpolating between 64 MHz clock cycles. A tapped delay line generates 8 versions of the translated measurement signal equally spaced at 1/8 of the 64 MHz signal period, or about 2 nanoseconds; this is shown in Figure 4-3. The 64 MHz signal clocks 8 latches that store the delay line values when the translated measurement signal goes low to high. The latch contents indicate the 64 MHz clock subinterval in which the low to high transition of the translated measurement frequency occurred.

The resulting electronic resolution extension is 16 times 8, or 128. λ/512 results when the λ/4 optical resolution of a double-pass plane mirror interferometer is subdivided by 128.

Figure 4-3 Delay Line Interpolator

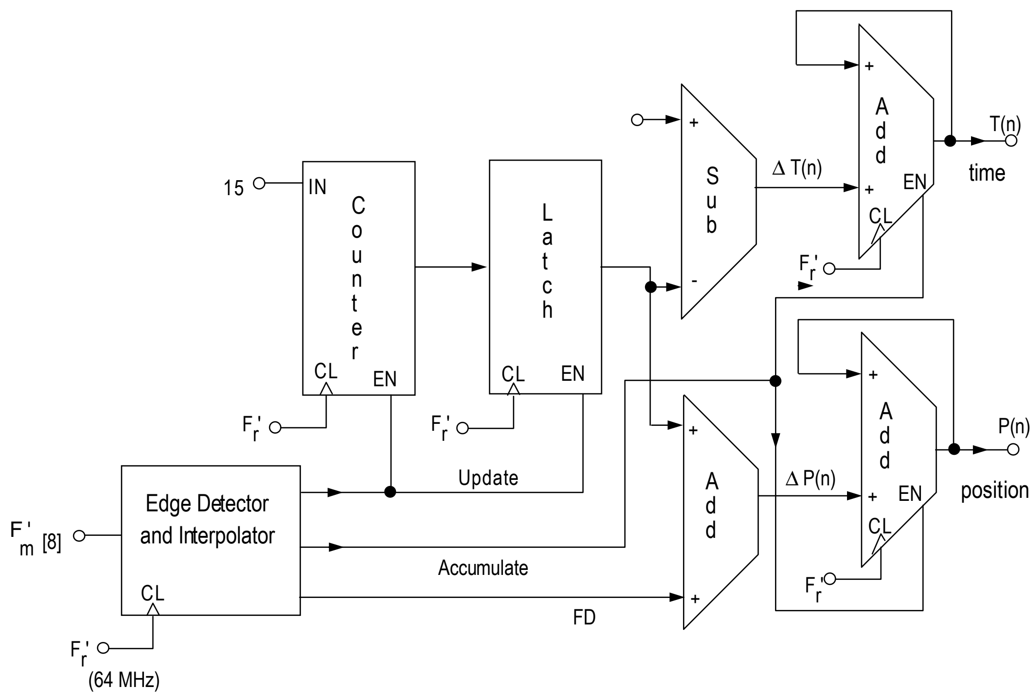


Reference Phase Counter/Interpolator

Figure 4-4 is a block diagram of the reference phase counter/interpolator on the Measurement Board. A counter is synchronously preset to 15 and its outputs are latched at every rising edge of the translated measurement signal. At rest, the counter counts down to exactly zero each time and zeros are added to the phase adder. The small adder adds the least significant bits from the interpolator to the most significant bits from the counter.

When the counter underflows, a negative twos - complement number is added, this occurs when interferometer motion retards the phase of the translated measurement signal. When the translated measurement signal phase advances, the counter doesn't reach zero and small positive numbers are added at each cycle of the translated measurement signal.

Figure 4-4 Reference Phase Counter/Interpolator



The subtractor adds 16 cycles back in to the counter result and the time adder accumulates elapsed time since it was reset. The exact time interval between successive edges of the translated measurement signal is also indicated by the clock cycle count since the clock has a highly stabilized, known frequency.

Since the phase measurements are made by counting the number of cycles of a fixed frequency (Fr' = 64 MHz), the phase measurement data can be used to indicate the time at which the measurement was made. Each phase measurement is added to a time accumulator. This is valuable information because it can tell the user exactly WHEN the position data measurement was valid. A 32-bit time accumulator gathers time data with a resolution of the 64 MHz clock period, or about 16 ns.

Application Examples

Chapter 5

In This Chapter

- Using the 32-bit Parallel, Constant Data Rate Mode
- Setting up the Measurement Board for ZYGO 2/20 Compatibility
- Synchronizing the Measurement Board Time Stamp to Ramp Generators

Using The 32-bit Parallel, Constant Data Rate Mode

This section describes using the 32-bit Parallel interface of the ZMI 1000A Measurement Board in the Constant Data Rate Mode. The reason for choosing a specific interface configuration is explained and a recommended interface is shown.

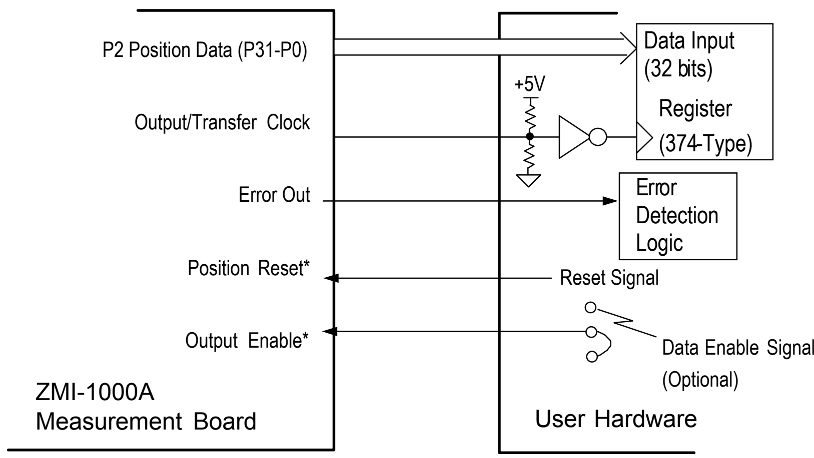
Constant Data Rate

The Constant Data Rate mode provides position data at a constant rate. The ZMI 1000A Measurement Board accomplishes this by sampling the position accumulator at a steady rate. A clock signal with a 50% duty cycle, whose edge transition occurs so there is sufficient data setup and data hold time, allows the user to capture the position data on the appropriate edge transition.

Applications that require a high speed hardwired parallel interface can use the Constant Data Rate Mode. If position data age uncertainty is critical, the Constant Data Delay Mode is recommended. The Controlled Data Rate Mode is recommended for ZYGO 2/20 compatibility.

Figure 5-1 shows a minimal interface configuration. The frequency of the clock signal, and thus the data rate, is software selectable. Storing the appropriate code to Control Register 2 will select a 2, 4, or 8 MHz data rate; 2 MHz is the default value.

Figure 5-1 Minimal P2 Interface for Constant Data Rate Mode



The recommended cable length between the Measurement Board and user hardware is 0.5 to 3 meters. However, at the 8 MHz data rate, the maximum length should be reduced to 1 meter.

Note: In all cases, proper signal terminating techniques are required. Refer to Figure 2-3 for the recommended termination.

If the users hardware is connected to one Measurement Board, as shown in Figure 5-1, the Output Enable* signal can be hardwired to ground. This enables the tri-state buffers that drive the 32-bit position data bus and the Error Out signal onto the P2 connector. For a multiple Measurement Board configuration using a single data cable, refer to Figure 5-2.

As shown in Figure 5-2, Individual Output Enable* signals must be connected to each Measurement Board. Only one enable signal can be active at any given time. JN4 is jumpered 1-2 so the Output/Transfer Clock from each Measurement Board can be connected together. Each Measurement Board should be set to the same data rate (2,4, or 8 MHz).

Care must be taken when disabling one board and enabling another. The output clocks of the three Measurement Boards are not in phase, thus switching from one to another may generate a false clocking edge. By controlling the Input Enable pin of the 374-type register, this problem can be eliminated.

Figure 5-2 Multiple Measurement Board Interface for Constant Data Rate Mode

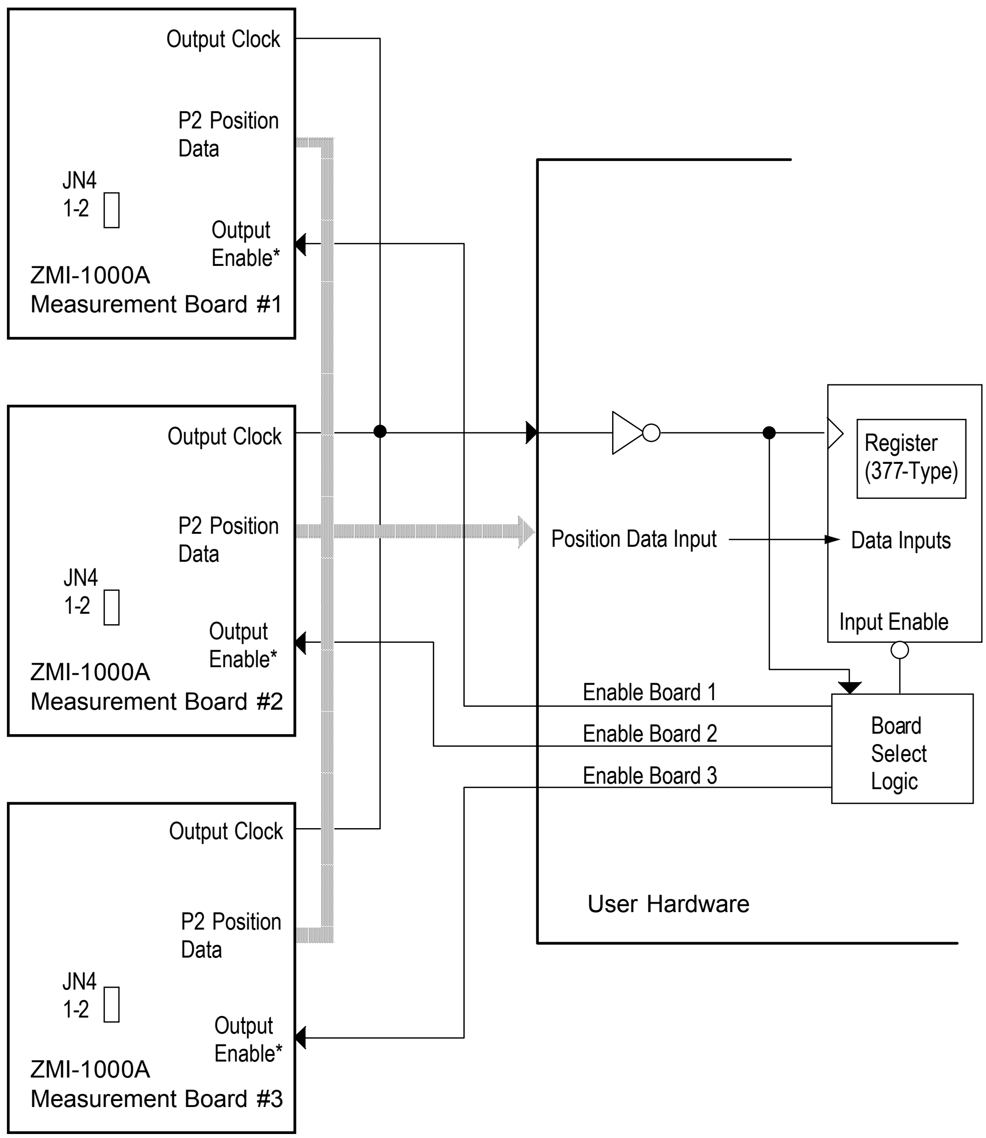
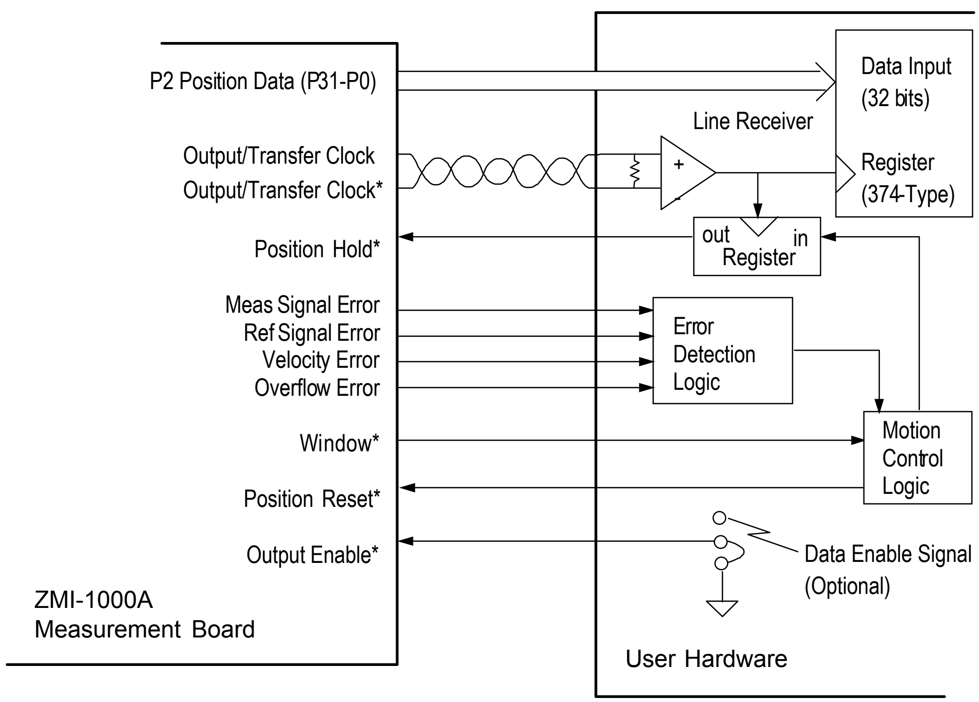


Figure 5-3 shows a more elaborate single Measurement Board configuration. The user can hold the current position data by generating the Position Hold* signal. Individual error signals can be examined and acted upon. The Window* output becomes active when the position is nearing zero. The position value that causes Window* to become active is determined by the value stored in the Window Mask Register.

The Output/Transfer Clock and Output/Transfer Clock* signals are driven by a differential line driver. The configuration shown in Figure 5-3 insures the received clock signal is noise free. The board to board connection can be twisted pair, as shown, or any wire connection with sufficient ground shielding. A recommended line receiver is a mA9637 or an AM26LS32.

> **Note:** Output/Transfer Clock is connected to the minus (-) input of the line receiver and Output/Transfer Clock* is connected to the plus (+) input of the line receiver.

Figure 5-3 P2 Interface for Constant Data Rate Mode



Setting up the Measurement Board for ZYGO 2/20 Compatibility

This section discusses how to configure the Measurement Board to be compatible with the ZYGO 2/20. The following information sets the Measurement Board to the Controlled Data Rate Mode with 16 bit data and Error Out signal multi-plexing.

The Zygo 2/20 Compatible (ZC) Output Cable Assembly (8020-0301-01) provides ZYGO 2/20 servo port compatibility; it connects to the P2 connector on the back of the VME card cage and supplies a DB-50 female connector. This assembly converts ZMI 1000A Measurement Board P2 output signals to ZYGO 2/20 Measurement Board servo port compatible signals and connector. One ZC Output Assembly is required for each measurement axis.

If installed in a Zygo Chassis, a ZC transition board J4 cable (1115-801-065) provides power from the Chassis connector board for up to six ZC transition boards. An optional ZC transition board common cable (8020-0404-01) may be installed to connect up to six Measurement Board Position Reset*, Time Reset*, and External Sample* signals together.

Measurement Board Hardware Setup

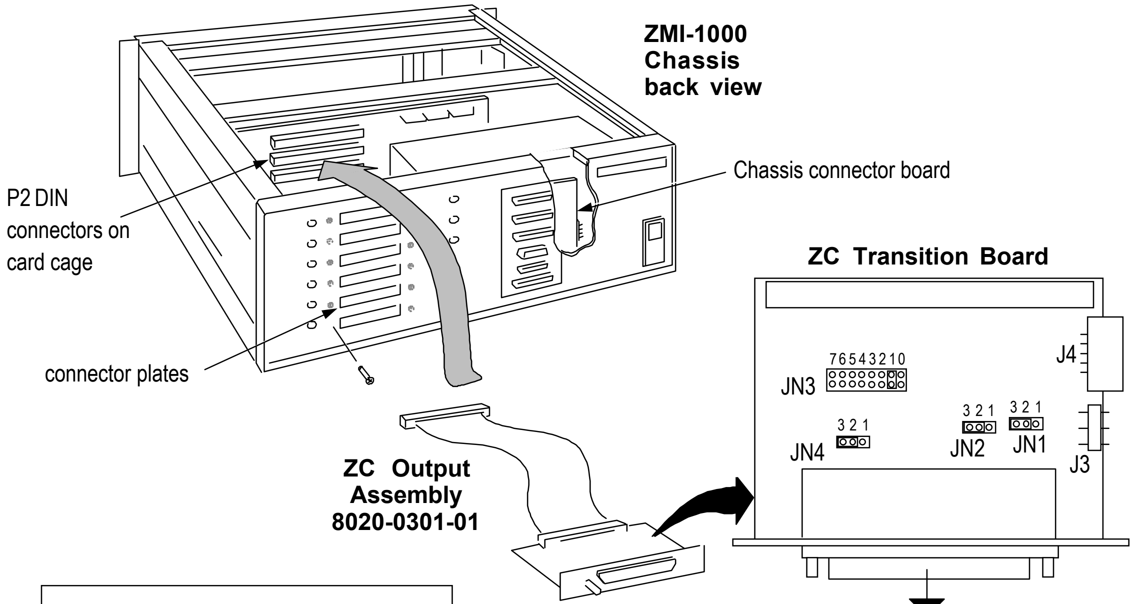
Refer to Figure 5-4 for signal and pin assignments.

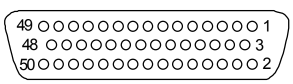
1. Connect the cable to the card cage P2 DIN connector and latch it in place.
2. Set the ZC transition board jumpers as shown below.

Function	*Jumper*	*Position*
Window* signal	JN1	1-2 enable 2-3 disable (default setting)
Transfer Clock signal	JN2	1-2 enable 2-3 disable (default setting)
Measurement Board Address	JN3	Set jumper to match axis number of corresponding Measurement Board.
ZYGO 2/20 bit mode selection	JN4	1-2 31-bit mode 2-3 30-bit mode (default setting)

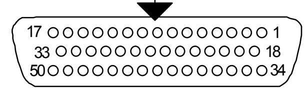
3. Ensure that the Measurement Board JN4 jumper is set to 2-3 position.

Figure 5-4 ZYGO 2/20 Compatible Installation





ZYGO 2/20 Servo Port Connector
DB-50 Female



ZC Output Assembly Connector
DB-50 Female

2/20 Pin	*Signal*	*ZMI Pin*	*2/20 Pin*	*Signal*	*ZMI Pin*
1	GND	1	26	GND	42
2	No Connection	34	27	P13	26
3	GND	18	28	GND	10
4	Error Out	2	29	P12	43
5	Transfer Clock*	35	30	GND	27
6	No Connection	19	31	Select Address1	11
7	No Connection	3	32	GND	44
8	Output H to L Enable*•	36	33	P3	28
9	Output Enable*	20	34	GND	12
10	Position Reset*	4	35	P2	45
11	Sample*	37	36	GND	29
12	GND	21	37	P1	13
13	Select Address0	5	38	GND	46
14	GND	38	39	P0	30
15	P11	22	40	GND	14
16	GND	6	41	P7	47
17	P10	39	42	GND	31
18	GND	23	43	P6	15
19	P9	7	44	GND	48
20	GND	40	45	P5	32
21	P8	24	46	GND	16
22	GND	8	47	P4	49
23	P15	41	48	GND	33
24	GND	25	49	Select Address2	17
25	P14	9	50	GND	50

ZMI-1000 Software Setup

1. Set the Measurement Board Control Register 2, bit 3 to 1, to select the controlled data rate interface. Reference page 3-26.
2. Then set the Measurement Board Control Register 2, bit 6 to 1, bit 5 to 0, and bit 4 to 0, to select P2 bus address 4. Reference page 3-26.

The following example Basic program statement uses the ZMI-1000 Control Board to set Control Register 2 of a ZMI 1000A Measurement Board at Axis 1 according to the steps above:

```
WRITE 1, H, #H48
or
WRITE 1,H, #B1001000
```

To transfer data from the ZMI 1000A Measurement Board to the user hardware, the user hardware must now control the wires connected to P2 according to the timing diagram on page 3-18.

Synchronizing the Measurement Board Time Stamp to Ramp Generators

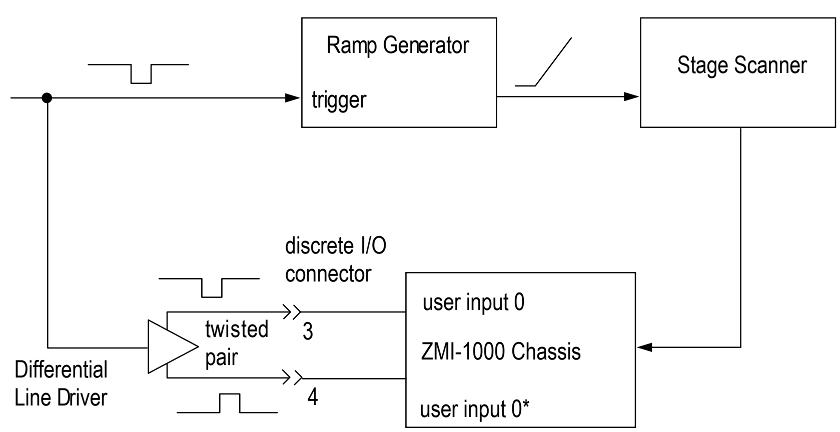
Two methods are described for synchronizing a stage scanning ramp generator and the Measurement Board time register. The first method uses the ramp generator trigger signal as the trigger for the ZMI-1000 MTS(AMPLE) command. The second method uses the Time Reset Out* signal from the ZMI 1000A Measurement Board as the trigger signal for the ramp generator. Minimum timing uncertainty is achieved using Method 2.

The MTS command programs the ZMI-1000 Control Board for automatic sampling and storage of ZMI 1000A Measurement Board data. The command is documented in Chapter 4 of the ZMI-1000 Chassis and ZMI Control Board Operation Manual, OMP-0328.

Method 1 - Ramp Generator Trigger Signal

An example system block diagram is shown in Figure 5-5. The ramp generator trigger is active on the low to high transition. The ramp generator trigger signal is delivered to the ZMI-1000 Chassis Discrete I/O connector using a differential line driver and a twisted pair. A standard TTL compatible differential line driver such as the Texas Instruments uA9638C is recommended. The Discrete I/O connector is located on the ZMI-1000 Chassis Rear Panel.

Figure 5-5 Ramp Generator Trigger Signal Diagram



The ZMI-1000 user input signal is differential and level sensitive. After the ZMI-1000 Control Board detects the logic low level it will begin executing the MTS command. To use this method, the operator sends the MTS command, the ramp generator trigger pulse and then reads the data with the MTS query command (MTS?). The minimum recommended trigger pulse width is 250 nanoseconds. Reference information, an example MTS command, and timing specifications are shown in Table 5-1.

The user input signals are unterminated inside the ZMI-1000, series damping resistors between the differential line driver outputs and the twisted pair are recommended to reduce ringing.

Table 5-1 Reference Information for Method 1

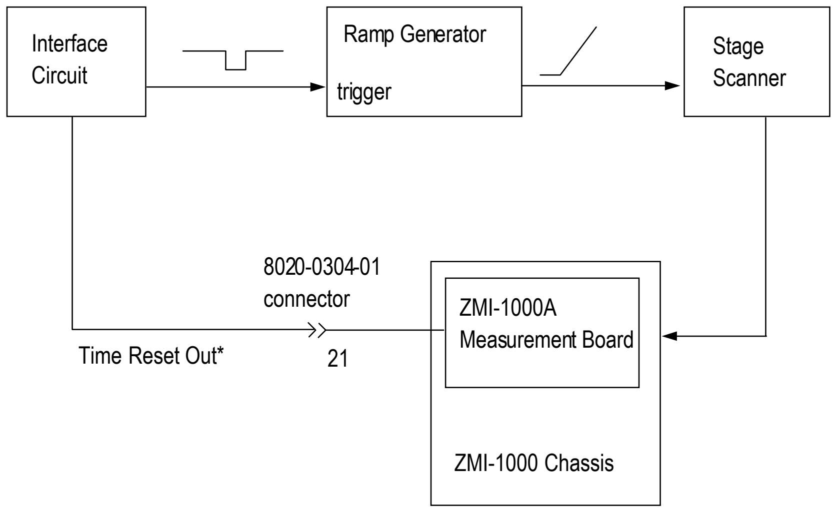
Subject	*Reference or Example*
Discrete I/O Connector Pinout	ZMI-1000 Chassis and ZMI Control Board Operation Manual, OMP-0328, Figure 2-5.
Example MTS Command	MTS 1,1,1024,100,C,0,10 number of measurement boards = 1 axis number(address) = 1 number of samples = 1024 sample rate = 100 kHz, nominal trigger type is user input 0, logic level low trigger time out after 10 seconds
Time delay between user input 0 high to low transition and first sample of MTS command.	30 microseconds minimum 250 microseconds maximum

Method 2 - Time Reset Out* Trigger Signal

An example system block diagram is shown in Figure 5-6. The ramp generator trigger is supplied by the ZMI 1000A Measurement Board. The MTS command triggers when the ZMI 1000A Measurement Board is reset. When the Measurement Board is reset the time register is set to 0, the position register is set to 0 and the Measurement Board output signal Time Reset Out* goes true. The timing relationship between the time defined as zero by the time register and the active edge of Time Reset Out* is very precise.

The 8020-0304-01 Connector Assembly shown in Figure 5-6 is an optional accessory available for attaching a ZMI 1000A Measurement Board connector on the ZMI-1000 Chassis rear panel. Other similar accessories with different pinouts are also available.

Figure 5-6 Time Reset Out* Trigger Signal Diagram



To use this method, the operator sends the MTS command then resets the Measurement Board using the WR(ITE) command. The ramp generator trigger pulse occurs when the Measurement Board reset occurs. The operator then reads the data with the MTS query command (MTS?). Reference information, an example MTS command, an example WR(ITE) command and timing specifications are shown in Table 5-2.

Table 5-2 Reference Information for Method 2

Subject	*Reference or Example*
8020-0304-01 Direct Output Assembly	ZMI-1000 Chassis and ZMI Control Board Operation Manual, OMP-0328, page 2-7.
Interface Circuit Schematic, P2 Input and Output Termination	ZMI 1000A Measurement Board Manual, OMP-0358, Figure 2-3.
Example MTS(AMPLE) Command	MTS 1,1,1024,100,E,1,10 number of measurement boards = 1 axis number(address) = 1 number of samples = 1024 sample rate = 100 kHz, nominal trigger type is immediate upon axis 1 reset, trigger time out after 10 seconds
Example WR(ITE) Command	WR 1,A,#H2 reset axis number 1 measurement board
Time delay between time register = 0 and Time Reset Out* high to low transition.	142 nanoseconds minimum 154 nanoseconds maximum ZMI 1000A Measurement Board Manual, OMP-0358, page 3-20.

Technical Support

Chapter

6

Technical Support

If you have difficulties, please refer to the provided manuals. They are designed to help you through the most common problems. If you still have questions or need assistance, contact the Zygo Service Department directly.

Preparing for Technical Support

Before communicating with our Service Department, please have the following information *written down* so that we can provide you with the quickest possible solution to your problem.

- The equipment's model number and serial number. If it is software related, the software version number.
- A description of the problem and the sequence of events that led up to your discovering the problem. Note any software error messages.
- Your company's name and complete shipping address.
- Refer to the addresses and phone numbers in the front of this manual.

Returning Equipment to Zygo

If it is necessary to return the board to Zygo for service, please follow the procedure outlined below. You must first contact Zygo to obtain a Return Authorization (**RA**) number; so that we can route your equipment properly when it arrives. Equipment returned without an RA number cannot be accepted.

1. Have the following information ready when requesting an RA number:
   - The name of the component and serial number if applicable.
   - Your company's name and complete shipping address.
   - A description of the problem and the sequence of events that led up to your discovering the problem.
2. Contact Zygo by telephone.
3. Zygo will provide an RA number and advise you of the next steps to take.
4. Pack the equipment securely to prevent any damage in shipping. Use the original shipping container and packing material when possible. Include the RA number on the shipping container and on any correspondence.

Handling and Packing Suggestions

- Use a grounding wrist strap to control static electricity when handling the board.
- Turn off power, disconnect any cables from the board, and remove the board from the card cage. Handle the board by its edges and avoid touching connectors.
- Put circuit boards in static control bags. Then wrap the board in bubble-wrap or similar padding.

Register Summary Tables

Appendix

A

The tables that appear on the following pages are a summary of the offset address locations of the various registers on the ZMI 1000A Measurement Board. Also provided is the function for the each register bit. Use these tables as a resource when programming the board for use in a VME backplane.

For the read registers, a Ø indicates the bit should be set to low. For the write registers, an X means not used.

OFFSET LOCATION	DESCRIPTION	READ REGISTER DATA B15	B14	B13	B12	B11	B1Ø	B9	B8	B7	B6	B5	B4	B3	B2	B1	BØ
1E	WINDOW MASK REGISTER	WM15	WM14	WM13	WM12	WM11	WM1Ø	WM9	WM8	WM7	WM6	WM5	WM4	WM3	WM2	WM1	WMØ
1C	CLIP MASK REGISTER	Ø	Ø	Ø	CM12	CM11	CM1Ø	CM9	CM8	CM7	CM6	CM5	CM4	CM3	CM2	CM1	CMØ
1A	STATUS REGISTER 3	AS15	AS14	AS13	AS12	AS11	AS1Ø	AS9	AS8	Ø	Disable Measure Error	Disable Reference Error	Reference Tolerance	Disable External Sample	Disable Common Reset	Disable Common Sample	Enable P2 Data
18	STATUS REGISTER 2	Ø	Encoder Status Bits 2	1	Ø	External Sample Flag	External Sample IRQ Enable	Interreupt Level 2	1	Ø	Select Address 2	1	Ø	P2 Interface Select 1	Ø	Fixed Data Rate Freq 1	Ø
16	LSB OFFSET REGISTER	O15	O14	O13	O12	O11	O1Ø	O9	O8	O7	O6	O5	O4	O3	O2	O1	OØ
14	MSB OFFSET REGISTER	O31	O3Ø	O29	O28	O27	O26	O25	O24	O23	O22	O21	O2Ø	O19	O18	O17	O16
12	LSB TIME REGISTER	T15	T14	T13	T12	T11	T1Ø	T9	T8	T7	T6	T5	T4	T3	T2	T1	TØ
1Ø	MSB TIME REGISTER	T31	T3Ø	T29	T28	T27	T26	T25	T24	T23	T22	T21	T2Ø	T19	T18	T17	T16
ØE	LSB SAMPLE POSITION REGISTER	SP15	SP14	SP13	SP12	SP11	SP1Ø	SP9	SP8	SP7	SP6	SP5	SP4	SP3	SP2	SP1	SPØ
ØC	MSB SAMPLE POSITION REGISTER	SP31	SP3Ø	SP29	SP28	SP27	SP26	SP25	SP24	SP23	SP22	SP21	SP2Ø	SP19	SP18	SP17	SP16
ØA	LSB POSITION REGISTER	P15	P14	P13	P12	P11	P1Ø	P9	P8	P7	P6	P5	P4	P3	P2	P1	PØ
Ø8	MSB POSITION REGISTER	P31	P3Ø	P29	P28	P27	P26	P25	P24	P23	P22	P21	P2Ø	P19	P18	P17	P16
Ø6	INTERRUPT VECTOR	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	IV7	IV6	IV5	IV4	IV3	IV2	IV1	IVØ
Ø4	COMMAND REGISTER	Ø	Ø	Ø	Ø	Ø	Ø	Ø	External Sample	Position Reset	Time Reset	Ø	Reset Time	Reset Overflow	Reset Erros	Reset Axis	Sample
Ø2	A24 BASE ADDRESS REGISTER	AD23	AD22	AD21	AD2Ø	AD19	AD18	AD17	AD16	AD15	AD14	AD13	AD12	AD11	AD1Ø	AD9	AD8
ØØ	STATUS REGISTER 1	Ø	A24 Enable	Preset Accum.	User LED	DTACK Hold-off	Velocity Enable	Measure Present	Ref. Present	Velocity Error	Overflow Error	Measure Error	Ref. Error	Interrupt Inhibit	Overflow Enable	Measure Enable	Ref. Enable

OFFSET LOCATION	DESCRIPTION	WRITE REGISTER DATA															
		B15	B14	B13	B12	B11	B1Ø	B9	B8	B7	B6	B5	B4	B3	B2	B1	BØ
1E		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1C		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1A	CONTROL REGISTER 3	X	X	X	X	X	X	X	X	X	Disable Measure Error	Disable Reference Error	Reference Tolerance	Disable External Sample	Disable Common Reset	Disable Common Sample	Enable P2 Data
18	CONTROL REGISTER 2	X	X	X	X	X	External Sample IRQ Enable	Interreupt Level 2	1	Ø	Select Address 2	1	Ø	P2 Interface Select 1	Ø	Fixed Data Rate Freq 1	Ø
16		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
14		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
12		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1Ø		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
ØE	WINDOW MASK REGISTER	WM15	WM14	WM13	WM12	WM11	WM1Ø	WM9	WM8	WM7	WM6	WM5	WM4	WM3	WM2	WM1	WMØ
ØC	CLIP MASK REGISTER	X	X	X	CM12	CM11	CM1Ø	CM9	CM8	CM7	CM6	CM5	CM4	CM3	CM2	CM1	CMØ
ØA	LSB OFFSET REGISTER	O15	O14	O13	O12	O11	O1Ø	O9	O8	O7	O6	O5	O4	O3	O2	O1	OØ
Ø8	MSB OFFSET REGISTER	O31	O30	O29	O28	O27	O26	O25	O24	O23	O22	O21	O2Ø	O19	O18	O17	O16
Ø6	INTERRUPT VECTOR	X	X	X	X	X	X	X	X	IV7	IV6	IV5	IV4	IV3	IV2	IV1	IVØ
Ø4	COMMAND REGISTER	X	X	X	X	X	X	X	External Sample	Position Reset	Time Reset	X	Reset Time	Reset Overflow	Reset Erros	Reset Axis	Sample
Ø2	A24 BASE ADDRESS REGISTER	AD23	AD22	AD21	AD2Ø	AD19	AD18	AD17	AD16	AD15	AD14	AD13	AD12	AD11	AD1Ø	AD9	AD8
ØØ	CONTROL REGISTER 1	X	A24 Enable	Preset Accum.	User LED	DTACK Hold-off	Velocity Enable	X	X	X	X	X	X	Interrupt Inhibit	Overflow Enable	Measure Enable	Ref. Enable

ZMI 1000
Chassis and Control Board
P/N's 8010-0100-XX and 8030-0200-01
Operating Manual
OMP-0328L

Zygo Corporation
Laurel Brook Road
P.O. Box 448
Middlefield, Connecticut 06455-0448

Telephone: (860) 347-8506
Fax: (860) 346-4188
E-mail: inquire@zygo.com
Website: www.zygo.com

ZYGO CUSTOMER SUPPORT

For help within North America, 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	Monday - Friday, 8 a.m. - 8 p.m. (Eastern Standard Time) (800) ZYGO NOW (800) 994-6669 *or* (860) 704-5191
FAX	(860) 346-4188
INTERNET	www.zygo.com support@zygo.com
WRITE	Zygo Corporation Laurel Brook Road P.O. Box 448 Middlefield, CT 06455-0448 Attn: Customer Support

MANUAL REVISION INFORMATION

The document (OMP) number and the applicable revision letter for this manual appear on the title page. The publication date appears below.

Revision	*Publication Date*	*Revision*	*Publication Date*
original	September 1992	G	September 1994
B	March 1993	H	December 1994
C	July 1993	J	January 1995
D	August 1993	K	October 1995
E	February 1994	L	December 2001
F	April 1994		

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 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.

01/96

CE Notice

Marking by the CE symbol indicates compliance of this Zygo Corp. instrument to EMC (electromagnetic compatibility) Directive and the Low Voltage Directive of the European Union. Such marking indicates that this system meets the following technical standards:

- EN 55011 – "Limits and methods of measurements or radio disturbance characteristics of ISM (Industrial Scientific & Medical) radio frequency equipment." Class A, for use in typical commercial environments.
- EN 55022 – "Limits and methods of measurements of radio disturbance characteristics of ITE (Information Technology Equipment)." Class A, for use in typical commercial environments.
- EN 50082-1 1992 – "Electromagnetic compatibility generic immunity standard for the residential, commercial and light industrial environments."
- EN 61010-1 1993 + A2: 1995 – "Safety requirements for electrical equipment for measurement, control and laboratory use – Part 1: General requirements."

A Declaration of Conformity in accordance with the preceding directives and standards has been made and is on file at Zygo Corporation, Middlefield, Connecticut, USA.

Page intentionally left blank

Contents

Contents

Command dictionary entries are listed on the following page.

CHAPTER 4 - COMMAND DICTIONARY (CONTINUED)

CHAPTER 5 - MAINTENANCE AND TECHNICAL SUPPORT

Page intentionally left blank

Chapter 1

INTRODUCTION

In This Chapter

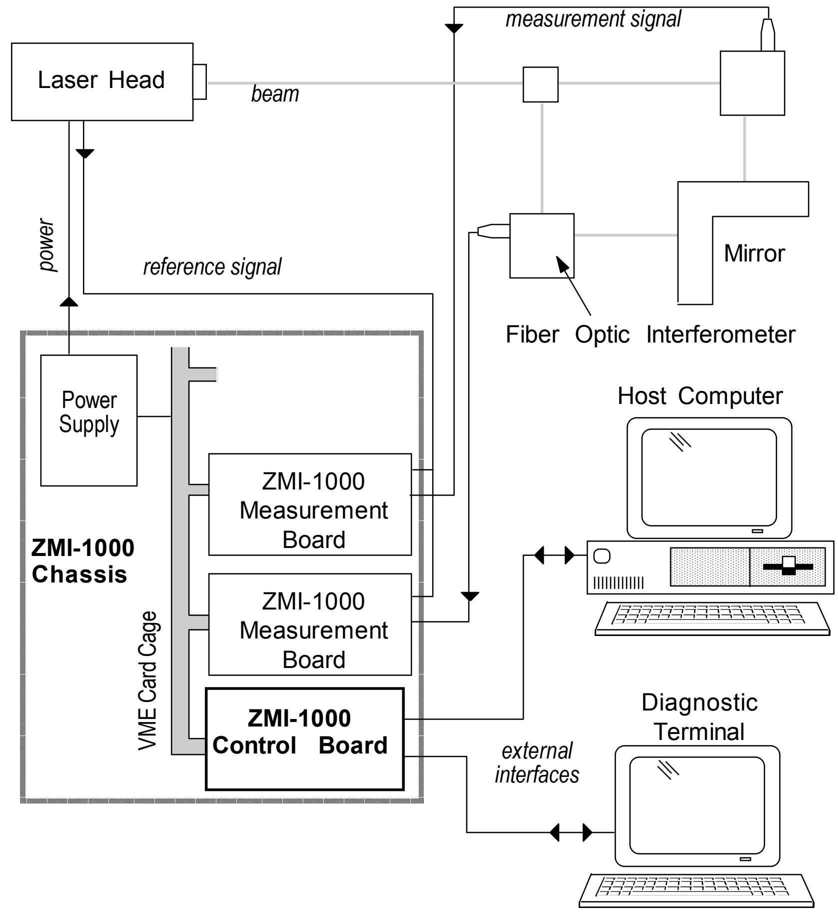
- What This Manual Covers
- Overview
- ZMI 1000 Chassis
- ZMI 1000 Control Board
- Electrical Safety
- Specifications
- Safety Labels

What This Manual Covers

This manual describes the installation and use of the Zygo ZMI 1000 Chassis and the Zygo ZMI 1000 Control Board. Both components are part of a complete displacement measuring interferometer system. Refer to Figure 1-1.

The information presented in this manual assumes that you are familiar with the VMEbus specification and interferometry principles. The manual is arranged as follows:

Chapter 1	Describes the ZMI 1000 Chassis and ZMI 1000 Control Board's features and specifications.
Chapter 2	Describes installation of the Chassis and Control Board.
Chapter 3	Provides information to create your own program for measurement system control.
Chapter 4	Dictionary of commands.
Chapter 5	Provides information for obtaining technical support.
Appendix A	Programming examples.
Appendix B	Illustrations of command syntax.
Appendix C	Comparison of ZMI and HP signals.



This manual describes the **ZMI 1000 Chassis** and the **ZMI 1000 Control Board**.
Also covered are the software commands used with the computer and terminal.

Typical ZMI System Diagram
Figure 1-1

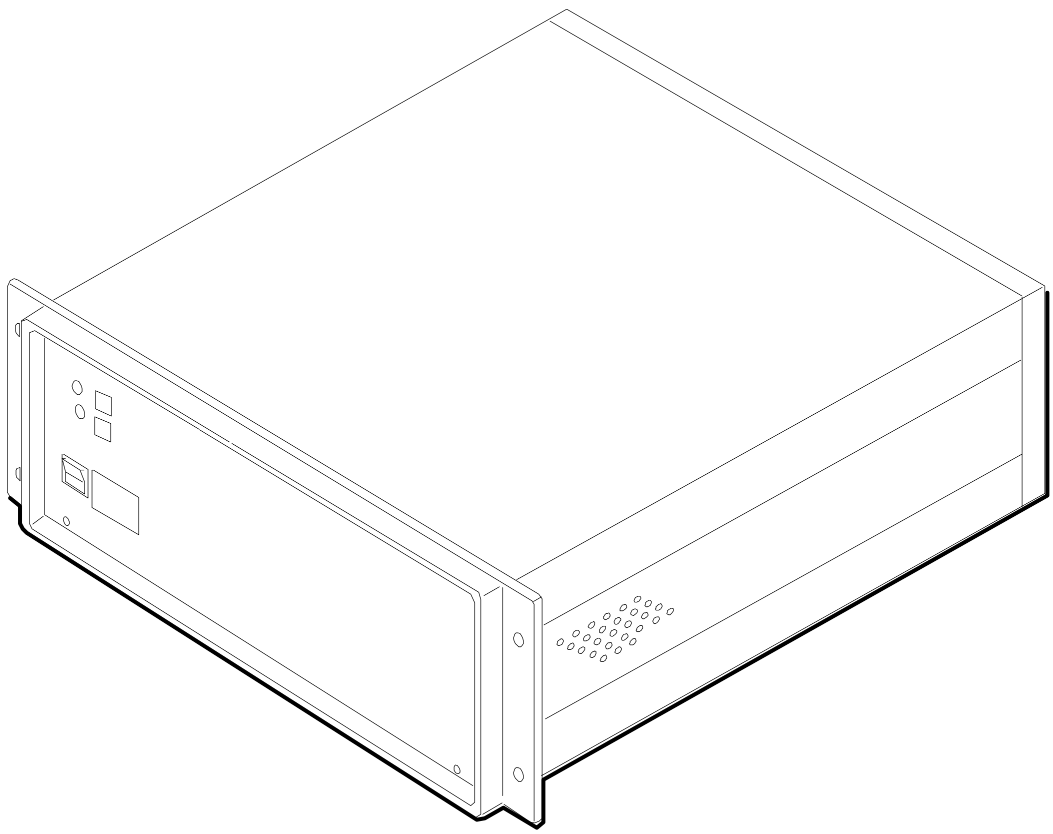
OVERVIEW

The Zygo ZMI 1000 Chassis and ZMI 1000 Control Board are part of a VME-based displacement measurement system. The ZMI 1000 Chassis serves as an enclosure for one ZMI 1000 Control Board and up to six other VME boards, such as the Zygo ZMI 1000 Measurement Board. The Chassis provides power to its VME card cage and the Zygo Laser Head. The back panel of the ZMI 1000 Chassis allows easy interconnection of external devices.

The ZMI 1000 Control Board serves as a VME master board, which controls the actions of other VME slave cards and provides multiple interfaces to the host computer and other equipment. Actual position information is output by the Zygo ZMI 1000 Measurement Board, which is described in Zygo manual OMP-0327.

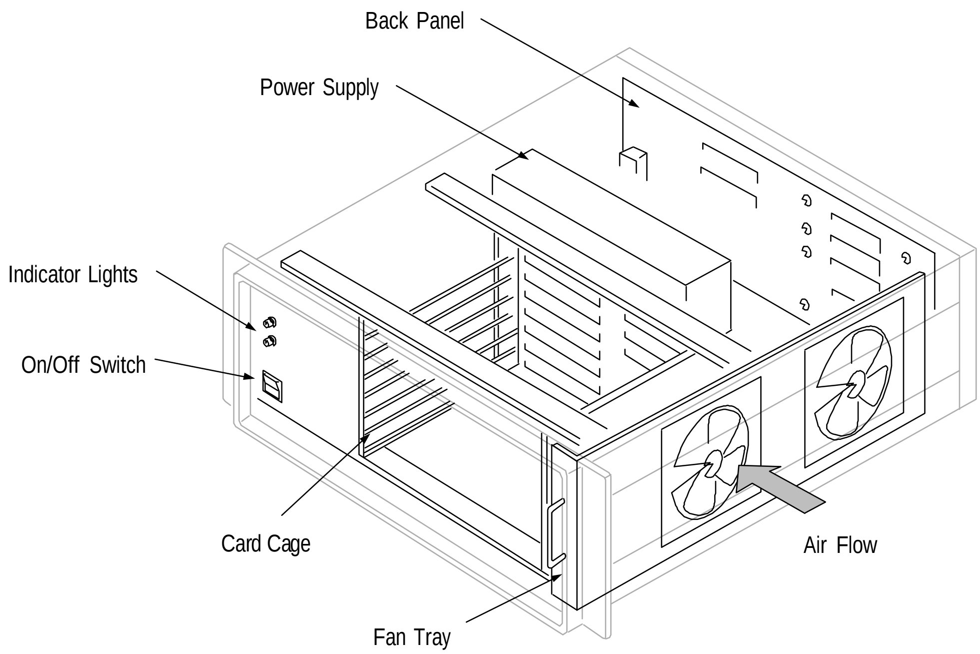
ZMI 1000 CHASSIS

The ZMI 1000 Chassis, part number 8010-0100-XX, shown in Figure 1-2, serves as an enclosure for the power supply and circuit boards for the ZMI 1000 measurement system. The Chassis has an all-metal case for RFI shielding and heat dissipation. The Chassis has integral 19-inch flanges for direct mounting into racks or cabinets; optional handles are available. Removable front and top covers provide accessibility to interior electronics. Rubber feet included with the Chassis may be installed for bench-top usage. Cooling is provided by two internal, filtered fans, mounted on a fan tray.



ZMI 1000 Chassis
Figure 1-2

The Chassis can be configured for either 100/120 or 220/240 volt operation; see Chapter 2 for more information. The power supply provides +5 volts to the VME backplane and ±15 volts to the laser head. It does not supply ±12 volts to the backplane as specified by the VME specification. The seven-slot VME card cage can support a measurement system with one ZMI 1000 Control Board and up to six ZMI 1000 Measurement Boards. See Figure 1-3 for an internal look at the Chassis.

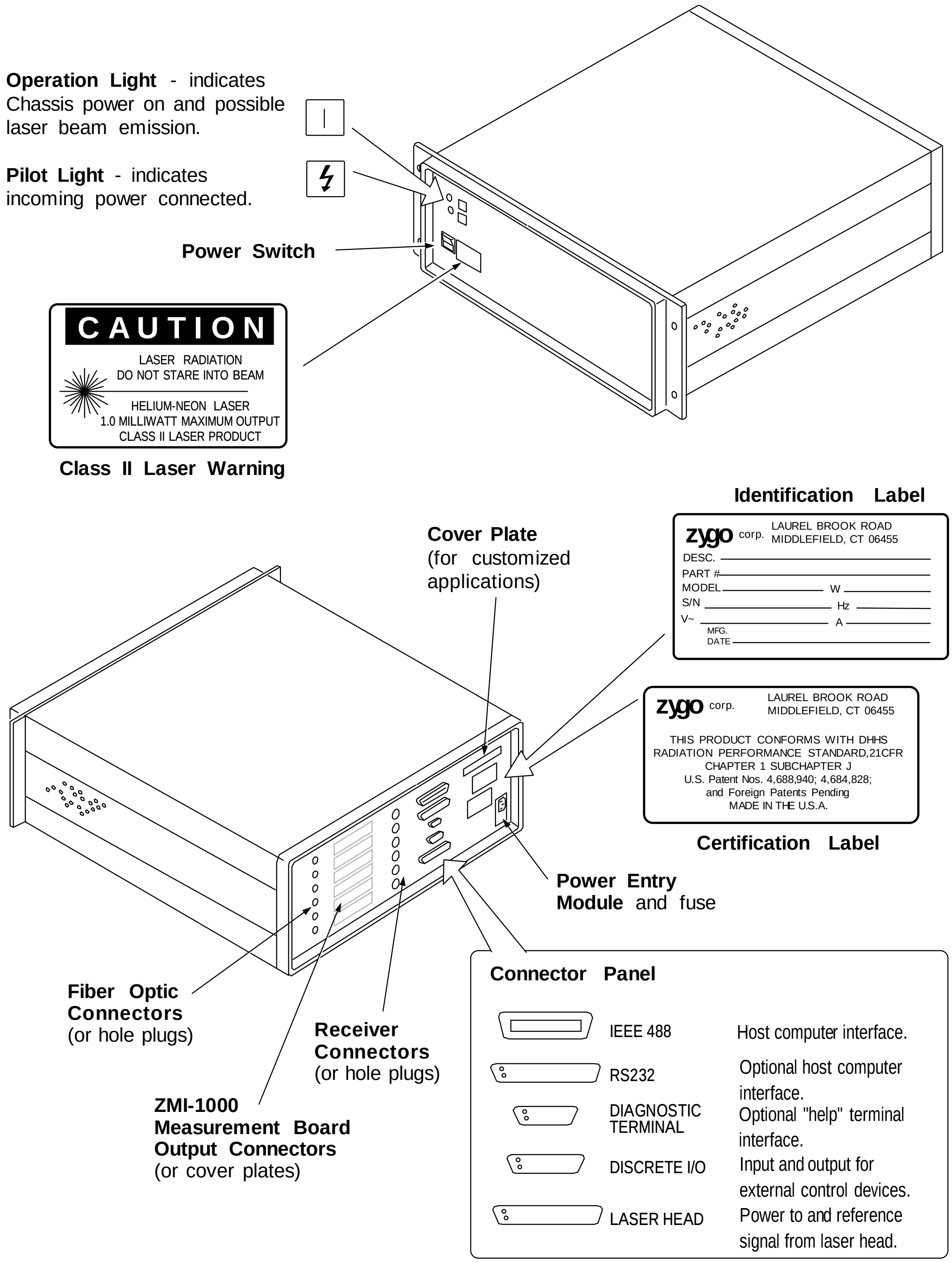


Chassis Internal View
Figure 1-3

The Chassis based measuring system is turned on and off with the power switch on the front of the Chassis. The neon pilot light indicates that power is connected to the Chassis. The green operation light indicates that the power switch is on, the laser head and boards are receiving power, and that the laser head may be emitting a beam.

The Chassis back panel serves as an interconnection hub. It provides for the input from six receivers, the output for six ZMI 1000 Measurement Boards, and the interface ports for the ZMI 1000 Control Board.

Figure 1-4 illustrates the Chassis controls, connectors, and labels. Additional specifications on the Chassis are located at the end of this chapter.

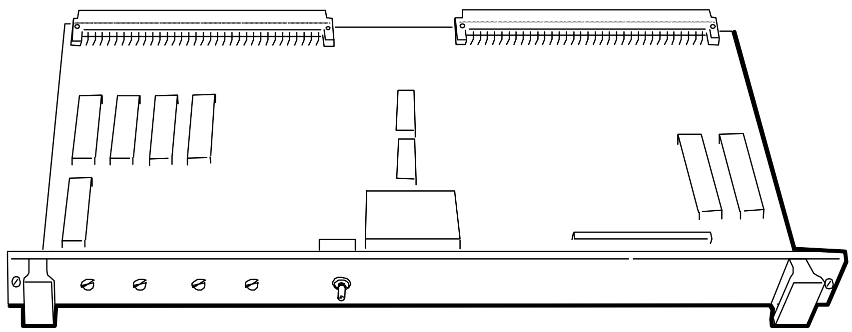


Chassis Controls, Connectors, and Labels

Figure 1-4

ZMI 1000 CONTROL BOARD

The ZMI 1000 Control Board, part number 8030-0200-01, shown in Figure 1-5, oversees the input and output of data and commands, and provides multiple interfaces to other equipment. The Control Board complies electrically and mechanically with Revision C.1 of the VMEbus specification. The Control Board should occupy the bottom slot of the Chassis card cage.



ZMI 1000 Control Board
Figure 1-5

The Control Board can serve as a VME master and system controller or just a master. It outputs VME SYSRESET*and SYSCLK signals. In addition, the Control Board performs bus arbitration and bus error detection. It supports A16 and A24 addressing capabilities with D8(E0) and D16 data transfer capibilities. It does not support the SYSFAIL*, ABORT*, ACFAIL*, HALT*, or BCLR* functions. It has limited VME interrupt support for Zygo Measurement Boards only.

The board contains a Motorola 68HC000 microprocessor, which is controlled by resident software stored in EPROM (Erasable Programmable Read Only Memory). This software directs operation, communication, and diagnostic routines.

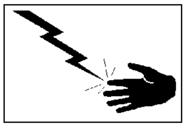
The ZMI 1000 Control Board provides the interface link between ZMI 1000 Measurement Boards and external host computers and other devices. The hardware interfaces provided by the ZMI 1000 Control Board are described in Table 1-1. Additional specifications on the Control Board are located at the end of this chapter.

Interface	*Description*
VMEbus	The card cage interface to other VME boards in the system. It supports A16 and A24 addressing.
IEEE 488	A GPIB (General Purpose Interface Bus) port for an external host computer. It conforms to the IEEE 488.1-1987 hardware and IEEE 488.2-1987 software specifications. 24-pin GPIB connector.
RS232	RS232 serial port for an external host computer in lieu of the IEEE 488 port. DB-25 receptacle connector; use shielded cable only.
Diagnostic Terminal	A RS232 serial port for connection to a VT100 compatible video display terminal for initial system setup and host software development. DB-9 receptacle connector; use shielded cable only.
Laser Head	Provides power to and returns the reference signal from the Zygo Laser Head. DB-25 receptacle connector.
Discrete I/O	Port for discrete inputs and outputs from external control devices. DB-15 receptacle connector.

Note: The P2 connector on the ZMI 1000 Measurement Board provides a user-configurable interface for applications that do not use a host computer. One example is the P2 controlled data rate transfer mode. For more information, see the Zygo ZMI 1000 Measurement Board Manual, OMP-0327.

Table 1-1 Control Board Interfaces

ELECTRICAL SAFETY



Failure to follow the recommendations in this manual regarding electrical safety can result in damage to the Chassis and Control Board and may void the warranty. Please be sure to observe all precautions as indicated.

WARNING!
DO use proper handling techniques when touching the ZMI 1000 Control Board to prevent the board from being damaged by electrostatic discharge (ESD). The board should be stored in a static shield bag and handled only by individuals using a static control wrist grounding strap.

DO remove power from the ZMI 1000 Chassis before installing the board or when connecting and disconnecting cables.

Where to go from here…

To install the ZMI 1000 Chassis or Control Board follow the instructions in Chapter 2.

Chapter 3 provides operating information.

Chapter 4 is a dictionary of commands.

Chapter 5 describes how to contact Zygo for technical assistance.

To review sample programs that show how to use the ZMI 1000 for data acquisition, refer to Appendix A.

SPECIFICATIONS

The general specifications for the ZMI 1000 Chassis and the ZMI 1000 Control Board are shown over the following pages. For specifications on cables refer to the ZMI Cable Guide, OMP-0333.

ZMI 1000 Chassis P/N 8010-0100-XX

Physical Characteristics:
Dimensions: See Figure
Clearance required for cables: 135 mm (5.3 in.)
Weight (with Control Board): 12.7 kg (28 lb)

Electrical:
Incoming Power:
100/120/220/240 VAC ±10%, 50/60 Hz
Fuse Rating: 250V 5A for 100/120 VAC operation
250V 2-1/2A for 220/240 VAC operation
Heat Dissipation: 300 watts maximum
Power Supply Output Voltages: +15 VDC @ 3A,
-15 VDC @ 3A, + 5 VDC @ 25A

AC Line:
Transient Tolerance: 2000 V @ 1 ns rise/fall times
Maximum AC Line Dropout Time @ 120V:
78 milliseconds, using (1) Control Bd,
(3) Measurement Bds, (1) 7701A Laser Head,
and (3) 7081 Receivers.

Electromagnetic Compatibility:
Meets or exceeds VDE 0871B limit of conducted and radiated standards.

Circuit Boards:
1 VMEbus Control Board and up to 6 VMEbus boards.

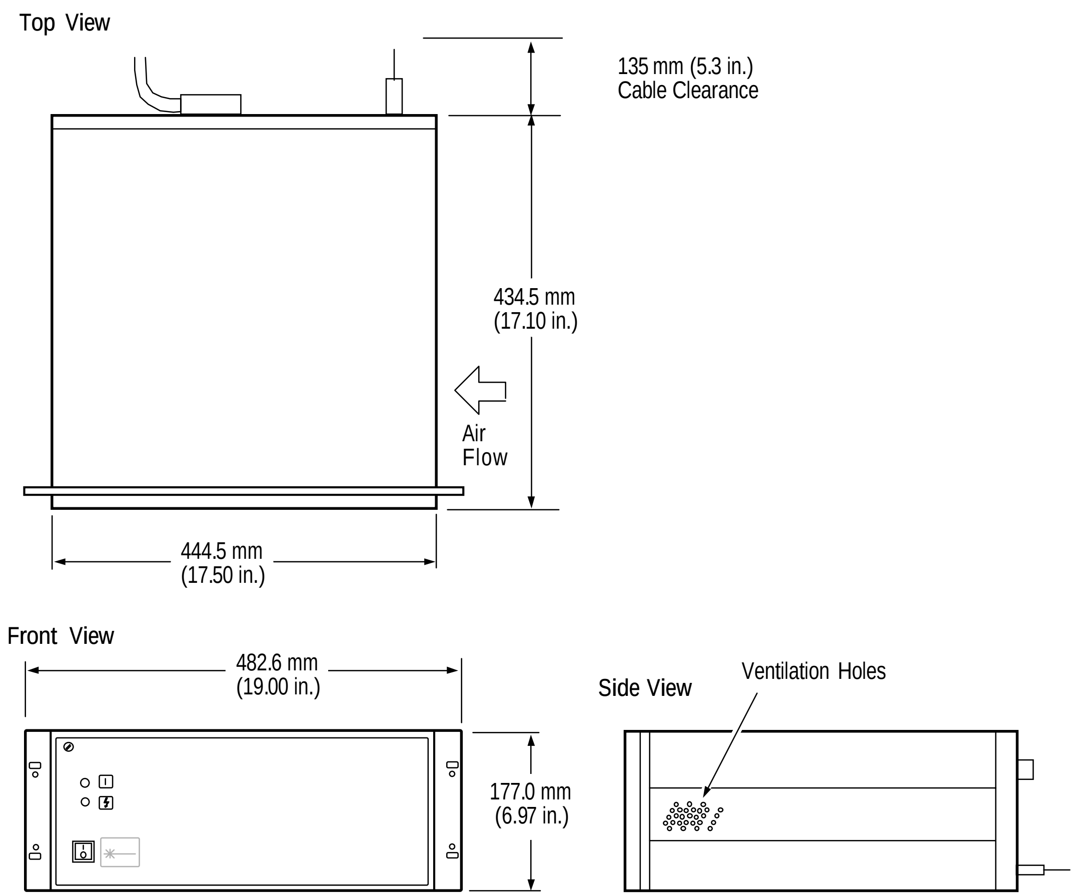
Backplane: VME
(conforms to VMEbus Rev C.1 standard)

Interface Connectors:
IEEE-488: GPIB external (host) computer
RS-232: external (host) computer(1)
RS-232: diagnostic display terminal
and laser head(1)
DB15: discrete I/O

Ventilation:
60 linear fpm by 2 fans, right to left (front view)

Environmental:
Operating Temperature: 0° to 40° C (32° to 104° F)
Non-operating Temperature:
-40° to 75° C (-104° to 167° F)
Operating Humidity: 0 to 90% (non-condensing)
Non-operating Humidity: 0 to 90% (non-condensing)

(1) Use shielded RS232 cable only.



ZMI 1000 Control Board P/N 8030-0200-01

Microprocessor: Motorola 68HC000

Power Requirement: + 5 VDC @ 1A

Interfaces:
VME bus
IEEE-488
RS232

Compliance: UL94VO, UL796

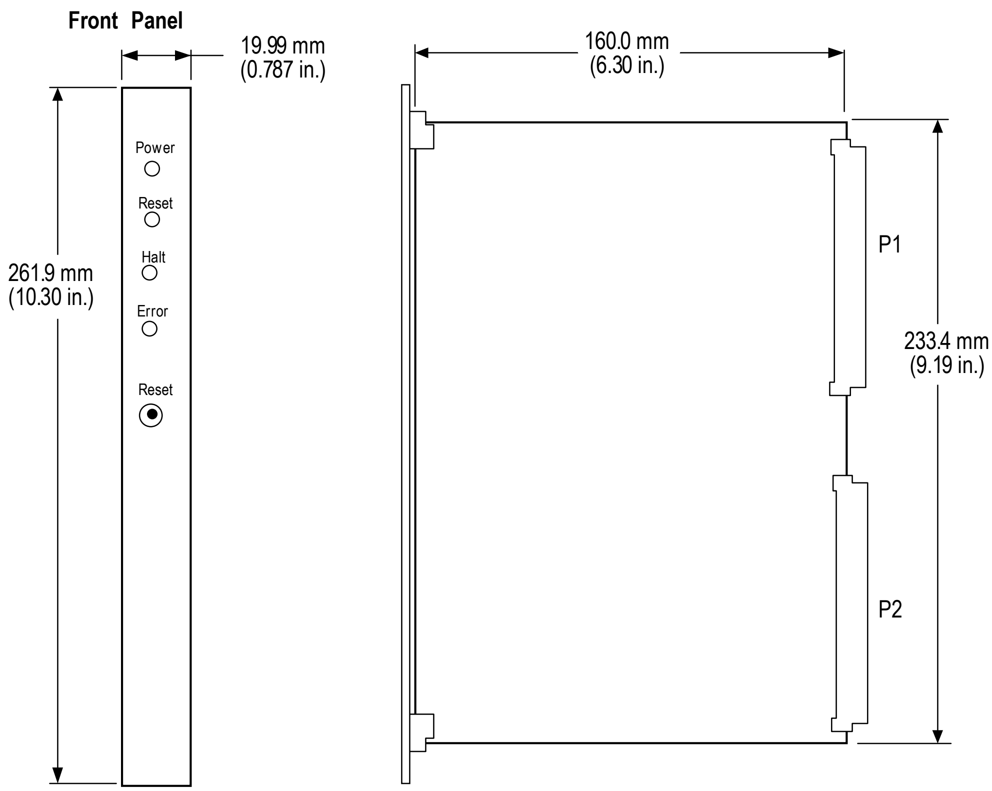
VME Compliance:
VMEbus Specification Rev. C.1
6U Size
A16, A24 - short or standard address range
D08(EO), D16 - 8-bit (even or odd) or 16-bit data transfer
SGL(3) - single level bus request on level 3
BTO(64) - bus data transfer watchdog timer, 64 μs timeout

Inputs/Outputs:
3 discrete differential inputs
5 discrete open collector outputs
1 discrete open collector error output

Environmental:
Operating Temperature: 0° to 55° C (32° to 151° F)
Non-operating Temp.: -40° to 75° C (-40° to 167° F)
Operating Humidity: 0 to 90% (non-condensing)
Non-operating Humidity: 0 to 90% (non-condensing)

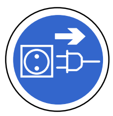
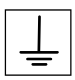
Cooling Requirements:
60 linear fpm minimum for 0° to 40° C (32° to 104° F)
250 linear fpm minimum for 0° to 55° C (32° to 151° F)

Maximum Transfer Rates:
RS232 Control Port: 19.2 k baud
Diagnostic port: 19.2 k baud
IEEE-488: 23 k bytes/sec
(2.9 k time/position samples per second)



SAFETY LABELS

The following table describes the general meaning of safety labels found on the instrument. Specific warnings are covered in the applicable section within this manual. Failure to follow the safety labels and the recommendations in this manual could result in damage to personnel and the instrument, and may void the warranty.

Label	*Meaning*
	General hazard. Proceed with caution. Refer to the manual for instructions.
	Electrical shock hazard. Proceed with caution, there is a risk of electrical shock.
	Disconnect power.
	Refer to the manual for instructions.
	Earth ground.
	Protective conductor terminal.

Chapter 2

INSTALLATION

In This Chapter

- CE Note Regarding Installation
- Checklist
- Unpacking
- Installing the Chassis
  - Installing Chassis Feet and the Optional Handles
  - Installing ZMI-1000 Measurement Board Kits
  - Installing Output Cable Assemblies
- Installing the Control Board
  - DIP Switch Settings
  - Default Settings
  - SW2 and SW3 Definitions
  - Control Board P1 and P2 Pin Assignments
- Chassis Connector Panel Pin Assignments
  - RS-232 Serial Port Parameters
  - RS-232 Minimum Cable Requirements
- Control Board Discrete I/O
  - Using the Discrete Inputs
  - Using the Discrete Outputs
- Chassis AC Line Voltage Selection

CE NOTE REGARDING INSTALLATION

The Chassis is intended for Category 2 Installation per EN 61010-1, Clause 5.4.1, of the Low Voltage Directive of the European Union.

CHECKLIST

The following list is provided as a summary of the installation procedures.

☐ Inspect all packages for signs of shipping damage. Report any damage to the carrier and to the Zygo Service Department, as described in Chapter 5.

☐ Check that the shipment is complete.

☐ If you've purchased all the components at the time of the original order, then the Chassis and boards are factory configured per your order. Just plug in the line cord.

☐ If you're adding Measurement Board Kits, configure the boards and install the internal cables.

- ☐ If necessary, configure the DIP switches on the Control Board for your selected interface. You may also want to review the connector pin assignments.
- ☐ Check, and if necessary, configure the Chassis power connector module for the incoming voltage.
- ☐ Connect the output from the Chassis to your host computer using either the IEEE-488 port, the RS-232 port, or the Measurement Board P2 output.
- ☐ If you are using a host computer you must write an application program to control your VME measurement system. See Chapter 3, Chapter 4, and Appendix A.

UNPACKING

Inspect all packages for signs of shipping damage. Report any damage to the carrier and notify your Zygo representative, as described in Chapter 5. If necessary, retain the shipping material for the carrier's inspection.

Ensure that your order is complete. If purchased as a unit, the ZMI-1000 Chassis *may* include:

- ZMI-1000 Control Board (pre-installed)
- ZMI-1000 Measurement Boards (pre-installed)
- Internal Chassis cabling (pre-installed)
- Line Cord
- Chassis Feet

ZMI-1000 Measurement Board kits may be purchased separately and added later. These kits include:

- ZMI-1000 Measurement Board
- Internal Chassis cabling for receiver or on-board fiber optic detector
- Static Wrist Strap

Cabling

External Cabling is available separately. Refer to the Zygo Cable Guide, OMP-0333, for more information.

INSTALLING THE CHASSIS

All Zygo ZMI-1000 Chassis components purchased at the same time as the Chassis are factory installed. In this case, installation is simply connecting the Chassis to incoming line power and other external devices.

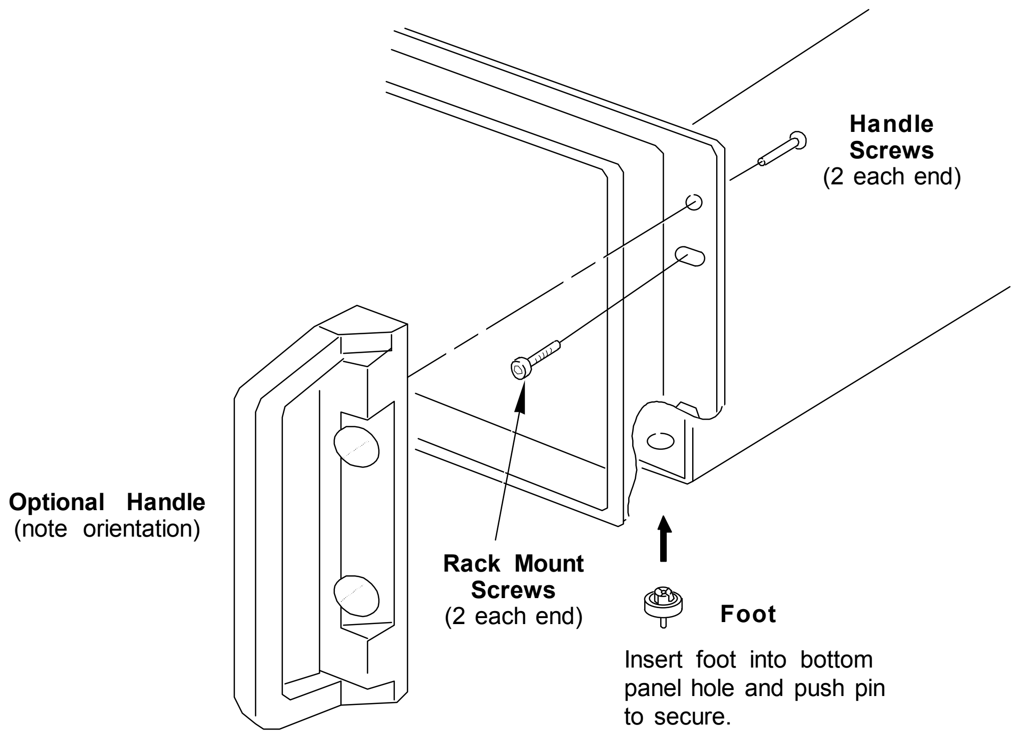
The Chassis can mount directly in a 19-inch rack or cabinet. To install the feet included with the Chassis or the optional handles refer to the sub-section titled “Installing Chassis Feet and the Optional Handles”. (Installation of the feet and handles is optional.)

To add ZMI-1000 Measurement Board kits refer to the procedure in the sub-section titled “Installing ZMI-1000 Measurement Board Kits”.

If you want to change the Chassis interface port settings refer to the section titled “Installing the Control Board”.

Installing Chassis Feet and the Optional Handles

To install the feet or handles refer to Figure 2-1.



Installing Chassis Feet and Handles
Figure 2-1

Installing ZMI-1000 Measurement Board Kits

This section describes how to add ZMI-1000 Measurement Board Kits to the Chassis. Refer to Figure 2-2.

> **Note:** All Measurement Boards purchased at the time of the original order are factory installed; if this is the case, this section is not applicable to you.

To install the ZMI-1000 Measurement Board Kit, perform the following procedures. Instructions are provided for installing both fiber optic detector cables and nonfiber receiver cables. However, keep in mind that each Measurement Board can use only one type of receiver cable; select the instructions for the type of cable included in your kit.

Boards must be positioned in specific slots in the card; start with the slot adjacent to the Control Board. The cables should be routed through the recommended cable clamps on the card cage.

Output from the Measurement Boards can be direct through the backplane or through the Control Board. See "Installing Output Cable Assemblies" for more information on direct output.

Preparation

1. Loosen four captive screws on the Chassis front panel and remove the panel.
2. Remove four screws on the Chassis top cover and remove the cover.

Installing an Internal Fiber Optic Cable

1. Remove the hole plug, that corresponds to the axis number, from the hole in the Chassis back panel. Holes for fiber optic cables are labeled **Fiber Optic** ***x*** (x = 1, 2, 3, 4, 5, or 6).
2. Insert the Fiber Optic Feed-Thru into the hole from the outside of the Chassis so the threaded portion is on the inside. Secure the Feed-Thru in place with the nut.
3. Connect the internal Fiber Optic Cable to the Feed-Thru and route the cable through the appropriate pair of cable clamps to the front of the card cage. The cable connects to the Measurement Board **Fiber** port.

Installing an Internal Nonfiber Receiver Cable

1. Remove the hole plug, that corresponds to the axis number, from the hole in the Chassis back panel. Holes for nonfiber optic cables are labeled **Receiver *x*** (x = 1, 2, 3, 4, 5, or 6).
2. Insert the threaded end of the cable into the hole from the inside of the Chassis. The key slot in the connector should be oriented up. Install the finish nut on the connector from the outside; this nut should be flush with the face of the connector body. Then tighten the inner nut.
3. Route the cable through the appropriate pair of cable clamps to the front of the card cage. The cable connects to the Measurement Board **Receiver** port.

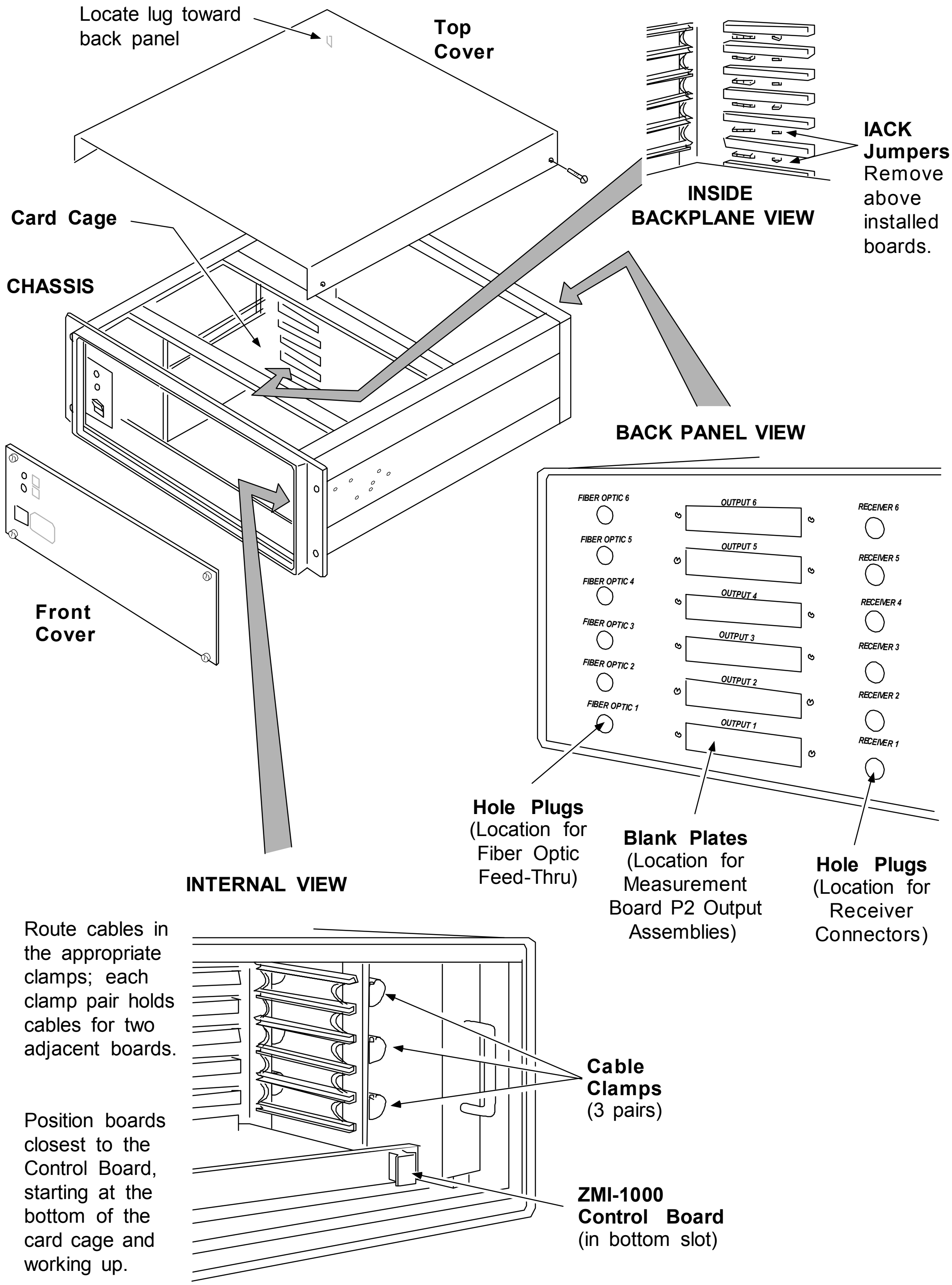
Installing the ZMI-1000 Measurement Board

WARNING!
Use proper handling techniques when touching the board to prevent it from being damaged by electrostatic discharge (ESD). The board should be stored in a static shield bag and handled only by individuals using a static control wrist grounding strap.

1. Remove the IACK P1 backplane jumpers above each slot where boards will be installed. It is not necessary to remove jumpers above unused slots.
2. Set interrupt level select jumper, JN6, on all Measurement Boards to IRQ3*, pins 5-6. Configure the rest of the switches and jumpers on the Measurement Board as described in OMP-0327, Chapter 2.
3. Insert the board into the VME backplane component side up; ensure that it is seated firmly. Thread the board front panel screws into the card cage frame.
4. Connect the laser head reference cable, identified by the "R" cable marker, to the **Ref In** connector on axis 1 Measurement Board. Connect the reference jumper cable from the **Ref Out** connector to the next Measurement Board **Ref In** connector. Ensure that each Measurement Board has an incoming reference signal.
5. To install a Measurement Board output cable assembly, see the next section.

Reinstalling Chassis Covers

1. Replace the Chassis top cover and install the four screws. Ensure that the ground lug on the cover is positioned toward the back panel.
2. Replace the Chassis front panel and tighten the four captive screws.



Installing ZMI-1000 Measurement Board Kits
Figure 2-2

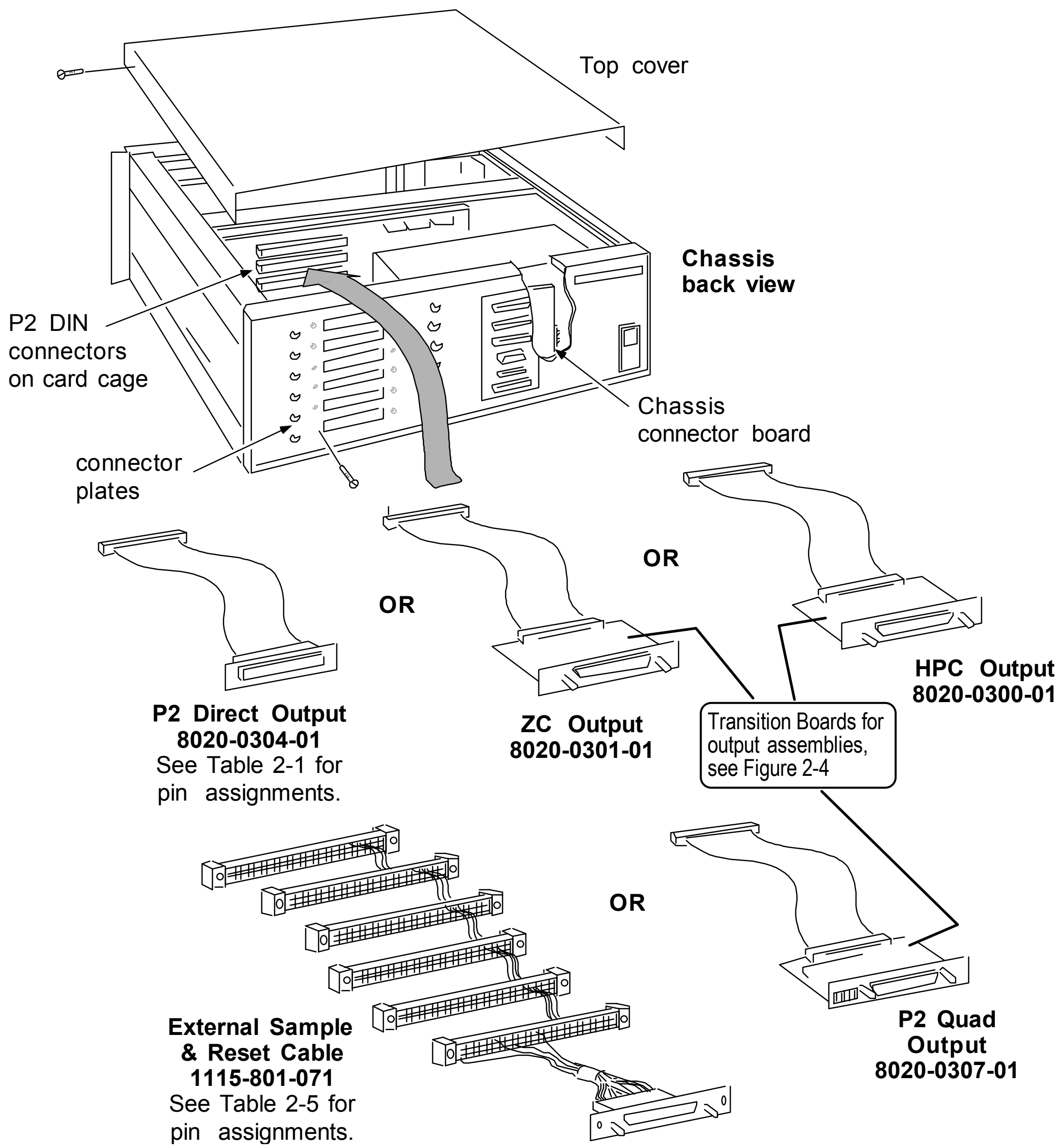
INSTALLING OUTPUT CABLE ASSEMBLIES

There are five Output Cable Assemblies available that transfer signals directly from the Measurement Board to an external device. All connect directly to the P2 connector on the card cage.

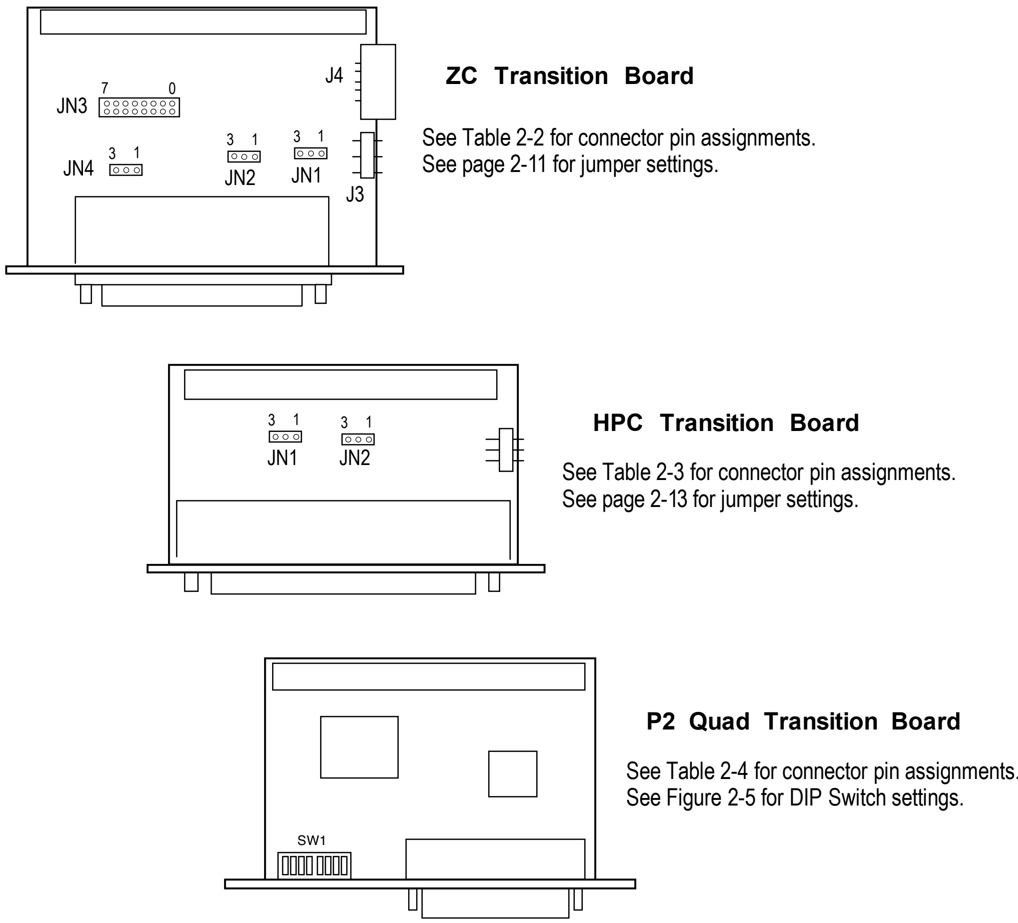
- **P2 Direct Output** Output Cable Assembly, 8020-0304-01, provides a direct transfer of P2 signals to the Chassis back panel.
- **ZYGO 2/20 Compatible (ZC) Output** Output Assembly, 8020-0301-01(31 bit mode) and 8020-0301-02 (32 bit mode), provide ZYGO 2/20 Servo port compatiblity. The ZC Output Assembly includes a transition board that connects to the Chassis back panel.
- **HP Compatible (HPC) Output** Output Assembly, 8020-0300-01, provides HP 5507A compatiblity. It includes a transition board that connects to the Chassis back panel.
- **P2 Quad Converter Output** Output Assembly, 8020-0307-01, converts 32 bit position data from the measurement board into quadrature (2 bit serial) format. This assembly includes a transition board that connects to the Chassis back panel.
- **External Sample and Reset Cable Assembly** Output Cable Assembly, 1115-801-071, connects up to six measurement boards together for common control of external sample commands.

For general installation of output assemblies, refer to Figure 2-3. Connector signal and pin assignments for all output cable assemblies are provided in Tables 2-1 through 2-5.

WARNING!
Use proper handling techniques when touching the output cable assemblies, boards, and connectors to prevent them from being damaged by electrostatic discharge (ESD). Touch components only if you are wearing a static control wrist grounding strap.



Output Assembly Connections
Figure 2-3

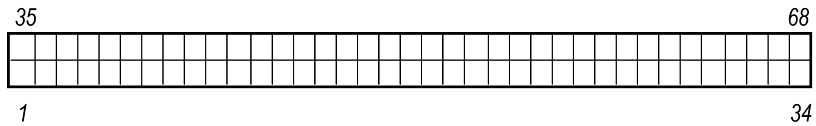


Output Assembly Transition Boards
Figure 2-4

Installing the P2 Direct Output (8020-0304-01) Assembly

Refer to Table 2-1 for signal and pin assignments.

1. Connect the cable to the card cage P2 DIN connector and latch it in place.
2. Remove the two screws from the connector plate, that corresponds to the axis number, from the hole in the Chassis back panel. It is labeled **Output *x*** (x = 1, 2, 3, 4, 5, or 6).
3. Attach the connector to the Chassis back panel with the screws from the connector plate.



Connector Pin Outs

This connector is manufactured by AMP Incorporated, Harrisburg, PA., part number 749611-7. Refer to this number if ordering a mating connector.

Pin No.	*Signal*	*Pin No.*	*Signal*	*Pin No.*	*Signal*
1	GND	24	P1	47	P20
2	64 MHz Ref	25	P2	48	GND
3	GND	26	P3	49	P21
4	64 MHz Ref*	27	P4	50	P22
5	GND	28	GND	51	P23
6	Error Out	29	P5	52	P24
7	Ref Signal Error	30	P6	53	P25
8	Meas Signal Error	31	P7	54	P26
9	Overflow Error	32	P8	55	P27
10	Window*	33	NC+	56	P28
11	GND	34	NC+	57	GND
12	Output H to L Enable*	35	P9	58	P29
13	Ext Sample*	36	P10	59	P30
14	Position Reset*	37	P11	60	P31
15	Position Hold*	38	P12	61	Select Address 2
16	Output Enable*	39	GND	62	Time Reset*
17	GND	40	P13	63	Select Address 1
18	Output/Transfer Clock	41	P14	64	Sample*
19	GND	42	P15	65	Select Address 0
20	Output Transfer Clock*	43	P16	66	GND
21	Time Reset Out*	44	P17	67	NC+
22	Velocity Error	45	P18	68	NC+
23	P0	46	P19		

+ indicates no connection   * indicates active low signal

P2 Direct Output Assembly 8020-0304-01 Pin Assignment and Signals

Table 2-1

Installing the ZC Output (8020-0301-01) Assembly

The ZC transition board converts ZMI-1000 Measurement Board P2 output signals to ZYGO 2/20 Measurement Board servo port compatible signals and connector. One ZC Assembly is required for each measurement axis. Refer to Table 2-2 for signal and pin assignments.

A ZC transition board J4 cable (1115-801-065) provides power from the Chassis connector board for up to six ZC transition boards. An optional ZC transition board common cable (8020-0404-01) may be installed to connect up to six Measurement Board POSITION RESET*, TIME RESET*, and EXTERNAL SAMPLE* signals together.

See the *ZMI-1000 Measurement Board Operation Manual*, OMP-0327, for register configuration and operation instructions. Use of the ZC Output Assembly slightly alters some of the timing specifications for the ZMI-1000 Measurement Boards' controlled data rate timing.

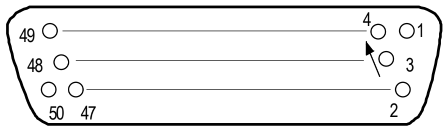
1. Connect the cable to the card cage P2 DIN connector and latch it in place.
2. Remove the two screws from the connector plate, that corresponds to the axis number, from the hole in the Chassis back panel. Connector plates are labeled **Output *x*** (x = 1, 2, 3, 4, 5, or 6).
3. Set the ZC transition board jumpers as shown below.

Function	*Jumper*	*Position*
Window* signal	JN1	1-2 enable 2-3 disable (default setting)
Transfer Clock signal	JN2	1-2 enable 2-3 disable (default setting)
Measurement Board Address	JN3	Set jumper to match axis number of corresponding Measurement Board. (1)
ZYGO 2/20 bit mode selection	JN4	1-2 31-bit mode 2-3 30-bit mode (default setting)

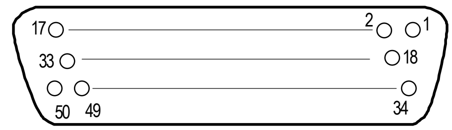
(1) The user must program the Measurement Board, Control Register 2, bits 4, 5, and 6, with the same axis number set on the ZC transition board jumper JN3. See page 3-24 in the *ZMI-1000 Measurement Board Operation Manual*, OMP-0327.

4. Attach the ZC transition board connector to the Chassis back panel with the screws from the connector plate.
5. Connect the 1115-801-065 cable to the Chassis connector board and then to each ZC transition board J4 connector. (If used, connect the optional 8020-0404-01 cable to each ZC transition board J3 connector.)

ZYGO 2/20 Servo Port Connector
DB-50 Female



ZC Output Assembly Cable Connector
DB-50 Female



Connector Pin Outs

ZYGO 2/20 Servo Port Pin No.	*ZC Output Pin No.*	*Signal*	*ZYGO 2/20 Servo Port Pin No.*	*ZC Output Pin No.*	*Signal*
1	1	GND	26	42	GND
2	34	No Connection	27	26	P13
3	18	GND	28	10	GND
4	2	Error Out	29	43	P12
5	35	Transfer Clock*	30	27	GND
6	19	No Connection	31	11	Select Address1
7	3	No Connection	32	44	GND
8	36	Output H to L Enable*•	33	28	P3
9	20	Output Enable*	34	12	GND
10	4	Position Reset*	35	45	P2
11	37	Sample*	36	29	GND
12	21	GND	37	13	P1
13	5	Select Address0	38	46	GND
14	38	GND	39	30	P0
15	22	P11	40	14	GND
16	6	GND	41	47	P7
17	39	P10	42	31	GND
18	23	GND	43	15	P6
19	7	P9	44	48	GND
20	40	GND	45	32	P5
21	24	P8	46	16	GND
22	8	GND	47	49	P4
23	41	P15	48	33	GND
24	25	GND	49	17	Select Address2
25	9	P14	50	50	GND

• indicates high-to-low

ZC Output Assembly 8020-0301-01 Pin Assignment and Signals
Table 2-2

Installing the HPC Output (8020-0300-01) Assembly

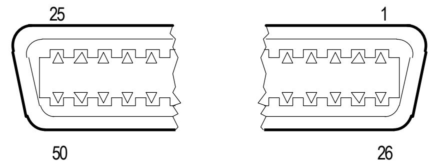
The HPC transition board converts ZMI-1000 Measurement Board P2 output signals to HP 5507A compatible signals and connector. One HPC Assembly is required for each measurement axis. Refer to Table 2-3 for signal and pin assignments.

1. Connect the cable to the card cage P2 DIN connector and latch it in place.
2. Remove the two screws from the connector plate, that corresponds to the axis number, from the hole in the Chassis back panel. It is labeled **Output *x*** (x = 1, 2, 3, 4, 5, or 6).
3. Set the HPC transition board jumpers as shown below.

Function	*Jumper*	*Position*
Output Clock* signal	JN1	1-2 enable 2-3 disable (default setting)
Window* signal	JN2	1-2 enable 2-3 disable (default setting)

4. Attach the HPC transition board connector to the Chassis back panel with the screws the connector plate.

AMP Shielded CHAMP Latch Connector



Connector Pin Out

This connector is manufactured by AMP Incorporated, Harrisburg, PA., part number 553813-3. Refer to this number if ordering a mating connector.

Pin No.	*Signal Name*	*Pin No.*	*Signal Name*
1	P8	26	P7
2	P9	27	P6
3	P10	28	P5
4	P11	29	P4
5	P12	30	P3
6	P13	31	P2
7	P14	32	P1
8	P15	33	P0
9	P16	34	P31
10	P17	35	P30
11	P18	36	P29
12	P19	37	P28
13	P20	38	P27
14	P21	39	P26
15	P22	40	P25
16	P23	41	P24
17	GND	42	GND
18	Output Clock	43	NC
19	GND	44	GND
20	Error Out	45	Output Enable*
21	GND	46	GND
22	Position Reset*	47	External Sample*
23	GND	48	GND
24	Position Hold*	49	NC
25	GND	50	GND

It is possible to connect Position Reset* pins together on all Transition Boards in the system by connecting all pins numbered 1 of the Mass Terminated Assembly (MTA) connectors on the Transition Boards. The same is true for Time Reset* and External Sample*. (See the second paragraph on page 2-11.)

HPC Output Assembly 8020-0300-01 Pin Assignment and Signals
Table 2-3

Installing the P2 Quad Converter Output (8020-0307-01) Assembly

The P2 Quad Converter Transition Board converts 32 bit, ZMI-1000 P2 output into quadrature or 2 bit serial format. Quadrature output is most easily accepted by commercially available servo controllers. One P2 Quad Assembly is required for each measurement axis.

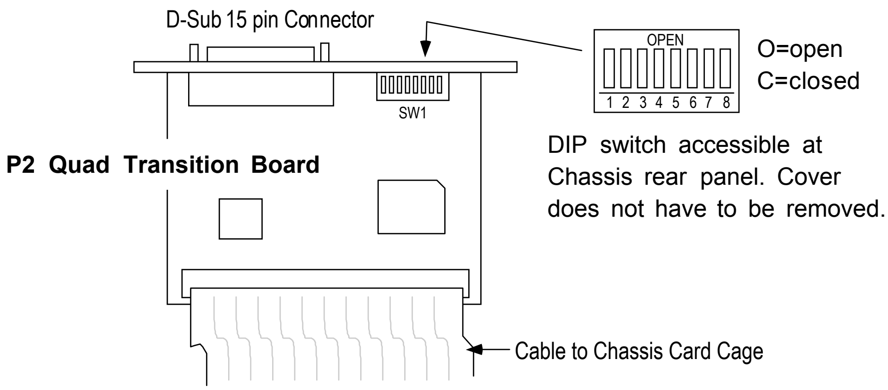
Output format, output resolution, and maximum output rate are user selectable. Output format can be changed from A/B quadrature to UP/DOWN counter signals or pulse and direction signals. Settings are made on an eight position DIP Switch on the transition board. The DIP Switch is accessible from the back panel of the ZMI-1000.

A P2 Quad Converter J1 cable, 1115-801-065, provides power from the Chassis connector board for up to six transition boards.

There are important output timing considerations when using the P2 Quad Transition Board. Refer to Figures 2-6 and 2-7.

Refer to Figure 2-3 when performing the following procedure.

1. Remove the two screws from the connector plate on the Chassis back panel that correspond to the desired measurement board. Connector plates are labeled **Output *x*** (x = 1, 2, 3, 4, 5, or 6).
2. Connect the P2 Quad Converter cable to the P2 DIN connector on the card cage that corresponds to the desired measurement board.
3. Position the Quad Converter transition board so that the 15 pin D-Sub connector passes through the connector hole on the Chassis back panel.
4. Attach the Quad Converter transition board connector to the back panel with the screws from the connector plate.
5. Connect the 1115-801-065 cable to the Chassis connector board and then to the P2 Quad Converter J1 connector.
6. Set the DIP switches as shown in Figure 2-5.



Maximum Output Rates - Switches 1, 2 & 3

Maximum Output Rates

Line MHz	*Count MHz*	*1*	*2*	*3*
4	16 (1)	C	C	C
2	8	C	C	O
1	4	C	O	C
0.5	2	C	O	O
0.25	1	O	C	C
0.125	0.5	O	C	O
0.0625	0.25	O	O	C
0.03125	0.125	O	O	O

(1) With UP/DOWN or Pulse/Direction, this setting provides Count Rate = 8 MHz

Output Resolution - Switches 4 & 5

Res. Factor	*Interferometer Output Resolutions* (2) (3)	*4*	*5*
1	λ/256 single pass, λ/512 double pass, λ/1024 four pass	C	C
1/2	λ/256*2 single pass, λ/512*2 double pass, λ/1024*2 four pass	C	O
1/4	λ/256*4 single pass, λ/512*4 double pass, λ/1024*4 four pass	O	C
1/8	λ/256*8 single pass, λ/512*8 double pass, λ/1024*8 four pass	O	O

(2) λ represents the nominal wavelength of the measurement beam (F1 = 632.991501 nm, F2 = 632.991528 nm). The actual wavelength varies due to air temperature, air pressure, and humidity.
(3) Single pass refers to Model 7002 Linear Interferometer; double pass to Models 7006, 7006A, and 7015 Plane Mirror Interferometers; and four pass to Model 7014 High Accuracy Plane Mirror Interferometer.

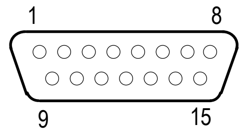
Output Format - Switches 6 & 7

Output Format	*6*	*7*
A/B Quadrature	O	C
UP/DOWN	C	C
Pulse/Direction	C	O

Output Polarity - Switch 8

Polarity	*8*
A	C
B	O
A=up, B=down	C
A=down, B=up	O
+5V=up, 0V=down	C
+5V=down, 0V=up	O

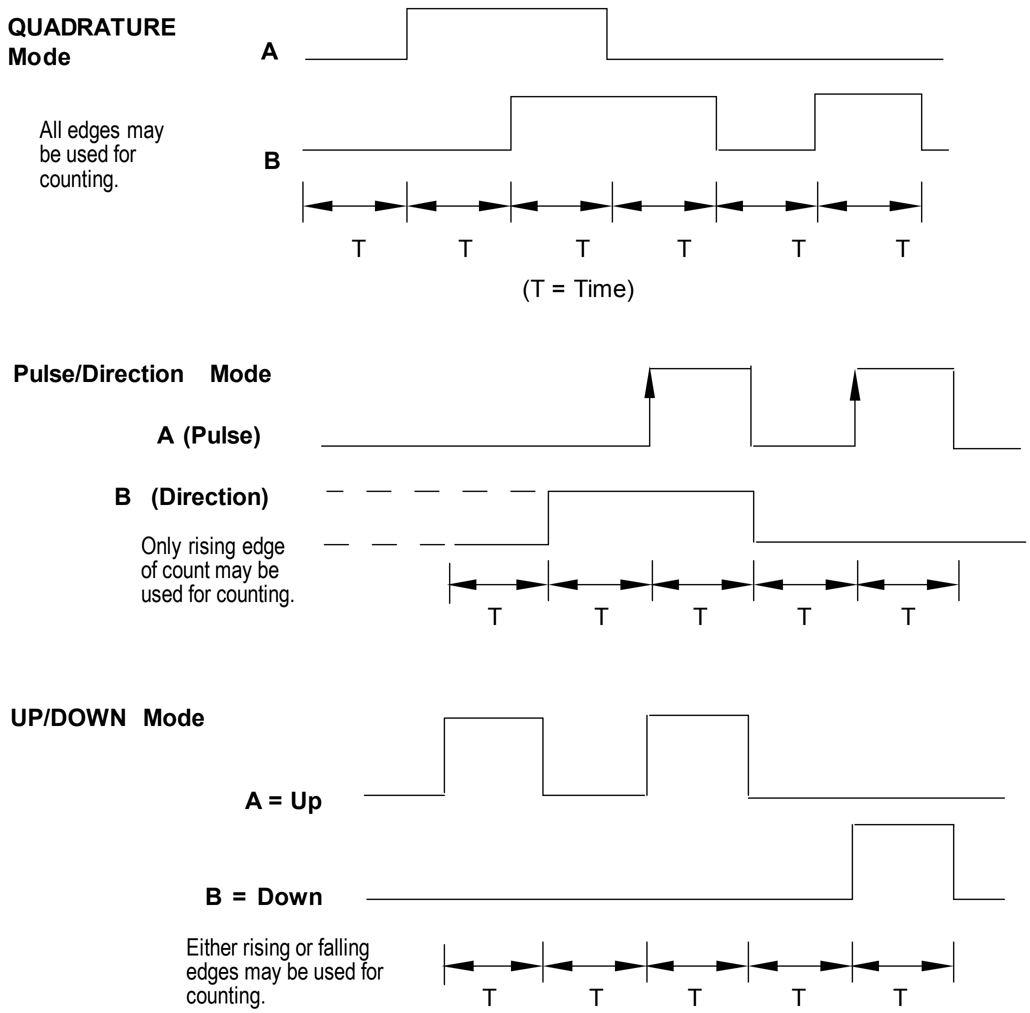
P2 Quad Transition Board DIP Switch Settings
Figure 2-5



Pin No.	*Signal Name*
1	Error* (Copy of the Measurement board error signal.)
2	Earth Ground
3	Reset* (Reset the P2 Quad Transition Board and the Measurement board position accumulator.)
4	Earth Ground
5	B* (B Quad channel or UP/Down or Direction)
6	Earth Ground
7	A* (A Quadrature channel or UP/Down or Pulse)
8	Earth Ground
9	Error (Copy of the Measurement board error signal.)
10	Signal Ground
11	Reset (Reset the Measurement board position accumulator.)
12	Signal Ground
13	B (B Quadrature Channel or UP/Down or Direction)
14	Signal Ground
15	A (A Quadrature Channel or UP/Down or Pulse)

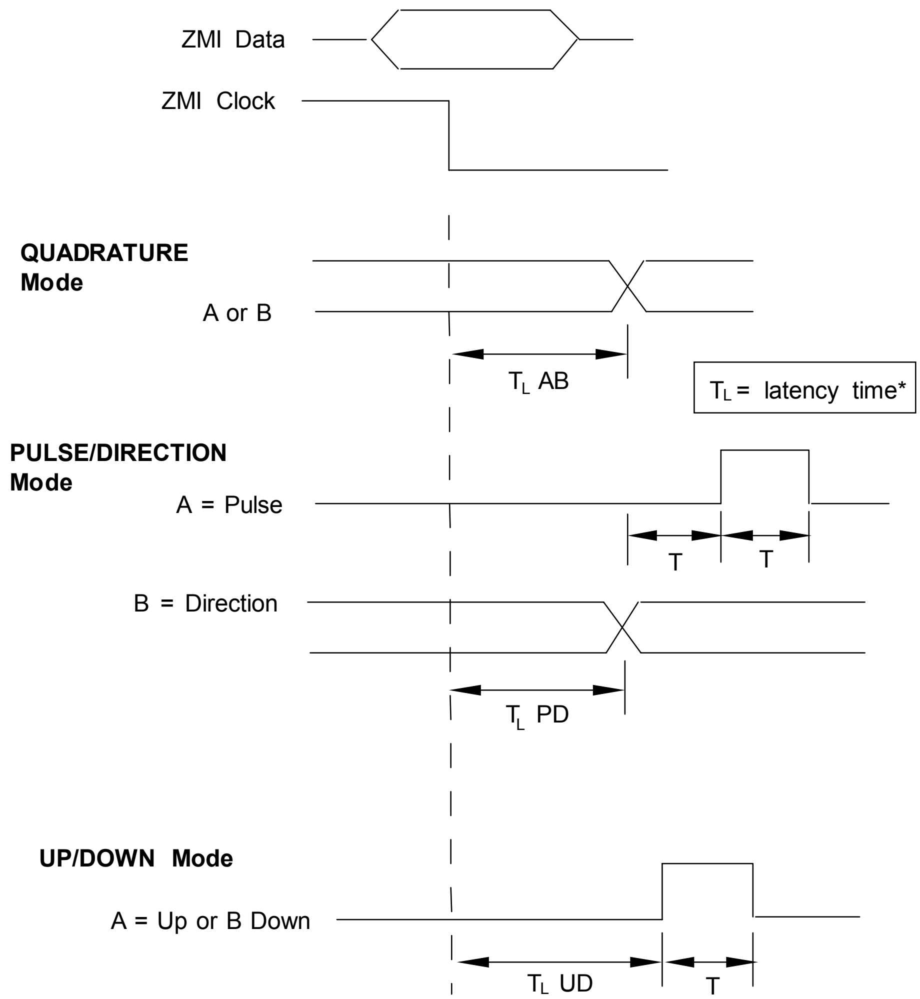
The A Quadrature channel may be changed to output count up pulses (UP,UP*) or pulse output (Pulse,Pulse*) for up/down counter operation. The B Quadrature channel may be changed to output count down pulses (DN,DN*) or direction output (Direction, Direction*) for up/down counter operation.

P2 Quad Converter Output Assembly Pin Assignment and Signals
Table 2-4



RATE	COUNT RATE		NOMINAL T	MINIMUM T	
0 0 0	16	MHz	62.5 ns	52 ns	(QUADRATURE Mode only)
0 0 0	8	MHz	125 ns	115 ns	(Pulse/Direction or UP/DOWN only)
0 0 1	8	"	125 ns	115 ns	(QUADRATURE, Pulse/Direction, or Up/Down)
0 1 0	4	"	250 ns	240 ns	
0 1 1	2	"	500 ns	490 ns	
1 0 0	1	"	1.0 µs	1.0 µs	
1 0 1	500	KHz	2.0 µs	2.0 µs	
1 1 0	250	KHz	4.0 µs	4.0 µs	
1 1 1	125	KHz	8.0 µs	8.0 µs	

P2 Quad Output Timing
Figure 2-6



C = 62.5 ns
T = Nominal Output Time (See Figure 2-6)
R = Resolution Factor (1, 2, 4, or 8)**

T_L AB (MAX) =2C+T*R
T_L AB (MIN) =3C
T_L PD (MAX) =3C+T*R
T_L PD (MIN) =4C
T_L UD (MIN) =3C+T*R
T_L UD (MIN) =4C

*Latency Time = the amount of time from when the measurement board data is available to when the P2 Quad Transition Board outputs data.

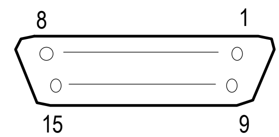
**Resolution: See Dip Switch settings 4 and 5 in Figure 2-5.

P2 Quad Latency Time
Figure 2-7

Installing the External Sample and Reset Cable Assembly (1115-801-071)

Refer to Table 2-5 for signal and pin assignments. This cable assembly connects up to six Measurement Board EXT Sample*, TIME RESET*, POS RESET, and OUPUT ENABLE* signals.

1. Connect the cable to the card cage P2 DIN connector and latch it in place.
2. Remove the two screws from the connector plate on the Chassis back panel that corresponds to the desired measurement board. Connector plates are labeled **Output *x*** (x = 1, 2, 3, 4, 5, or 6).
3. Attach the connector to the Chassis back panel with the screws from the connector plate.



Pin No.	*Signal Name*
1	Error Out 5
2	Error Out 4
3	Error Out 3
4	Error Out 2
5	Error Out 1
6	Ext Sample
7	Time Reset
8	Position Reset
9	Error Out 6
10	Output Enable
11	Ground
12	Ground
13	Ground
14	Ground
15	Ground

External Sample and Reset Cable Assembly Pin Assignment and Signals
Table 2-5

INSTALLING THE CONTROL BOARD

Typically, ZMI-1000 Control Boards are installed in the Chassis at the factory. However, if it is necessary to reconfigure or replace the board, refer to the following procedure.

WARNING!
Use proper handling techniques when touching the board to prevent it from being damaged by electrostatic discharge (ESD). The board should be stored in a static shield bag and handled only by individuals using a static control wrist grounding strap.

1. Configure DIP switches as described the section titled "DIP Switch Settings".
2. Insert the board into the VME backplane component side up; ensure that it is seated firmly. Thread the captive front panel screws into the card cage frame.

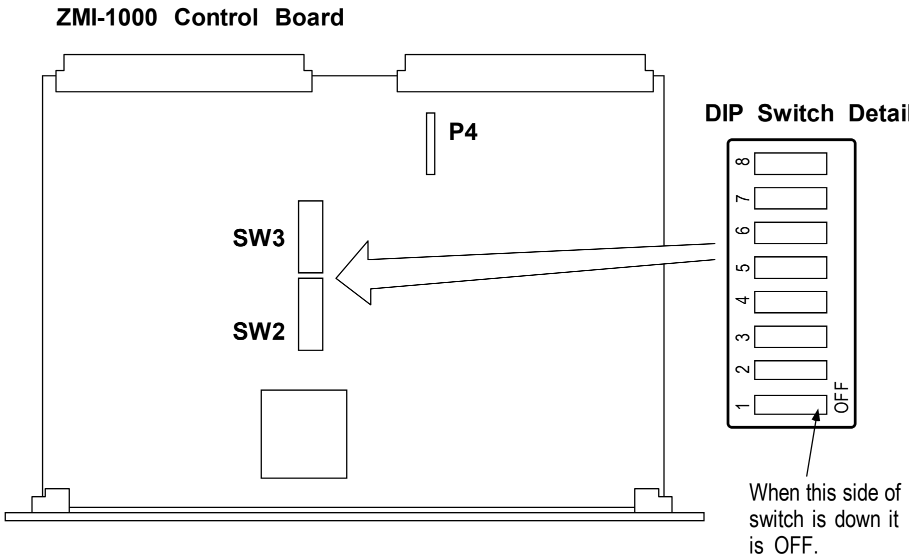
The Control Board coordinates the measurement output of the installed Measurement Boards and relays this information through the IEEE 488 port or the RS232 port to a host computer.

DIP Switch Settings

Two 8-position DIP switches, SW2 and SW3, control the interface port settings for the ZMI-1000 Control Board. Table 2-6 shows the DIP Switch assignments. Figure 2-6 shows their location on the board.

Switch	*Position*	*Function*
SW2	1, 2, 3, 4, 5	Selects GPIB address.
SW2	6, 7	Reserved.
SW2	8	Disable/enable ZMI-1000 interrupt handler.
SW3	1	Enable/disable Control Board power-on self test.
SW3	2	Reserved.
SW3	3, 4, 5	RS232C Control port baud rate.
SW3	6, 7, 8	RS232C diagnostic terminal port baud rate.

Table 2-6 Control Board DIP Switch Assignments



Control Board DIP Switch Locations
Figure 2-8

Default Settings

The default settings of the DIP switches are:

SW2								SW3							
1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
off	off	off	on	on	off	off	off	off	-	on	off	on	on	off	on

SW2 and SW3 Definitions

SW2 determines the GPIB address and VME functions as shown below.

SW2 Switch	1	2	3	4	5
GPIB address value when ON	16	8	4	2	1

For example, when switches 1-5 are set to - OFF/OFF/OFF/ON/ON - the GPIB address is 3.

SW2 Switch	6	7	8
Function when ON	Reserved	Reserved	Disable VME interrupt handler

SW2 positions 6 and 7 are set at Zygo and should not be changed. SW2 position 8 enables or disables the Control Board VME interrupt handler; set to OFF for the Control Board to process Measurement Board interrupts. This feature is used with the External Sample command set described in Chapter 3.

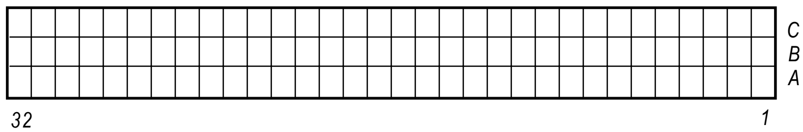
SW3, position 1, when ON the Control Board performs self test each time the power is turned on or the front panel RESET button is pressed. SW3, positions 3 through 8, determine the baud rate for the RS-232 ports as shown below. Note that SW3, position 2, is not used.

	RS232 Control Port			*Diagnostic Terminal Port*		
Baud Rate	3	4	5	6	7	8
100	off	off	off	off	off	off
300	off	off	on	off	off	on
1200	off	on	off	off	on	off
2400	off	on	on	off	on	on
4800	on	off	off	on	off	off
9600	on	off	on	on	off	on
19200	on	on	off	on	on	off
reserved	on	on	on	on	on	on

Control Board P1 and P2 Pin Assignments

VME signal pins on the Control Board P1 connector are shown in Table 2-7. VME signal pins that are not used by the Control Board are not connected and are indicated by a dash (–).

P1 Connector Pin Out - Pin View

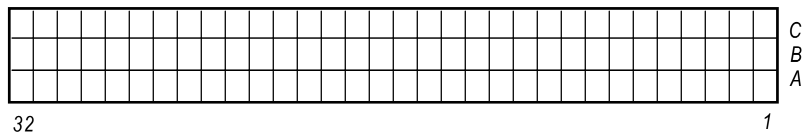


Pin #	*Row A*	*Row B*	*Row C*
1	D0	BSSY*	D8
2	D1	-	D9
3	D2	-	D10
4	D3	-	D11
5	D4	-	D12
6	D5	-	D13
7	D6	-	D14
8	D7	-	D15
9	GND	-	GND
10	SYSCLK	BG3*	-
11	GND	BG3OUT*	BERR*
12	DS1*	-	SYSRESET*
13	DS0*	-	-
14	WRITE*	-	AM5
15	GND	BR3*	A23
16	DTACK*	AM0	A22
17	GND	AM1	A21
18	AS*	AM2	A20
19	GND	AM3	A19
20	IACK*	GND	A18
21	IACKIN*	-	A17
22	IACKOUT*	-	A16
23	AM4	GND	A15
24	A7	-	A14
25	A6	-	A13
26	A5	-	A12
27	A4	-	A11
28	A3	IRQ3*	A10
29	A2	IRQ2*	A9
30	A1	IRQ1*	A8
31	-	-	-
32	+5V	+5V	+5V

Table 2-7 P1 Pin Assignment

The Control Board P2 connector pin assignments are shown in Table 2-8.

P2 Connector Pin Out - Pin View



Pin #	*Row A*	*Row B*	*Row C*
1	GND	+5V	V_BIAS
2	Trigger Input +	GND	Trigger Input -
3	User Input 0 +	RESERVED	User Input 0 -
4	User Input 1 +	-	User Input 1 -
5	User Input 2 +	-	User Input 2 -
6	GND	-	GND
7	Error Output	-	User Output 0
8	User Output 1	-	User Output 2
9	User Output 3	-	User Output 4
10	Reserved	-	GND
11	GND	-	GND
12	RxD_LH	GND	TxD_LH
13	GND	+5V	GND
14	RxD_DT	-	TxD_DT
15	GND	-	GND
16	GND	-	DCD0
17	DSR0	-	DTR0
18	RTS0	-	CTS0
19	RxD0	-	TxD0
20	GND	-	GND
21	DIO5	-	DIO1
22	DIO6	GND	DIO2
23	DIO7	-	DIO3
24	DIO8	-	DIO4
25	REN	-	EOI
26	GND	-	DAV
27	GND	-	NRFD
28	GND	-	NDAC
29	GND	-	IFC
30	GND	-	SRQ
31	GND	GND	ATN
32	GND	+5V	NC

Table 2-8 P2 Pin Assignment

CHASSIS CONNECTOR PANEL PIN ASSIGNMENTS

Located on the back panel of the Chassis is a "connector panel" for interfacing to other equipment. These connectors are described in Table 2-9. The pin assignments are shown in Figure 2-9.

Name	*Connector Type*	*Connects to…*
IEEE 488	GPIB, 24-pin	Host computer
RS232	DB-25 receptacle	Host computer
DIAGNOSTIC TERMINAL	DB-9 receptacle	Optional "help" terminal
DISCRETE I/O	DB-15 receptacle	User I/O signals
LASER HEAD	DB-25 receptacle	Zygo's Laser Head

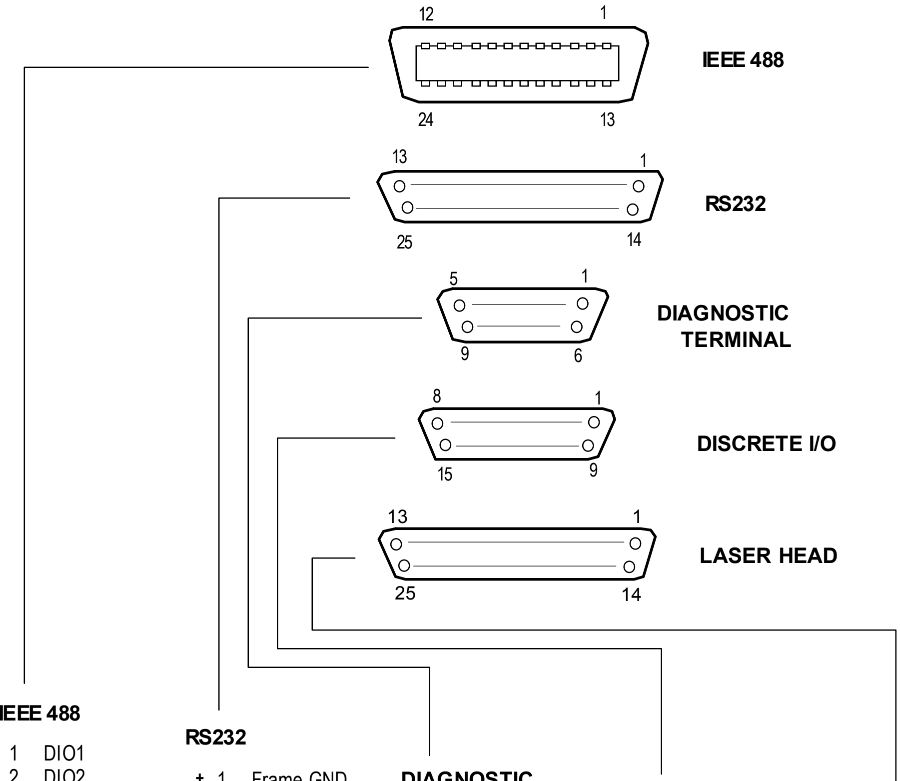
Table 2-9 Chassis Connectors

RS-232 Serial Port Parameters

The default parameters for both RS-232 serial ports are listed in Table 2-10.

	RS232	*DIAGNOSTIC TERMINAL*
Function	RS-232 port for connection to host or control computer.	RS-232 port for connection to VT100 display terminal for Help screens.
Connector type	DB-25 female	DB-9 female
Parameters	8-bit, no parity, 1 stop bit	8-bit, no parity, 1 stop bit
Protocol	XON/XOFF	XON/XOFF
Baud Rate	9600, change with SW3 (3-4-5)	9600, change with SW3 (6-7-8)
Miscellaneous parameters	Full duplex, carriage return and line feed termination, local echo on	Full duplex, carriage return and line feed termination, local echo off

Table 2-10 Serial Port Parameters



IEEE 488

Pin	Signal
1	DIO1
2	DIO2
3	DIO3
4	DIO4
5	EOI*
6	DAV*
7	NRFD*
8	NDAC*
9	IFC*
10	SRQ*
11	ATN*
12	Main Shield
13	DIO5
14	DIO6
15	DIO7
16	DIO8
17	REN*
18	GND
19	GND
20	GND
21	GND
22	GND
23	GND
24	Signal GND

RS232

	Pin	Signal
‡	1	Frame GND
‡	2	RxD
‡	3	TxD
	4	CTS
	5	RTS
	6	DSR
‡	7	Signal GND
	8	DCD
	20	DTR

DIAGNOSTIC TERMINAL

Pin	Signal
2	RxD
3	TxD
5	Signal GND

DISCRETE I/O

Pin	Signal
1	Reserved
2	Reserved
3	User Input0
4	User Input0*
5	User Input1
6	User Input1*
7	User Input2
8	User Input2*
9	GND
10	Error Output*
11	User Output0
12	User Output1
13	User Output2
14	V_BIAS
15	Main Shield

LASER HEAD

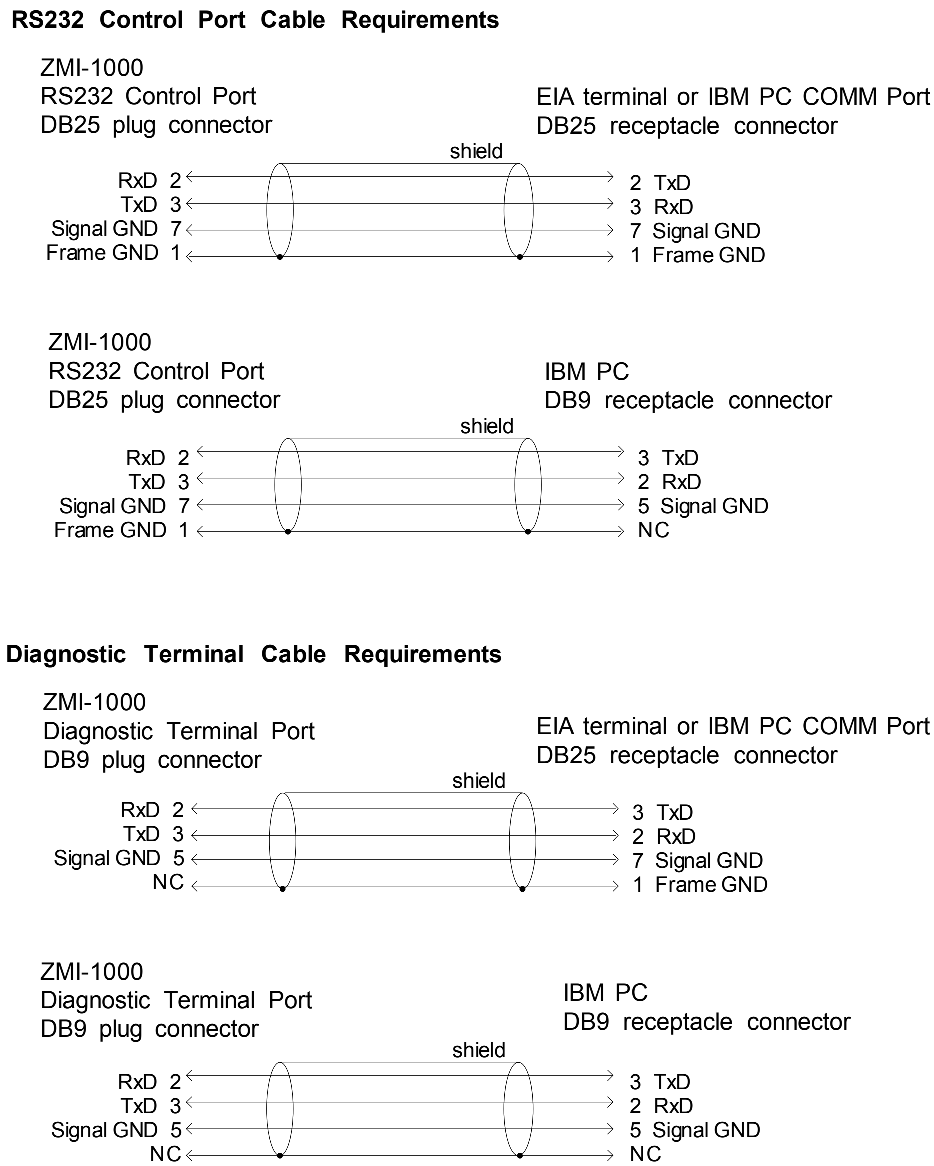
Pin	Signal
1	RTS
2	CTS
3	DSR
4	DTR
5	TxD
6	RxD
7	GND
8	GND
9	GND
10	ECL Shield
11	REF
12	-15V
13	-15V
14	+15V
15	TTL REF
16	TTL REF*
17	Service*
18	Unstable*
19	LTO*
20	LTO
21	+15V
22	ECL REF
23	ECL REF*
24	REF Shield
25	Main Shield

‡ minimum requirement for software handshake.

Chassis Connector Panel Pin Assignments
Figure 2-9

RS-232 Minimum Cable Requirements

Zygo recommends that all cables are shielded, and that the shields are connected to a metal back shell.



RS-232 Cable Requirements
Figure 2-10

CONTROL BOARD DISCRETE I/O

Three discrete inputs and three discrete outputs are available to the user through the Discrete I/O connector on the Chassis back panel.

Using the Discrete Inputs

The inputs are level sensitive and are sampled by the firmware. They are differential pairs received on the Control Board by 26LS32A differential RS422 line receivers.

Zygo recommends driving the inputs with a differential pair for best performance. However, single ended TTL level signals can be used by connecting the V_BIAS output signal on pin 14 to one of the differential inputs and connecting the external signal to the other input. See Table 2-11 for different operation configurations using V_BIAS. Remember to connect the GND signal on pin 9 to the host system ground to establish a common reference.

V_BIAS connected to:	*External Signal connected to:*	*External Signal Level*	*Input Level read by Control Board*
input -	input +	0	0
input -	input +	1	1
input +	input -	0	1
input +	input -	1	0

V_BIAS Configurations
Table 2-11

The discrete input states can be read with the INPUT? command and used as a trigger for the MTSAMPLE command. See Chapter 4.

Using the Discrete Outputs

The discrete outputs are driven by 7407 open collector drivers. The Control Boards are shipped from Zygo with a SIP resistor pack installed in the on board connector, P4. The SIP pack pulls each output up to +5 volts through a 470 ohm resistor. See figure 2-9 for the P4 connector location.

The outputs may be pulled up to different voltages by removing the SIP pack then pulling up the outputs through a resistor externally. Remember to limit the sink current to less than 40 milliamps and not to exceed +30 volt DC, as dictated by the 7407 specification. Also, connect the GND signal on pin 9 to the external power supply ground to establish a common reference.

The discrete outputs are high at power-on reset. The OUTPUT command controls the discrete outputs. See Chapter 4.

Using the Error Output

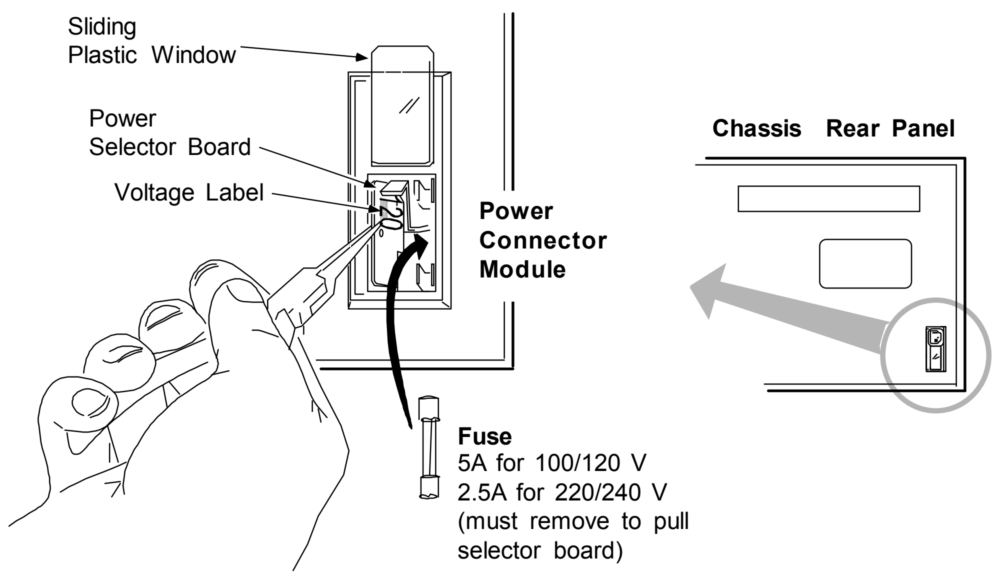
The discrete error output is also driven by a 7407 open collector driver and is also pulled up by the SIP resistor pack installed in P4. This output is set low when the Control Board registers an error condition. Issuing the *CLS or ERROR? commands reset this output. The output is also cleared by a power-on reset or the RESTART command. This output can be used to priority interrupt the host computer in the event of an ZMI-1000 error.

CHASSIS AC LINE VOLTAGE SELECTION

The ZMI-100 Chassis can be set to operate at 100, 120, 220, or 240 VAC by configuring the power connector module located on the rear of the Chassis. Follow the procedure below and refer to Figure 2-11.

> **WARNING!**
> **The power connector module configuration sets the operating voltage for the Chassis. If the module is set incorrectly, electronic components may be damaged when power is applied.**

1. Locate the power connector module at the lower right side of the Chassis rear panel.
2. Unplug the power cord; then slide the plastic window out of the way.
3. Make sure that the fuse in the power module is rated for 5A if the line voltage is 100 or 120 VAC, or 2.5A if the voltage is 220 or 240 VAC.
4. Next to the fuse in the module there is a small circuit (power selector) board with a number visible. This number *must* match the incoming line voltage. If the number shown is correct, slide the plastic window in place and go to step 9. If the voltage shown is incorrect complete steps 5 through 8.
5. Remove the line fuse by pulling out the black plastic tab labeled “FUSE PULL”.
6. Pull the power selector board from its slot with a needle-nose pliers as shown in Figure 2-10.
7. Orient the board so the correct voltage label is visible and replace the board in the slot. Be sure it is pushed in all the way.
8. Install the correct fuse as explained in step 3; then slide the plastic window in place.
9. Plug the power cord into the Chassis.



Configuring the Chassis for Incoming Voltage

Figure 2-11

Chapter 3

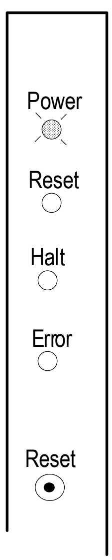
OPERATION

In This Chapter

- Control Board LED's
- Overview
  ZMI-1000 Sample Data Acquisition Programs
- Using the Diagnostic Terminal
  - Example Diagnostic Terminal Session
- ZMI-1000 Service Requests
- ZMI-1000 External Sample

CONTROL BOARD LED's

The Control Board indicator lights are shown in Figure 3-1. Control Board operation is explained in the remainder of this Chapter.



Power LED - when on indicates board is receiving +5 volts; green.

Reset LED - when on indicates a hardware Reset is active; red.

Halt LED - when on indicates the microprocessor has stopped and the board is not functioning; amber.

Error LED - when on indicates that an error has occurred but the board is still functional; red. At power-on (if SW3, switch 1 is on) and during the *TST? command, this LED will flash once if the EPROM test is okay; twice if the SRAM test is okay, and three times if the EEPROM test is okay. *CLS and ERROR? commands will turn off this LED.

Reset Switch - when pressed performs a hardware reset of the board to clear error conditions.

During Normal operation only the Power LED is on.

Control Board LED's
Figure 3-1

OVERVIEW

This chapter describes some of the operational features of the ZMI-1000 system. The hardware connection and configuration of the Control Board is described in Chapter 2.

It is necessary for you to write and execute a program on your host computer to get data to and from the VMEbus measurement system to a host computer through the ZMI-1000 Control Board IEEE-488 or RS-232 interface. Your customized program must use the set of commands described in Chapter 4. These commands execute software stored in EPROM on the ZMI-1000 Control Board.

The software performs the following functions:

Component	*Functions*
ZMI-1000 Control Board	• Configures after power-on reset. • Interfaces with a host computer. • Reads and writes to user VMEbus boards. • Tests after power-on reset or on command.
ZMI-1000 Measurement Board	• Configures after power-on reset or on command. • Reads measurement data. • Reads status. • Writes control information.
Diagnostic Terminal	• Outputs device status.

While it is possible for the ZMI-1000 to receive commands from both the IEEE-488 and RS232 control ports, Zygo does not recommend this configuration, because of the complexity involved in synchronizing the host computers and ZMI-1000.

ZMI-1000 Sample Data Acquisition Programs

Appendix A of this manual contains sample programs that show the steps involved in acquiring position data from the ZMI-1000. These programs are intended to be used as programming aids. The programs do not include steps for presenting data, storing data to disk, or analyzing data.

A menu driven program is available from Zygo and is explained in the ZMI-1000 PC Software Application Manual, OMP-240.

USING THE DIAGNOSTIC TERMINAL

A VT100 display terminal connected to the Chassis Diagnostic Terminal port serves as a simple tool to set up and check the ZMI system. Set the parameters of the terminal to those listed in Table 2-10. The terminal is used by entering commands and reading the output.

The Diagnostic Terminal can also be used to help debug the host computer program because it displays the received commands and the ZMI-1000 responses sent. It does, however, slow down the ZMI-1000 and is recommended as a diagnostic tool only. Data output to the diagnostic terminal can take so long that the GPIB card in the host may timeout and loose sync with the ZMI-1000 when using the FORMAT E or FORMAT F commands with MTSAMPLE?, SAMPLE?, or EXSAMPLE?, and a large number of data points. To avoid this problem, temporarily increase the host GPIB timeout time and decease the ZMI-1000 number of data points to a very small value.

To activate the diagnostic port, press any terminal key. A summary of some diagnostic functions are listed below.

Function	*Type*
Get Help Screen	**h** <CR>
Enter a single command	**c** zmi command <CR>
Enter multiple commands	**cc** <CR> zmi command zmi command etc…
Quit multiple commands	<ESC>
Toggle status reports	**t** status code <CR>
List status codes	**t** <CR>
Device clear	<ctrl>**C** or **SC** <CR>
Turn off diagnostic port	**q** <CR>
Delete previous character sent	<backspace>

Example Diagnostic Terminal Session

```
Zygo VME Bus Control Board Diagnostic Monitor (Software Version = D)

> h
C <command>   SEND A COMMAND TO THE INSTRUMENT
CC            SEND COMMANDS TO THE INSTRUMENT
SC            SEND A DEVICE CLEAR TO THE INSTRUMENT
T <item>      TOGGLE THE REPORTING OF AN ITEM (JUST TYPE T FOR LIST OF
ITEMS)
H             SHOW HELP
Q             QUIT (TURN THE DIAGNOSTICIAN OFF)
> t
SPECIFY              TO TOGGLE REPORTING OF
-------   ---------------------------------------------
  CR        COMMANDS RECEIVED
  RS        COMMAND RESPONSES SENT
  CE        COMMAND EXECUTION
  EV        CHANGES TO THE STANDARD EVENT STATUS REGISTER
> c READ? 1,G
SENDING "READ? 1,G"

FETCHED COMMAND:        "READ? 1,G"
EXECUTING COMMAND:      READ?
SENT RESPONSE DATA:     176.         31  37  36  0A

> t cr
  REPORTING OF COMMANDS RECEIVED OFF
> t ce
  REPORTING OF COMMAND EXECUTION OFF
> c READ? 1,G
SENDING "READ? 1,G"

SENT RESPONSE DATA:     176.         31  37  36  0A

> Q



Zygo VME Bus Control Board Diagnostic Monitor (Software Version = D)

> c *OPT?
SENDING "*OPT?"

FETCHED COMMAND:        "*OPT?"
EXECUTING COMMAND:      *OPT?
SENT RESPONSE DATA:     SW2 18,SW3   53  57  32  20  31  38  2C  53  57  33
                         2D,MB1 10   20  32  44  2C  4D  42  31  20  31  30
                        0,MB2 0,MB   30  2C  4D  42  32  20  30  2C  4D  42
                        3 0,MB4 0,   33  20  30  2C  4D  42  34  20  30  2C
                        MB5 0,MB6    4D  42  35  20  30  2C  4D  42  36  20
                        0.           30  0A
```

```
> c *idn?
SENDING "*idn?"

FETCHED COMMAND:        "*idn?"
EXECUTING COMMAND:      *IDN?
SENT RESPONSE DATA:     Zygo,VMEbu   5A  79  67  6F  2C  56  4D  45  62  75
                        s Control    73  20  43  6F  6E  74  72  6F  6C  20
                        Board,004,   42  6F  61  72  64  2C  30  30  34  2C
                        D.           44  0A

> cc
TO SEND A DEVICE CLEAR, JUST PRESS <ENTER>
PRESS <ESC> TO QUIT

COMMAND> *opt?

FETCHED COMMAND:        "*opt?"
EXECUTING COMMAND:      *OPT?
SENT RESPONSE DATA:     SW2 18,SW3   53  57  32  20  31  38  2C  53  57  33
                         2D,MB1 10   20  32  44  2C  4D  42  31  20  31  30
                        0,MB2 0,MB   30  2C  4D  42  32  20  30  2C  4D  42
                        3 0,MB4 0,   33  20  30  2C  4D  42  34  20  30  2C
                        MB5 0,MB6    4D  42  35  20  30  2C  4D  42  36  20
                        0.           30  0A

COMMAND> *idn?

FETCHED COMMAND:        "*idn?"
EXECUTING COMMAND:      *IDN?
SENT RESPONSE DATA:     Zygo,VMEbu   5A  79  67  6F  2C  56  4D  45  62  75
                        s Control    73  20  43  6F  6E  74  72  6F  6C  20
                        Board,004,   42  6F  61  72  64  2C  30  30  34  2C
                        D.           44  0A

COMMAND> READ? 1,g

FETCHED COMMAND:        "READ? 1,g"
EXECUTING COMMAND:      READ?
SENT RESPONSE DATA:     176.         31  37  36  0A

COMMAND> READ? 1,H

FETCHED COMMAND:        "READ? 1,H"
EXECUTING COMMAND:      READ?
SENT RESPONSE DATA:     8192.        38  31  39  32  0A

COMMAND> read? 1,I

FETCHED COMMAND:        "read? 1,I"
EXECUTING COMMAND:      READ?
SENT RESPONSE DATA:     256.         32  35  36  0A

COMMAND>
```

ZMI-1000 SERVICE REQUESTS

The ZMI-1000 can be configured to request service from the host on any of the following conditions:

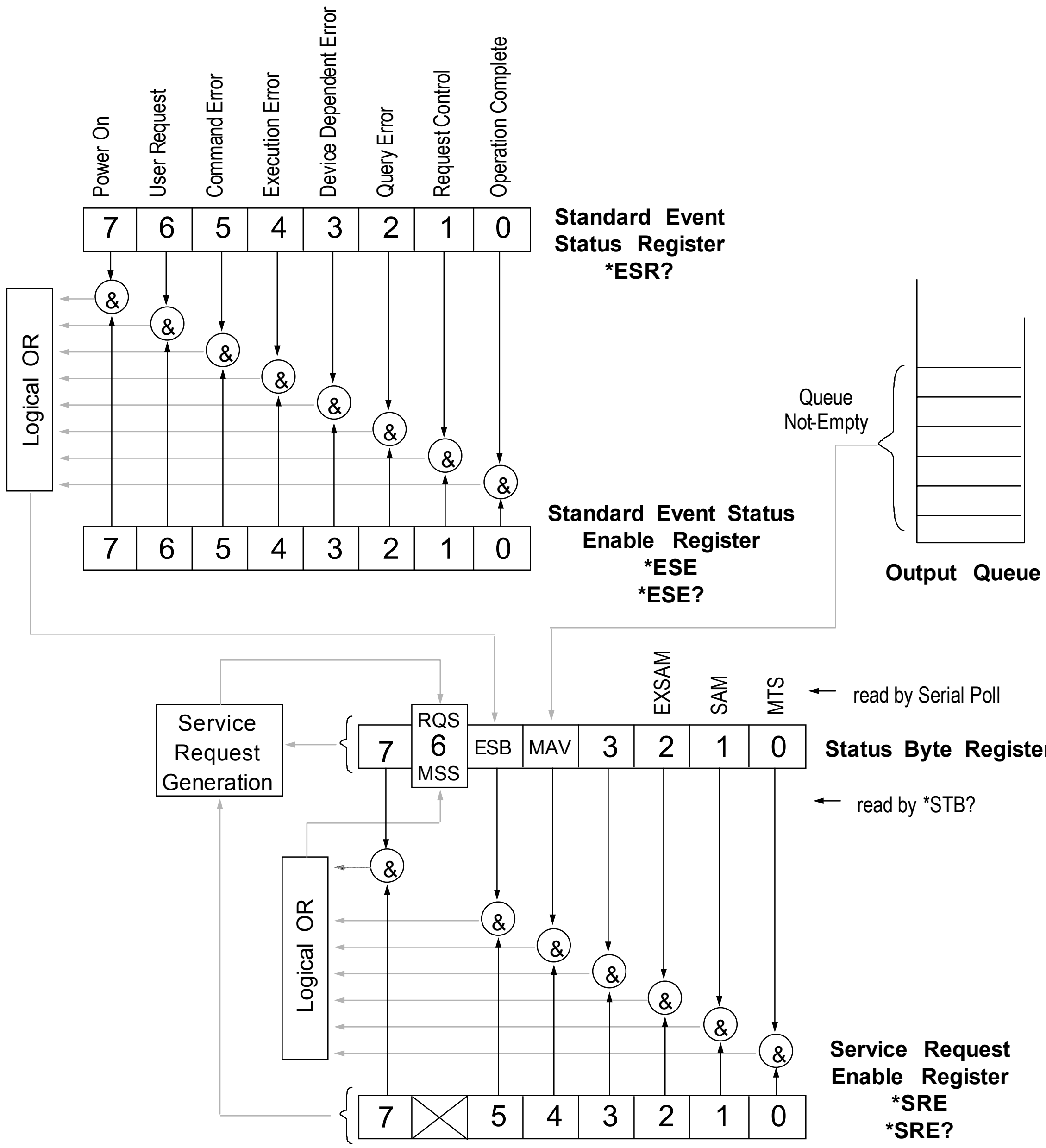
- Error detection
- SAMPLE command complete
- MTSAMPLE command complete
- EXSAMPLE buffer half full

When using the IEEE 488 interface, the Control Board issues a service request, SRQ, to the host. If more than one device is connected to the interface, then host responses by performing a serial poll to determine which device requested service. If the ZMI-1000 is the only device connected to the interface, then the host reads the status byte using the *STB? command to determine what event cause the SRQ.

When using the RS232 control port, the Control Board outputs the ASCII escape character, 0x1B, to request service from the host. Because the ZMI-1000 is the only device connected to the serial port, the host simply determines what event cause the service request by reading the status byte.

An SRQ is issued when one or more of the 7 maskable bits in the Status Byte Register is set and the corresponding Service Request Enable Register is also set. The Service Request Enable Register is programmed with the *SRE command and can be read with the *SRE? command.

Figure 3-2 depicts the interaction between the Standard Event Status Register, the Standard Event Status Enable Register, the Service Request Enable Register, and the Status Byte Register.



Service Request Interaction
Figure 3-2

Status Byte

As mentioned before, the status byte can be read with the *STB? command. Tables 3-1 and 3-22 describe the individual status bits. See the IEEE 488.2 specification for more details.

MSB							LSB
7	6	5	4	3	2	1	0

Table 3-1 Bit Order

Bit Number	*Bit Mnemonic*	*Status Indication When Bit Is Set*
0	MTS	MTSample command data collection complete.
1	SAM	SAMple command data collection complete.
2	EXSAM	EXSAMple command data buffer half full.
3		Reserved
4	MAV	Message AVailable in the send buffer.
5	ESB	Event Status Bit summary message is the result of a logical AND between the standard event status register and the standard event status enable register.
6	RQS or MSS	ReQuest Service indicates if SRQ bus signal is active. Master Summary Status indicates that there is one or more reasons to request service.
7		Reserved

Table 3-2 Status Byte Register Bit Definitions

Standard Event Status Register

The standard event status register provides status on the operations of the device. Tables 3-1 and 3-3 describe the individual status bits. See the IEEE 488.2 specification for more details.

Bit Number	*Bit Mnemonic*	*Status Indication When Bit Is Set*
0	OPC	OPeration Complete - used in conjunction with the *OPC command to determine when all operations are complete.
1	RQC	Reserved
2	QYE	QuerY Error - indicates when a query error has occurred.
3	DDE	Device Dependent Error - indicates when a device dependent error has occurred.
4	EXE	EXecution Error - indicates when a execution error has occurred.
5	CME	CoMmand Error - indicates when a command error has occurred.
6	URQ	Reserved
7	PON	Power On indicates device power has made a off-to-on cycle.

Table 3-3 Standard Event Status Register Bit Definitions

Detecting ZMI-1000 Errors Using SRQ

There are three different methods to detect errors during operation.

1) The host software can read the standard event status register using *ESR? or the read the error number using ERROR? after each command to determine if an error has occurred.
2) The discrete Error Out* signal can be connected to the host. The host can then sample this signal or interrupt on this signal. The host knows an error occurred when the signal goes active.
3) The host can configure the ZMI-1000 to issue an SRQ when an error occurs. To accomplish this the host must issue the following commands:

   *ESE 60
   *SRE 32

Now, the host can read the error number using the ERROR? command when the SRQ signal goes active.

Detecting MTSAMPLE or SAMPLE Data Collection Complete Using SRQ

The SRQ signal can be used to interrupt the host when a MTSAMPLE or a SAMPLE data collection process has finished. To accomplish this the host must issue one the following commands, depending on sampling method used.

*SRE 1 for MTSAMPLE
or
*SRE 2 for SAMPLE

The host can perform other operations while waiting for the data collection process to finish. The Control Board will set the SRQ signal active when data collection is complete. The host then issues MTSAMPLE? or SAMPLE? to retrieve the data.

When using MTSAMPLE, the host may enable the execution error bit in the standard event status enable register and the ESB bit in the service request enable register. Thus, the Control Board will generate an SRQ if the MTSAMPLE command timed out while waiting for a trigger.

Detecting EXSAMPLE Buffer Half Full Using SRQ

If enabled, the EXSAMPLE data collection routines will activate SRQ when the data collection buffer is half full. Using this technique, the host can perform other operations while waiting for data. When the buffer is half full, the Control Board will issue an SRQ. The host can then determine the number of samples in the buffer using the EXSTATUS? command and read the data using the EXSAMPLE? command. The host must issue the following command to enable this feature.

*SRE 4

ZMI-1000 EXTERNAL SAMPLE

The EXSAMPLE command set allows the user to collect position or time and position data from one to six ZMI-1000 Measurement Boards. An external signal strobes the Measurement Board External Sample* P2 connector pins to capture a data point. The Control Board reads the data from the Measurement Boards and stores it in a ring buffer. The host computer may read the data at will.

Hardware Configuration for External Sample

Set the interrupt level select jumper, JN6, on all Measurement Boards to IRQ3* (pins 5 and 6). Connect all External Sample* inputs together. Remove the IACK backplane jumpers positioned between slots with installed boards. Configure the rest of the system using the standard setup procedure. Set position 8 of SW2 to OFF to enable the Control Board's VME interrupt handler.

The customer connects the External Sample* and GND signals to the host system. The External Sample* signal must be driven by a TTL compatible driver. An optional Zygo cable assembly, 1115-801-071, interconnects the Measurement Board External Sample*, Position reset*, and Time Reset* signals together. This cable connects these signals along with the individual Measurement Board Error Out signals to a DB-25 receptacle mounted to the Chassis back panel.

Overview of External Sample

System Initialization

Issue the EXSAM command from the host computer. The Control Board then: configures its internal pointers, registers, and circular data buffer; configures the selected Measurement Boards for external sample; enables one Measurement Board to generate an interrupt on external sample; enables its corresponding on-board interrupt; and returns to normal command processing.

Data Collection and Storage

Activate External Sample* signal from the host system. The Measurement Boards latch the current position and time values. A designated Measurement Board generates a VME interrupt. The Control Board then: starts interrupt processing by disabling all other on-board interrupts; reads the position and time registers, storing the data in the circular buffer; updates the data value counter and pointers; initiates an SRQ if the buffer became half full at the end of the current read; processes an error if the buffer was overrun at the end of the current read; and enables all other on-board interrupts.

Data Retrieval

Issue the EXSTATUS? command from the host computer. The Control Board responds by outputting the number of data samples currently in the buffer.

Issue the EXSAMPLE? command with the desired number of data samples from the host. The Control Board responds by outputting the desired number of samples in the format selected by the FORMAT command.

External Sample Termination

Issue the EXEND command from the host. The Control Board then: terminates any pending SRQ's; disables the Measurement Board VME interrupt; disables the Measurement Boards external sample; disables the on-board interrupt; clears the pointers and buffers; and returns to normal command processing.

External Sample Limitations

The speed at which the Control Board can save Measurement Board data and the amount of GPIB and RS232 activity will determine the maximum sampling rate. Table 3-4 shows the sampling rates Zygo was able to achieve using a 486/66 MHz PC computer with a National Instruments AT-GPIB/TNT card and the indicated number of Measurement Boards. Both time and position data were collected from each board.

Number of Measurement Boards	*Max. Continuous External Sampling Rate*
1	2300 Hz
2	1200 Hz
3	810 Hz
4	620 Hz

Table 3-4 Typical External Sample Rates

The Control Board firmware is designed to read data from up to 6 Measurement Boards. Control Board memory limits the data storage capability. Currently, the Control Board can store 20000 external sample position data values.

The user may not use the MTSAMPLE or SAMPLE commands while the EXSAMPLE command is active. The MTSAMPLE and SAMPLE commands will output an error if executed while EXSAMPLE is active. These commands store data in the same memory space.

Chapter 4

COMMAND DICTIONARY

In This Chapter

- Overview
  - Characters Used in this Chapter
  - Using Commands
  - Data Formats
  - Summary of Commands
- Command Dictionary

OVERVIEW

A host computer is used to control the ZMI-1000 system. Commands are sent from the computer to the ZMI-1000 Control Board. This chapter describes the commands in detail and the meaning of the ZMI-1000 responses.

The system software complies with ANSI/IEEE Standard 488.1-1987 and ANSI/IEEE 488.2-1987. A copy of either standard is available from:

The Institute of Electrical & Electronics Engineers, Inc.
345 East 47th Street
New York, NY 10017

Characters Used in this Chapter

Character	*Description*	*Sample*
*	Common commands that comply with the ANSI/IEEE 488.2-1987 standard.	*CLS
?	Generates a response from a device.	*ESE?
< >	Command parameter.	<state>
x	Any parameter value other than those listed.	
...	Means continuation.	<1,…n>
''	Single quotes indicate ASCII character string.	'0' - '9'
H	Hexadecimal number.	H30 - H39
B	Binary number.	B10101
Q	Octal number.	Q170
#	Start of a number string.	#H100
b	Used to describe a bit (0 or 1).	b0
^	Control character.	^C

Using Commands

This chapter refers to the ZMI-1000 Control Board, ZMI-1000 Measurement Board, and the Laser Head, globally as a “device”.

All commands are case insensitive. Uppercase or lowercase may be used. Mixing uppercase and lowercase is allowed. For example:

```
READ? = read? = ReAd?
```

The hexadecimal characters A-F may be uppercase, lowercase, or mixed. For example:

```
BGET? #H2D,#Ha000
```

All commands are sequentially executed. The command names are unique and consist of one to twelve characters. Any unknown command generates a command error. Commands are sent to the device as an ASCII string. Parameter and response values are ASCII coded decimal numbers. The ASCII character range H30 - H39 corresponds to ASCII characters '0' through '9'. A space must be placed between commands and their associated parameters. A space may or may not be placed after a parameter separating comma.

Data Formats

Parameter and response data have different data types. The following table describes some of the response data types referred to in the command dictionary. Data format syntax drawings are provided in Appendix B. (NL) refers to new line or linefeed character terminator. All formats are in accord with IEEE-488.2-1987 specifications.

Output data formats for position, offset, and time data are selected by the FORMAT command.

Data Type	*Description*	*Examples*
NR1	Integer or whole number expressed without a decimal point. Positive numbers are implied, negative numbers have a minus sign.	0 (NL) -213534565 (NL) 10003 (NL)
NR2	Integer and real numbers expressed with a decimal point with up to 9 digits. Positive numbers are implied, negative numbers have a minus sign. The user must decide how many of the 9 fractional digits are significant.	0.000000000 (NL) -21344.323232565 (NL) 12.234569809 (NL)
NR3	Integer and real numbers expressed with an exponent. There must be one digit before the decimal point and up to 9 digits after. Positive numbers are implied, negative numbers have a minus sign. The user must decide how many of the 9 fractional digits are significant.	0.000000000E0 (NL) -2.134567876E9 (NL) 3.345234789E-180 (NL)
Hexadecimal	Values as ASCII coded hex strings. 32-bit signed and unsigned integers are output as a string of 8 ASCII coded hex digits.	#H01B4 (NL) #HFFF738C (NL)
Arbitrary Block	Series of values output in 8-bit wide binary format. Series starts with a header. First character is an ASCII '#'; the second character is an ASCII coded digit, '1' - '9', which indicates the number of ASCII coded digits to follow. The ASCII coded digits are strung together to form an integer which indicates the number of binary bytes to follow. The last byte is terminated with EOI. Each data value transmitted by the ZMI-1000 is composed of 4 binary bytes.	MTS 1,1,2,100,E,1,1 FORMAT E MTS? #216**b**bbb**b**bbb**b**bbb**b**bbb 1st time value / 1st position value / 2nd time value / 2nd position value b = 1 binary byte **b**bbb MSB LSB
NR1 Block	Series of values output in NR1 format separated by commas. Series starts with a header. First character is an ASCII '#'; this is followed by a value equal to the number of data values in the series.	MTS 1,1,2,100,E,1,1 FORMAT F MTS? #4,665,-1,1305,0 (NL) 1st time value / 1st position value / 2nd time value / 2nd position value

Summary of Commands

The ANSI/IEEE 488.2-1987 standard requires all IEEE 488 based instruments to implement the mandatory common commands. Zygo chose also to implement the some of the optional common commands, because they apply to the operation of the VME system. The device specific commands apply only to Zygo's ZMI-1000 measurement system.

The commands currently implemented are listed in Table 4-1.

Common Commands	
`*CLS`	Clear Standard Event, Service Request, Status byte Register, IEEE 488 queue, and terminate active operations.
`*ESE`	Set the Standard Event Status Enable Register bits.
`*ESE?`	Read Standard Event Status Enable Status.
`*ESR?`	Read Standard Event Status Register.
`*IDN?`	Read Identification Information.
`*OPT?`	Read Option Identification Information.
`*RCL`	Recall Device State.
`*RST`	Reset Command.
`*SAV`	Save Device State.
`*SRE?`	Determine the current contents of the Service Request Enable Register.
`*STB?`	Read the Status Byte and Master Summary Status bit.
`*TST?`	Invokes a device self-test.
Device Specific Commands	
`ADDRESS`	Changes board number associated with a Measurement Board address.
`AVERAGE?`	Computes average and standard deviation.
`BGET?`	Get byte from VMEbus.
`BPUT`	Put byte on VMEbus.
`ERROR?`	Read error message.
`EXEND`	Terminates the current external sample session.
`EXSAMPLE`	Starts an external sample session.
`EXSAMPLE?`	Reads data stored in the buffer by an external sample session.
`EXSTATUS?`	Reads the number of data samples currently stored in the external sample buffer.
`FORMAT`	Select output format.
`INPUT?`	Return the value of the specified discrete input.
`LGET?`	Get long word from VMEbus.
`LPUT`	Put long word on VMEbus.
`MTSAMPLE`	Read position and time values from 1 to 6 Measurement Boards.
`MTSAMPLE?`	Output the data sampled by the MTSAMPLE command.
`OUTPUT`	Set the specified discrete output to the specified value.
`READ?`	Read from Measurement Board.
`RESTART`	Emulates a device hardware reset.
`SAMPLE`	Samples a Measurement Board.
`SAMPLE?`	Reads data collected with SAMPLE command.
`WGET?`	Get word from VMEbus.
`WPUT`	Put word on VMEbus.
`WRITE`	Write to Measurement Board.

Table 4-1 Summary of Commands

COMMAND DICTIONARY

The commands listed in Table 4-1 are explained in alphabetical order and in greater detail in this section.

Dictionary Format

Where applicable, each command is described as shown below.

Command Syntax

Shows the command name and any optional items. For example:

Command	*Means*
`*ESE?`	*ESE? is the command, the * is necessary and used to indicate that it is a IEEE 488.2 specified command.
`*SAV <state>`	*SAV is the command, and <state> is a required parameter, the * is necessary.
`FO[RMAT] <format>`	FO is the command, <format> is a required parameter. FORMAT is an alternate name for the command.

Functional Description

Describes what the command does.

Parameter or Response Specification

Describes the types and acceptable value ranges for parameters (input) and response (output) data. Appendix B shows syntax illustrations of data formats.

Example

Shows an example of using the command and the response, if any, from the device.

Command Syntax

`*CLS`

Functional Description

The Clear Status Command is a mandatory common command. *CLS clears the Standard Event Register, Service Request Register, Status Byte Register, error codes, error LED, and the status data structures summarized in the Status Register.

*CLS should be executed at the start of any ZMI-1000 program. This command also clears the IEEE 488 input queue and terminates any active operations.

Command Syntax

```
*ESE <enable mask>
```

Functional Description

Standard Event Status Enable, a mandatory common command. The *ESE command sets the Standard Event Status Enable Register bits.

See also Figure 3-2 and Table 3-3.

Parameter Specification

```
<enable mask>
```

Type: Decimal numeric program data
Range: '0' - '255'

Command Syntax

```
*ESE?
```

Functional Description

Read Standard Event Status Enable Status, a mandatory common command. The *ESE? command allows the programmer to determine the current contents of the Standard Event Status Enable Register.

See also Figure 3-2 and Table 3-3.

Response Specification

Type: NR1 Numeric response data

Range: '0' - '255'

Command Syntax

```
*ESR?
```

Functional Description

Read Standard Event Status Register, a mandatory common command. The *ESR? command allows the user to determine the current contents of the Standard Event Status Register. Reading the register clears it.

See also Figure 3-2 and Table 3-3.

Response Specification

Type: NR1 Numeric response data

Range: '0' - '255'

Command Syntax

```
*IDN?
```

Functional Description

Read Identification Information, a mandatory common command. The *IDN? command reads the device identification information over the host computer interface. The output includes the manufacturer, model name, Control Board serial number, and Control Board software revision level.

Response Specification

Type: Arbitrary ASCII response data

Format: Manufacturer, model, serial number, software level

Example

Command: *IDN?

Response: Zygo,VMEbus Control Board,006,E

Command Syntax

`*OPT?`

Functional Description

Read Option Identification Information, an optional common command. The *OPT? command reports the Control Board DIP switch settings and the Measurement Board VMEbus A16 addresses. If a Measurement Board is not present in the device, its address will be reported as 0.

Response Specification

Type: Arbitrary ASCII response data

Format: <header> <value>,<header> <value>,...
A total of 8 header/value pairs are output. The <value> parameter is an ASCII coded hexadecimal.

Output Order	*Description*	*Header*	*Value Range*
1	Control Board DIP switch	SW2	'0' - 'FF'
2	Control Board DIP switch	SW3	'0' - 'FF'
3	Measurement Board 1	MB1	'0' - 'FF00'
4	Measurement Board 2	MB2	'0' - 'FF00'
5	Measurement Board 3	MB3	'0' - 'FF00'
6	Measurement Board 4	MB4	'0' - 'FF00'
7	Measurement Board 5	MB5	'0' - 'FF00'
8	Measurement Board 6	MB6	'0' - 'FF00'

Table 4-2 *OPT? Response Header and Value Range

Example:

Command: *OPT?

Response:
SW2 19,SW3 2D,MB1 100,MB2 200,MB3 300,MB4 400,MB5 000,MB6 000

Control Bd settings Measurement Board Addresses

Command Syntax

```
*RCL <state>
```

Functional Description

Recall Device State, an optional common command. The *RCL command configures the device with device state information stored in local memory. The device state is also read from NVM during power on initialization.

See also the *SAV command.

Parameter Specification

`<state>`

Type: Decimal numeric program data

Range: '0' -'1' (H30 - H31)

<state>	*Action*
0	Recall previously saved device state from NVM.
1	Recall factory default device state from ROM.
x	Execution Error.

Table 4-3 *RCL Parameter Description

Command Syntax

```
*RST
```

Functional Description

Reset Command, a mandatory common command. The *RST command performs a complete device reset. *RST should be executed at the start of every ZMI-1000 program.

The following device dependent actions will be executed in addition to those actions specified in the ANSI/IEEE Std 488.2-1987:

- Resets all Measurement Board axes.
- Sets operation complete bit in the Standard Event Status Register.

See also the RESTART command.

Command Syntax

```
*SAV <state>
```

Functional Description

Save Device State, an optional common command. The *SAV command saves the device state in NVM. This includes the contents of all writable Measurement Board registers for all Measurement Boards in the system.

See also the *RCL command.

Parameter Specification

`<state>`

Type: Decimal numeric program data

Range: '0' (H30)

<state>	*Action*
0	Save the current device state into NVM.
x	Execution Error.

Table 4-4 *SAV Parameter Description

Command Syntax

`*SRE <enable mask>`

Functional Description

Service Request Enable, a mandatory common command. The *SRE command sets the Service Request Enable Register bits.

See also Figure 3-2 and Table 3-2.

Parameter Specification

`<enable mask>`

Type:	Decimal numeric program data
Range:	'0' - '63' and '128' - '191'

Command Syntax

`Y`

Functional Description

Read Service Request Enable Status, a mandatory common command. The *SRE? command allows the programmer to determine the current contents of the Service Request Enable Register.

See also Figure 3-2 and Table 3-2.

Response Specification

Type: NR1 Numeric response data

Range: '0' - '63' and '128' - '191'

Command Syntax

```
*STB?
```

Functional Description

Read Status Byte, a mandatory common command. The *STB? command allows the user to read the status byte and master summary status bit. This command is executed immediately, however, the resultant output is placed in the output queue after the current command has finished using the output queue.

See also Figure 3-2 and Table 3-2.

Response Specification

Type: NR1 Numeric response data

Range: '0' - '255'

Command Syntax

```
*TST?
```

Functional Description

Execute Self-Test and Read Status, a mandatory common command. The *TST? command invokes a device self-test. It is the same test executed when the Control Board is first powered-on, if this feature is enabled.

The character '0' is placed in the output queue if no errors were detected. The character '1' is placed in the output queue if an error(s) is found. The last error number of the first error encountered may be read with the ER? command.

The Power-On-Self Test and the *TST? command perform the same set of power-on-self-test routines. However, the *TST? command provides output (or summary information) and the Power-On-Self Test does not. The routine is executed at power up or when a RESTART command is issued. This test verifies the EPROM integrity by computing its checksum, performing a write/read test on the static RAM, and verifying the EEPROM checksum.

Response Specification

Type: NR1 Numeric response data

Range: '0' or '1'.

Command Syntax

`ADDR[ESS] <board>,<base address>`

Functional Description

Address Command, a device specific command. The ADDR command associates a <board> number with a Measurement Board base address. This command allows a user to change association between <board> number and the address selected by the DIP switch on the Measurement Board. Note that the <board> number parameter is logical, not physical. Thus, two different <board> number parameters could be assigned to the same Measurement Board. The *SAV command will record changes made with the ADDR command in NVM.

Parameter Specification

`<board>`

Type: Decimal numeric program data

Range: '1' - '6' (H31 - H36)

`<base address>`

Type: Non-Decimal numeric program data

Range: '#H100' - '#HFF00'

The <base address> is a 16 bit value. However, only the upper most significant byte is used, and the lower byte is set to 00. While #H0000 is a valid Measurement Board address, the *OPT? command uses #H0000 to indicate that a Measurement Board is not present. Therefore, it is recommended that address #H0000 is not used unless absolutely necessary.

Examples:

Command: ADDR 1, #HAB00

Measurement axis 1 is assigned to the Measurement Board at base address of #HAB00

Command Syntax

`AV[ERAGE]?`

Functional Description

Average and Standard Deviation of Measurement Board Position Data, a device specific command. The AV? command outputs the average and standard deviation (STD) of the Measurement Board position data collected with the SAMPLE command.

Response Specification

`<mean>`

Type: NR2 Numeric response data, with one digit after the decimal.

`<STD>`

Type: NR3 Numeric response data, with 9 digits after the decimal.

Example

Command: AV?

Response: -123467.3 } average

5.008261995E-02 } STD

Command Syntax

```
BG[ET]? <address modifier>,<address>
```

Functional Description

Get Byte, a device specific command. The BG? command gets a byte (8 bits) from the VMEbus address defined by <address modifier> and <address>.

Parameter Specification

<address modifier>

Type: Non-Decimal numeric program data
Range: '#H2D', '#H3D'

<address>

Type: Non-Decimal numeric program data
Range: for #H2D: '#H0' - '#HFFFF'
for #H3D: '#H0' - '#HFFFFFF'

Response Specification

Type: Hexadecimal numeric response data

Range: '#H0' - '#HFF'

Example

Suppose the memory values starting at hexadecimal address A000 in the VMEbus short address space are:

A000 8F A1 12 78 DB 1F 72 88 65 41 03 00 34 90 CD BB

Command: BGET? #H2D,#HA000

Obtains the 8 bit memory value at H2D and address HA000; the response is:

#H8F

Command Syntax

```
BP[UT] <address modifier>,<address>,<byte>
```

Functional Description

Put Byte, a device specific command. The BP command writes the <byte> (8 bits) value at the address defined by the <address modifier> and <address>.

Parameter Specification

`<address modifier>`

Type: Non-Decimal numeric program data
Range: '#H2D', '#H3D'

`<address>`

Type: Non-Decimal numeric program data
Range: for #H2D: '#H0' - '#HFFFF'
for #H3D: '#H0' - '#HFFFFFF'

`<byte>`

Type: Non-Decimal numeric program data
Range '#H0' - '#HFF'

Example

Suppose the memory values at hexadecimal address A000 in the VMEbus short address space are as shown:

A000 8F A1 12 78 DB 1F 72 88 65 41 03 00 34 90 CD BB

Command: BPUT #H2D,#HA000,#H0

Writes an 8 bit value at H2D and address HA000; the outcome is:

A000 00 A1 12 78 DB 1F 72 88 65 41 03 00 34 90 CD BB

Command Syntax

`ER[ROR]?`

Functional Description

Read Error Message, a device specific command. The first error encountered is output as an ASCII coded decimal value.

Response Specification

Type: NR1 Numeric response data

Each error number is described in the following list. The letters under Type are as follows: CE is command error, EE is execution error, and DDE is device-dependent error.

Number	*Error*	*Type*
0	No Error.	-
4	No Such Command.	CE
6	Too Many Command Arguments.	CE
7	Missing Command Argument.	CE
8	Invalid Command Argument.	CE
10	Invalid Address.	EE
11	Data Runs Past Allowed Address Space.	EE
12	Invalid Address Modifier.	EE
13	Bus Error.	DDE
14	Invalid Measurement Board Number.	EE
15	Invalid Register Specification.	CE
16	The Specified Measurement Board Isn't Present.	DDE
17	Invalid Format Specification.	EE
18	Data Too Large To Fit In Register.	EE
19	Invalid Sample Count.	DDE
20	Invalid Sampling Rate.	EE
22	Arbitrary Data Block Too Short.	CE
24	There Is No Valid Sample Data.	EE
25	Invalid Setup Number.	EE
26	Measurement Board Error Occurred During SAMPLE.	EE

Number	*Error*	*Type*
28	Serial Control Port Framing Error.	DDE
30	Serial Control Port Overrun Error.	DDE
31	Serial Diagnostic Port Framing Error.	DDE
33	Serial Diagnostic Port Overrun Error.	DDE
34	Must Deactivate The Trigger Input.	DDE
35	I/O Command Parameter Out of Range.	DDE
36	Invalid Number of Measurement Boards.	EE
38	Sample Count Out of Range.	EE
39	Sample Frequency Out of Range.	EE
40	Invalid Trigger Type.	EE
41	Invalid Trigger Specifier.	EE
42	Trigger Time Out Value Out of Range.	EE
43	Measurement Error During MTS Command.	EE
44	MTS Trigger Timeout.	EE
45	EPROM Failed Checksum.	DDE
46	Static RAM Failed the Write/Read Test.	DDE
47	EPROM Failed the Checksum Test.	DDE
48	Invalid EXSAMPLE Sample Count.	EE
49	EXSAMPLE Buffer Overflow.	EE
50	EXSAMPLE Is Currently Active.	EE
51	Measurement Board Error Occurred During EXSAMPLE.	EE
52	Unexpected Measurement Board Interrupt Occurred.	DDE

Command Syntax

```
EXE[ND]
```

Functional Description

External Sample End, a device specific command. This command terminates the external sample operation, disables the external sample feature on the Measurement Boards, clears any pending SRQ's, and disables the VME interrupts. The command also clears the pointers, counters, and the circular buffer. A device clear also terminates this operation.

Command Syntax

`EXSA[MPLE] <boards>,<1,..n>,<data type>`

Functional Description

External Sample, a device specific command. The EXSAMPLE command configures the selected Measurement Boards for external sample. It enables the first specified Measurement Board to generate a VME interrupt on external sample. It also creates a circular buffer in memory and enables the onboard VME interrupt. The command can record either time and position or position only. A device clear will terminate external sampling and clear the buffer. While EXSAMPLE is active MTSAMPLE and SAMPLE are inhibited.

Parameter Specification

`<boards>`

Description:	Number of sampled Measurement Boards.
Type:	Decimal numeric program data
Range:	'1' - '6'

`<1,…n>`

Description:	Axis numbers of the sampled Measurement Boards.
Type:	Decimal numeric program data
Range:	'1' - '6' up to six values separated by commas

`<data type>`

Description:	Type of data to be sampled.
Type:	Character program data
Range:	'T' for time and position, 'P' for position only

Example

Command: EXSAMPLE 1,1,P

Informs the Control Board that position only data will be collected from Measurement Board 1.

Command: EXSA 3,1,2,6,T

Informs the Control Board that time and position data will be collected from Measurement Boards 1, 2, and 6.

Command Syntax

```
EXSA[MPLE]? <samples>
```

Functional Description

Read External Sample, a device specific command. This command outputs data collected by the EXSAM command. The Control Board outputs the number of values specified by the <samples> parameter for each Measurement Board. Data is output in the order in which the Measurement Board axis numbers were listed when the EXSAM command was issued. Data is formatted according to the last FORMAT command processed. An error condition is processed if the request number of samples exceeds the available number of samples. If this error occurs the Control Board will leave the buffer undisturbed and continue to collect data. If the time and position data type was earlier selected then the firmware will output the time value followed by the position value.

Parameter Specification

`<samples>`

Description:	Number of values sampled per Measurement Board.
Type:	Decimal numeric program data
Range:	'1' to the maximum value output by the EXSTATUS? command.

Response Specification

Type:	Determined by the current data format specified with the FORMAT command. If the selected data type is 'T', then a time value is followed by a position value; if it is 'P', then only a position value.

Example

Command:	EXSA? 2000
Response:	Control Board outputs 2000 sample values for each Measurement Board.
Command:	EXSAMPLE? 349
Response:	Control Board outputs 349 sample values for each Measurement Board.

Command Syntax

```
EXST[ATUS]?
```

Functional Description

Read External Status, a device specific command. The EXSTATUS? command causes the ZMI-1000 system to output the number of data samples currently in the buffer. It checks the Measurement Boards for errors. If errors occurred then an error is reported and the number of samples outputted is multiplied by -1. The host software should test the <samples> value and read Measurement Board status if it is less than 0.

In addition to this command, bit 2 of the Status Byte Resister is set active when the buffer becomes more than 50% full. The bit is cleared once a sufficient number of samples have been read to make the buffer less than 50% full. An error is reported if the buffer overflows.

Response Specification

`<samples>`

Description:	Number of samples in the buffer
Type:	NR1 Numeric response data
Max. Range:	'0' - '5000' time and position samples '0' - '10000' position only samples Control Boards S/N 043 or earlier.
	'0' - '20000' time and position samples '0' - '40000' position only samples Control Boards S/N 044 or later.

Command Syntax

```
FO[RMAT] <format>
```

Functional Description

Select Output Format, a device specific command. The FORMAT command selects the output format for Measurement Board data. The selected format is the same for all axes. The results of this command are not affected by *RST or *RCL.

See page 4-3 for a description of the different data formats. See also the READ? command.

Parameter Specification

```
<format>
```

Type: Character program data

Range: 'A' - 'F' (H41 - H46)

The <format> parameter is a single ASCII character; Table 4-5 lists the options.

<Format>	*IEEE-488 Output*	*RS232 Control Part*
A	NR1 Numeric response data.	NR1 Numeric response data.
B	NR2 Numeric response data.	NR2 Numeric response data.
C	NR3 Numeric response data.	NR3 Numeric response data.
D	Hexadecimal Numeric response data.	Hexadecimal Numeric response data.
E	Definite length arbitrary block response data.	Hexadecimal Numeric response data.
F	NR1 Block response data.	NR1 Block response data.

Table 4-5 Measurement Board Data Output Formats

Command Syntax

```
IN[PUT]? <input number>
```

Functional Description

Get discrete input value, a device specific command. The INPUT? command returns the current value of the specified discrete input. The inputs accept both differential and single ended TTL signals.

Also see "Using the Discrete Inputs" in Chapter 2.

Parameter Specification

`<input number>`

Type: Decimal numeric program data
Range: '0' - '2'

Response Specification

Type: NR1 Numeric response data

Range: '0' or '1'

Command Syntax

```
LG[ET]? <address modifier>,<address>
```

Functional Description

Get Long, a device specific command. The LG command gets a long word (32 bits) from the VMEbus address defined by <address modifier> and <address>. The command executes by reading individual bytes.

Parameter Specification

`<address modifier>`

Type: Non-Decimal numeric program data
Range: '#H2D', '#H3D'

`<address>`

Type: Non-Decimal numeric program data
Range: for #H2D: '#H0' - '#HFFFF'
for #H3D: '#H0' - '#HFFFFFF'

Response Specification

Type: Hexadecimal numeric response data

Range: '#H0' - '#HFFFFFFFF'

Example

Suppose the memory values starting at hexadecimal address A000 in the VMEbus short address space are:

A000 8F A1 12 78 DB 1F 72 88 65 41 03 00 34 90 CD BB

Command: LGET? #H2D,#HA000

Obtains the 32 bit memory value at H2D and address HA000; the response is:

#H8FA11278

Command Syntax

```
LP[UT] <address modifier>,<address>,<long>
```

Functional Description

Put Long, a device specific command. The LP command writes the <long> (32 bits) value at the address defined by the <address modifier> and <address>. The command executes by reading individual bytes.

Parameter Specification

`<address modifier>`

Type: Non-Decimal numeric program data
Range: '#H2D', '#H3D'

`<address>`

Type: Non-Decimal numeric program data
Range: for #H2D: '#H0' - '#HFFFF'
for #H3D: '#H0' - '#HFFFFFF'

`<long>`

Range: '#H0' - '#HFFFFFFFF'

Example

Suppose the memory values at hexadecimal address A000 in the VMEbus short address space are as shown:

A000 8F A1 12 78 DB 1F 72 88 65 41 03 00 34 90 CD BB

Command: LPUT #H2D,#HA000,#H0

Writes a 32 bit memory value at H2D and address HA000; the outcome is:

A000 00 00 00 00 DB 1F 72 88 65 41 03 00 34 90 CD BB

Command Syntax

```
MTS[AMPLE] <boards>,<1,…n>,<samples>,<rate>, <trigger type>,
<trigger specifier>,<trigger timeout>
```

Functional Description

Triggered Sample Command, a device specific command. The MTS command reads position and time values from 1 to 6 Measurement Boards. The sampling rate and the number of samples per board are programmable. The user may specify when to begin sampling the Measurement Boards. The Control Board will check for Measurement Board errors after sampling. This command sets bit 0 of the Status Byte Register active once sampling is complete.

Parameter Specification

`<boards>`

Description: Number of boards to be sampled.
Type: Decimal numeric program data
Range: '1' - '6' (one value)

`<1,…n>`

Description: List of sampled Measurement Board axes.
Type: Decimal numeric program data
Range: '1' - '6' (up to six values separated by commas)

`<samples>`

Description: Number of values sampled per Measurement Board.
Type: Decimal numeric program data
Range: minimum = '1', see table 4-6 for maximum.

`<rate>`

Description: Rate at which values are sampled.
Type: Character program data
Range: See table 4-7 for value range in KHz.

`<trigger type>`

Description: Event which determines the start of sampling.

Type: Character program data

Range: 'A' for time delayed trigger, 'B' for position trigger, 'C' for user inputted trigger (input value = 1), 'D' for user input trigger (input value = 0), and 'E' for immediate MB reset trigger.

`<trigger specifier>`

Description: Specific information to quantify the specified <trigger type>.

Type: Decimal numeric program data

Range: For time delayed trigger '0' - '1800000' ms. For position trigger '-2147483648' to '2147483648' units in counts, use first measurement specified in axis list for user input '0', '1', or '2' for immediate MB reset trigger '1', '2', '3', '4', '5', or '6' specifies Measurement Board to be reset.

`<trigger timeout>`

Description: Trigger wait time. MTS command is aborted if trigger does not occur during this wait time.

Type: Decimal numeric program data

Range: '1' - '86400' seconds

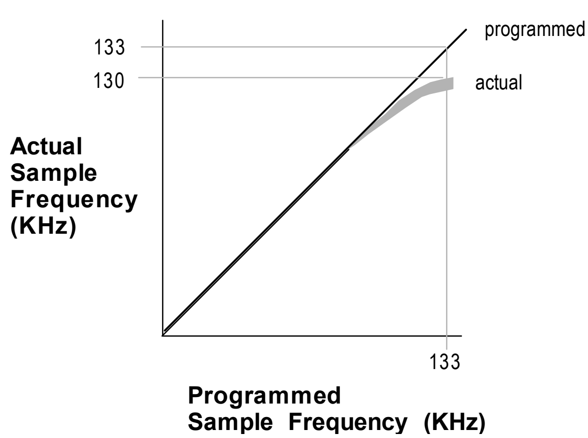
No of Installed Measurement Bds	*Max. Time & Position Samples per Board (S/N 043 or less)*	*Max. Time & Position Samples per Board (S/N 044 and up)*
1	'5000'	'20000'
2	'2500'	'10000'
3	'1666'	'6666'
4	'1250'	'5000'
5	'1000'	'4000'
6	'833'	'3333'

Table 4-6 <sample> Parameter Maximum Values

Installed Measurement Boards	*Range for Time & Position Rate in KHz*
1	'0.0001' - '133'
2	'0.0001' - '83'
3	'0.0001' - '60'
4	'0.0001' - '47'
5	'0.0001' - '39'
6	'0.0001' - '33'

Table 4-7 <rate> Parameter Value Range

The MTS command uses a software delay to control the sampling rate. The quantization nature of this delay causes the actual sampling rate to differ from the program rate. An example is graphed below. Use the recorded time data when manipulating the position data.



Command Syntax

`MTS[AMPLE]?`

Functional Description

Read Triggered Sample Command Data, a device specific command. The MTS? command outputs the data sampled by the MTS command. The current data value format set by the FORMAT command is used to format the triggered sample data. Time and position data are output with time value first followed by the position value. Data is output in the order in which the Measurement Board axis numbers were listed when the MTS command was issued.

Response Specification

Type: Determined by the current data format specified with the FORMAT command.

Example

If the MTS command has been entered as: MTS 1,1,2,1,e,1,1

Command: MTS?

Assuming the data format is NR1, the system responds:

1840
0
65840
0

Command Syntax

`OUT[PUT] <output number>,<value>`

Functional Description

Control Board Discrete Output, a device specific command. The OUTPUT command sets the specified discrete output to the specified value. A '0' value corresponds to a low voltage level at the output. A '1' corresponds to a high voltage level at the outputs.

See also "Using the Discrete Outputs" in Chapter 2.

Parameter Specification

`<output number>`

Type: Decimal numeric program data
Range: '0' - '2'

`<value>`

Type: Decimal numeric program data
Range: '0' or '1'

Example

Enter: OUT 0,1
Changes the discrete output 0 to a high voltage state.

Enter: OUTPUT 2,0
Changes the discrete output 2 to a low voltage state.

Command Syntax

```
R[EAD]? <board>,<register>
```

Functional Description

Read Measurement Board, a device specific command. Information is read from the selected register on the selected Measurement Board. One or two registers may be read depending upon the <register> parameter used. Tables 4-8 and 4-9 describe the <board> and <register> parameters.

Parameter Specification

`<board>`

Type: Decimal numeric program data

Range: '1' - '6' (H31 - H36)

`<Register>`

Type: Character program data

Range: 'A' - 'N' (H41 - H4E)

Both input parameters are single ASCII characters. Tables 4-8 and 4-9 describe the correlation between the parameter output ASCII character and the action taken.

<board>	*Action*
1	Read Board 1
2	Read Board 2
3	Read Board 3
4	Read Board 4
5	Read Board 5
6	Read Board 6
x	Execution Error

Table 4-8 <board> Parameter Description

<register>	*Action*
A	Read command register
B	Read clip mask register
C	Read window mask register
D	Read offset register
E	Read interrupt vector register
F	Read A24 base address register
G	Read status register 1
H	Read status register 2
I	Read status register 3
J	Read time register
K	Read position register
L	Read time register Read position register
M	Read sampled position register
N	Read time register Read sampled position register
x	Execution Error

Table 4-9 <format> Parameter Description

Response Specification

Table 4-10 describes the data output format for the various types of Measurement Board registers. Two values are output when reading registers L and N for all format types.

<Register>	*Output Formats*
A-C, E-I	NR1 Numeric response data (signed 16 Bit integer).
D, J-N	As selected by the FORMAT command. The default FORMAT is NR1 Numeric response data. Only time data is unsigned.

Table 4-10 Measurement Board Data Output Format Definition

Command Syntax

```
RESTART
```

Functional Description

Emulates a device hardware reset; it is the same as turning power off and then on. RESTART sets the Measurement Boards and the Control Board to their default settings; addresses and switch settings are re-read.

See also the *RST command.

Command Syntax

```
SAM[PLE] <board>,<samples>,<rate>
```

Functional Description

Sample Position Data from a Measurement Board, a device specific command.

The Control Board reads time and position data from a Measurement Board at a specified rate. The Control Board then calculates the average and standard deviation of the position data. The calculation results are saved and may be retrieved by using the AVERAGE? command. The time and position data may be retrieved using the SAMPLE? command. The SAM command sets bit 1 of the Status Byte register active once sampling is complete. A device clear aborts this command.

Parameter Specification

`<board>`

Type: Decimal numeric response data
Range: '1' - '6' (H31 - H36)

`<samples>`

Type: Decimal numeric response data
Range: '2' - '5000' for Control Boards with S/N 043 or less
'2' - '20000' for Control Boards with S/N 044 or greater

`<rate>`

Type: Character program data
Range: 'A' - 'H' (H41 - H48)

All three parameters are single ASCII characters. See Tables 4-11 and 4-12 for descriptions of the <board> and <rate> parameter values.

<board>	*Measurement Board Number*
1	Measurement Board 1
2	Measurement Board 2
3	Measurement Board 3
4	Measurement Board 4
5	Measurement Board 5
6	Measurement Board 6
x	Execution Error

Table 4-11 <board> Parameter Description

<rate>	*Sampling Rate*
A	0.1 Hz
B	0.2 Hz
C	0.5 Hz
D	1 Hz
E	2 Hz
F	5 Hz
G	10 Hz
H	20 Hz
I	50 Hz
J	100 Hz
K	200 Hz
L	500 Hz
M	1 KHz
N	2 KHz
O	5 KHz
P	10 KHz
x	Execution Error

Table 4-12 <rate> Parameter Description

Command Syntax

SAM[PLE]?

Functional Description

Output Sampled Measurement Board Position Data, a device specific command. The SAMPLE? command causes the Control Board to output the Measurement Board time and position data collected with the SAMPLE command.

Output Parameter Specification

Type: As selected by the FORMAT command

Time and position data are output on pair. A time value is output first then its corresponding position value, followed by the next time value etc...

Example

If the SAM command has been entered as: SAM 1,4,D

Command: SAM?

Response:
2502166768
0
2566375200
-1
2630583856
-1
2694792544
1

Command Syntax

```
WG[ET]? <address modifier>,<address>
```

Functional Description

Get Word, a device specific command. The WG? command gets a word (16 bits) from the VMEbus address defined by <address modifier> and <address>. The command executes by reading individual bytes.

Parameter Specification

`<address modifier>`

Type: Non-Decimal numeric program data

Range: '#H2D', '#H3D'

`<address>`

Type: Non-Decimal numeric program data

Range: for #H2D: '#H0' - '#HFFFF'
for #H3D: '#H0' - '#HFFFFFF'

Response Specification

Type: Hexadecimal numeric response data

Range: '#H0' - '#HFFFF'

Example

Suppose the memory values starting at hexadecimal address A000 in the VMEbus short address space are:

A000 8F A1 12 78 DB 1F 72 88 65 41 03 00 34 90 CD BB

Command: WGET? #H2D,#HA000

Obtains the 16 bit memory value at H2D and address HA000; the response is:

#H8FA1

Command Syntax

```
WP[UT] <address modifier>,<address>,<word>
```

Functional Description

Put Word, a device specific command. The WP command writes the <word> (16 bits) value at the address defined by the <address modifier> and <address>. The command executes by reading individual bytes.

Parameter Specification

`<address modifier>`

Type: Non-Decimal numeric program data
Range: '#H2D', '#H3D'

`<address>`

Type: Non-Decimal numeric program data
Range: for #H2D: '#H0' - '#HFFFF'
for #H3D: '#H0' - '#HFFFFFF'

`<word>`

Type: Hexadecimal numeric response data
Range: '#H0' - '#HFFFF'

Example

Suppose the memory values at hexadecimal address A000 in the VMEbus short address space are as shown:

A000 8F A1 12 78 DB 1F 72 88 65 41 03 00 34 90 CD BB

Command: WPUT #H2D,#HA000,#H0

Writes a 16 bit memory value at H2D and address HA000; the outcome is:

A000 00 00 12 78 DB 1F 72 88 65 41 03 00 34 90 CD BB

Command Syntax

```
WR[ITE] <board>,<register>,<data>
```

Functional Description

Write Measurement Board, a device specific command. The value of the data parameter is written into the register of the selected Measurement Board. Tables 3-14 and 3-15 define the board and register parameters. The value of the data parameter for the command register is also shown.

Parameter Specification

`<board>`

Type: Decimal numeric program data
Range: '1' - '6' (H31 - H36)

`<register>`

Type: Character program data
Range: 'A' - 'I' (H41 - H49)

`<data>`

Type: Non-Decimal numeric program data
Range: Depends on the Measurement Board register being written to.

The <board> and <register> input parameters are composed of a single ASCII characters. Tables 4-13 and 4-14 describe the correlation between the parameter output ASCII character and the action taken.

<board>	*Action*
1	Write board 1
2	Write board 2
3	Write board 3
4	Write board 4
5	Write board 5
6	Write board 6
x	Execution Error

Table 4-13 <board> Parameter Description

<register>	*Action*
A	Write command register
B	Write clip mask register
C	Write window mask register
D	Write offset register
E	Write interrupt vector register
F	Write A24 base register
G	Write control register 1
H	Write control register 2
I	Write control register 3
x	Execution Error

Table 4-14 <register> Parameter Description

The <data> parameter is composed of a '#', followed by an 'H' and the ASCII coded hexadecimal data, or Q for ASCII coded octal data, or B for ASCII coded binary data. Again, the range of the <data> depends on the specific register accessed.

Example <data> parameters:

#H3F
#HFF001234
#h00ABcd56
#H4a5D
#H4a5D
#Q170
#B1011011011

Example

Command: WR 1,A,#H2

Writes H2 to Command Register of Measurement Board 1; the axis is reset.

Command: WR 4,G,#B0001000000000000

Writes B0001000000000000 to Control Register of Measurement Board 4; the user LED is turned on.

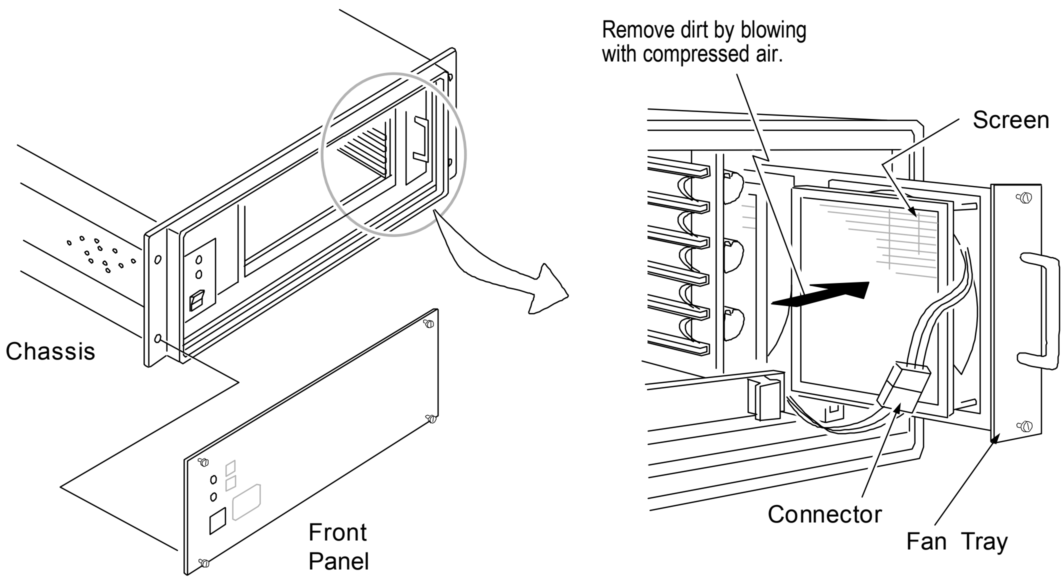
Chapter 5

MAINTENANCE AND TECHNICAL SUPPORT

CHASSIS MAINTENANCE

The ZMI-1000 Chassis is basically maintenance free. Occasionally, clean the Chassis covers with a mild, soap-based cleaner. Also, remove dust from the Chassis fan screens.

Cleaning the Fan Screens

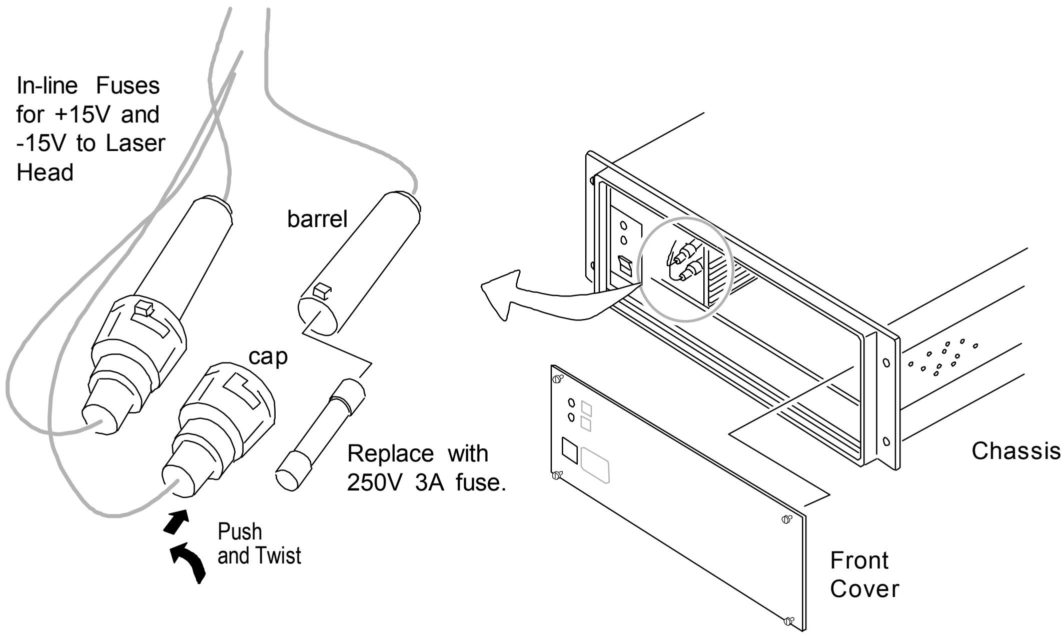


Cleaning Fan Screens
Figure 5-1

1. Turn off power to the Chassis and disconnect the AC power cord.
2. Loosen four captive screws on the Chassis front panel and remove the panel.
3. Loosen two captive screws on the fan tray; slide out the tray a few inches.
4. Disconnect the fan connector and completely remove the fan tray by pulling it straight out.
5. Using compressed air, remove built-up dirt by blowing air through the fans in reverse direction of normal airflow.
6. Slide the fan tray into the Chassis and join the connector. Secure the captive screws, reinstall the front panel and connect the Chassis to power.

Replacing Laser Head Power Fuses

For ZMI-1000 Chassis with serial numbers 93-30-V022 through 94-26-V052 only. For Chassis with other serial numbers, contact the Zygo Service department.



Replacing Laser Head Power Fuses
Figure 5-2

1. Turn off power to the Chassis and disconnect the AC power cord.
2. Loosen four captive screws on the Chassis front panel and remove the panel.
3. Hold the barrel portion of the in-line fuse holder with one hand. With the other hand, push and twist the cap to open the fuse holder. Remove the old fuse.
4. Insert a new fuse and reassemble the fuse holder. Reinstall the front panel and connect the Chassis to power.

TECHNICAL SUPPORT

If you have difficulties, please refer to the provided manuals. They are designed to help you through the most common problems. If you still have questions or need assistance, contact Zygo directly.

Preparing for Technical Support

Before communicating with our Service Department, please have the following information *written down* so that we can provide you with the quickest possible solution to your problem.

- The equipment model number and serial number. If it is software related, the software version number.
- A description of the problem and the sequence of events that led up to your discovering the problem. Note any software error messages.
- Your company's name and complete shipping address.

Returning Equipment to Zygo

To return equipment to Zygo Corporation it is necessary to have an RA (return authorization) number. Contact Zygo Corporation for an RA number and instructions on packing and shipping equipment.

Note: Do *not* return equipment to Zygo without an RA number.

Appendix A

SAMPLE PROGRAMS

In This Appendix

- Introduction
- Sample Data Acquistion Program
- Sample C Program Using the External Sample Feature

INTRODUCTION

This appendix provides sample programs that can be used as a tutorial when developing a program for acquiring data with Zygo's ZMI-1000 measurement system. It does not include code for formatting data, storing data to disk, or analyzing data.

For information on commands, refer to Chapter 4 of this manual.

The ZMI-1000 firmware is designed to simplify the interface between the personal computer and the user's measurement application. The firmware controls the IEEE-488 and RS-232C control ports and provides a set of commands that enable the user to acquire position and time measurements in a variety of output formats.

Internal oscilloscope like features, error detection, and statistical sample routines are included to reduce the amount of code needed by the user's program. In this way the user can take advantage of the internal storage of the ZMI-1000 which allows data acquisition at rates much higher than those of the two control ports. The ZMI firmware allows for the simultaneous use of the IEEE-488 and RS-232C ports.

Programming to Acquire Data

The process of acquiring position measurements from the ZMI-1000 system involves four steps which are described below. The following code assumes the user is interfacing to the RS-232C port on the ZMI-1000 using a standard PC compatible computer.

Step 1 Initialize the PC Control Ports

Set Baud Rates

Set Data Bits and Parity

Set Control Port EOL and Hardware Handshaking

Set Buffer Size

Step 2 Clear Measurement Board Errors and Registers

Clear Control Port with ^C

Issue *CLS to Clear Status Registers

Issue *RST to Reset System

Step 3 Read Position from an Axis

Issue READ? <board>, <reg>

Step 4 Transfer Data

Check Control Port Buffer

Transfer bytes until ASC 10 Received

Convert from Counts to Units desired

Check for Errors

SAMPLE DATA ACQUISITION PROGRAM

Refer to OMP-0333 for Cable settings. Chapter 2 of this manual includes Control Board settings.

The following program shows how these four steps are performed. The code is written in Microsoft Quick Basic Version 4.5, RS-232C Version. This program will:

Calculate an Interferometer Resolution
Initialize the Serial Port
Initialize ZMI Control Port
Reset Errors
Clear Axis 1 Accumulator
Check Errors
Continuously Read and Display Position from Axis 1

```
'Variables:
' Name         Description                                               Type
'==========================================================================
'  Comm$:       Commands sent to ZMI through Serial Port                String
'  A$:          Temporary String Variable                               String
'  Output$ :    String returned from ZMI                                String
'  Lambda# :    Vacuum Wavelength of F1 Light                           Double
'  Resolution#: Resolution of System                                    Double
'  N#:          Index of Refraction of Ambient Air                      Double
'  Axis1#       Axis  1 Displacement                                    Double
'  Count:       Accumulator Counts                                      Single
'  XOFF%:       Flag for Xoff Handshaking                               Integer

' Open Com Port on PC

' 9600 Baud
' No Parity 8 Data Bits 1 Stop Bit
' DS0 = Ignore Data Set Ready (DSR)
' CD0= Ignore Clear to Send (CTS)
' LF= Enable auto Carriage Return (CR) on Line Feed (LF)
' Use COM2 for Com Port # 2

Start:         ' Start Program
     N# = 1.000271296#                  ' Index at STP
     Lambda# = .000000632991501#        ' Wavelength of Vert Pol F1
     Resolution# = Lambda# / (N# * 512) ' Calculate Resolution for
                                        ' Double Pass Interferometer
CLS                                     ' Clear the Screen
LOCATE 2, 22
PRINT " Zygo ZMI Example Display Program"

LOCATE 8, 28
PRINT "*********************"
LOCATE 9, 30
     PRINT " Axis 1 in meters"


OPEN "COM1:9600,N,8,1,CS0,DS0,LF,RB5000" FOR RANDOM AS #1

Comm$ = CHR$(3)              ' Control C Resets Control Port
GOSUB WriteToSerialPort      ' Write to Port

Comm$ = "*CLS"               ' Clear Registers and Errors
GOSUB WriteToSerialPort      ' Write to Port
```

```
Comm$ = "*RST"                ' Reset ZMI Device
GOSUB WriteToSerialPort       ' Write to Port

DO                                 ' A Do Loop...Until a Key Hit
     Comm$ = " READ? 1,M"          ' Read the Position Register
                                   ' from Measurement Board 1
     GOSUB WriteToSerialPort       ' Write to Port

     GOSUB ReadFromSerialPort      ' Read the Output
     Count = VAL(Output$)          ' Convert it to a Number

     Axis1# = Count * Resolution# ' Change to Metric
     LOCATE 10, 20                 ' Print it on Screen

     PRINT USING "######.#########"; Axis1#

     Comm$ = "READ? 1,G"            'Check for Error
     GOSUB WriteToSerialPort       ' Write to Port

     GOSUB ReadFromSerialPort      ' Read the Output

          Er = VAL(Output$)          ' Convert Output to Value
          Er = Er AND 240            ' Mask of All but Board Errors
    IF Er > 0 THEN
          LOCATE 20, 20
          PRINT "Error"            ' If the returned value is
                                   ' not Zero then there's an Error
          ELSE
          LOCATE 20, 20
          PRINT "      "            ' If not Clear Error Display
     END IF

LOOP WHILE INKEY$ = ""

END

WriteToSerialPort:

     IF XOFF% = 0 THEN               ' If Xoff% Flag is Set, Don't Write
             PRINT #1, Comm$ + CHR$(10) ' Else Write the Command String
     END IF
RETURN


\
```

```
ReadFromSerialPort:
       OUTPUT$ = ""            ' Clear strings
              A$ = ""          '
    WHILE A$ <> CHR$(10)       ' If the last byte was not LF then
       IF LOC(1) THEN          ' as long as the buffer has bytes
           A$ = INPUT$(1, #1)  ' take them and store in a temp string
       SELECT CASE A$          ' Check to see if the byte was XOFF
           CASE CHR$(19)
               XOFF = 1        ' If it is then set it
           CASE CHR$(17)       ' If it is XON
               XOFF = 0        ' then reset XOFF to 0
           CASE CHR$(10)
           CASE ELSE           ' Otherwise Build a string until LF
               Output$ = Output$ + A$
       END SELECT
       END IF
    WEND
RETURN

'******************   Program End   *****************
```

SAMPLE C PROGRAM USING THE EXTERNAL SAMPLE FEATURE

This program configures the ZMI-1000 to capture the time and position data from three measurement axes each time the external sample signal is activated. The ZMI-1000 issues an SRQ when its buffer is half full. The host then reads the data from the ZMI-1000 and processes it. This program tracks the minimum and maximum time difference between samples for each axis. It does not track Measurement Board time register roll over.

The following code assumes the user is interfacing to the GPIB port on the ZMI-1000. This code was written in Microsoft C.

```
//
#include <bios.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include "c:\at-gpib\c\decl.h"

#define BASE_TEN           10
#define NUMBER_OF_MEAS_BDS  3
#define BYTE_PER_SAMPLE     8

//Global variables
unsigned long  RawZmiDataBytes[10000];
         short Zmi1000;
         short GpibBoard;
         long  TotalNumberOfZmiSamplesReceived;
         long  MaxDeltaTimeForMeasBd1;
         long  MinDeltaTimeForMeasBd1;
         long  MaxDeltaTimeForMeasBd2;
         long  MinDeltaTimeForMeasBd2;
         long  MaxDeltaTimeForMeasBd3;
         long  MinDeltaTimeForMeasBd3;
         char  ErrorFlag;
```

```
//----------------------------------------------------------------
// Function to retrieve data from ZMI-1000
//----------------------------------------------------------------
void GetExsampleDataInFormatE(void)
 {
           char *StartPntr;
           char *StopPntr;
           char  ReceivedZmiCharacters[20];
           char  ZmiCommands[20];
           char  Temp1;
           char  Temp2;
           char  Temp3;
           char  Temp4;
           long  NumberOfZmiDataSamples;
  unsigned long *TimeValuePntr1;
  unsigned long *TimeValuePntr2;
  unsigned long  NumberOfZmiDataBytes;
  unsigned long  Cntr;

  //Read the EXSAMPLE buffer status
  ibwrt(Zmi1000, "EXST?\n", 6);
  ibrd(Zmi1000, ReceivedZmiCharacters, 10);
  StartPntr =  ReceivedZmiCharacters;
  StopPntr  = &ReceivedZmiCharacters[20];
  NumberOfZmiDataSamples = strtol(StartPntr, &StopPntr, BASE_TEN);
  if(NumberOfZmiDataSamples == 0) return;
  if(NumberOfZmiDataSamples < 0)
   {
    printf("A measurement board error has occurred.\n");
    NumberOfZmiDataSamples *= -1;
   }

  //Read '#' and data byte count character
  sprintf(ZmiCommands, "EXSAM? %d\n", NumberOfZmiDataSamples);
  Cntr = (unsigned long)strlen(ZmiCommands);
  ibwrt(Zmi1000, ZmiCommands, Cntr);
  ibrd(Zmi1000, ReceivedZmiCharacters, 2);
  if(ReceivedZmiCharacters[0] == '#')
   {
    // Read the number of bytes to be transmitted from the ZMI-1000
    NumberOfZmiDataBytes = (unsigned long)(ReceivedZmiCharacters[1] - 0x30);
```

```
ibrd(Zmi1000, ReceivedZmiCharacters, NumberOfZmiDataBytes);
ReceivedZmiCharacters[NumberOfZmiDataBytes] = (char)0x00;
StartPntr =  ReceivedZmiCharacters;
StopPntr  = &ReceivedZmiCharacters[NumberOfZmiDataBytes];
NumberOfZmiDataBytes = strtoul(StartPntr, &StopPntr, BASE_TEN);
printf("Reading %lu bytes from the ZMI-1000...\n",NumberOfZmiDataBytes);

//Read the binary data from the ZMI-1000
ibconfig(Zmi1000, 12, 0);  //disable board EOS read termination
ibconfig(GpibBoard, 12, 0);  //disable board EOS read termination
ibrd(Zmi1000, (char *)RawZmiDataBytes, NumberOfZmiDataBytes);
if(NumberOfZmiDataBytes != ibcntl)
 {
  printf("*** Status = %x, Error = %d, Byte Count = %lu\n",ibsta,iberr,ibcntl);
  ErrorFlag = 1;
  ibconfig(GpibBoard, 12, 10);  //disable board EOS read termination
  ibconfig(Zmi1000, 12, 10); //enable board EOS read termination
  return;
 }
ibconfig(GpibBoard, 12, 10);  //disable board EOS read termination
ibconfig(Zmi1000, 12, 10); //enable board EOS read termination
if(ErrorFlag) return;

//Shuffle the data bytes for the Intel processor
StartPntr = (char *)RawZmiDataBytes;
for(Cntr=NumberOfZmiDataBytes/4; Cntr; Cntr--)
 {
  Temp1 = *StartPntr;
  Temp2 = *(StartPntr+1);
  Temp3 = *(StartPntr+2);
  Temp4 = *(StartPntr+3);
  *StartPntr = Temp4;
  *(StartPntr+1) = Temp3;
  *(StartPntr+2) = Temp2;
  *(StartPntr+3) = Temp1;
  StartPntr += 4;
 }
TotalNumberOfZmiSamplesReceived += NumberOfZmiDataSamples;
printf("%ld samples have been received so far.\n",TotalNumberOfZmiSamplesReceived);
```

```
    //Determine the min and max time between samples
    TimeValuePntr1 = TimeValuePntr2 = RawZmiDataBytes;
    TimeValuePntr2 += 2 * NUMBER_OF_MEAS_BDS;
    for(Cntr=NumberOfZmiDataSamples-1; Cntr; Cntr--)
     {
      if(MaxDeltaTimeForMeasBd1 < labs((long)(*TimeValuePntr2 - *TimeValuePntr1)))
       {
        MaxDeltaTimeForMeasBd1  = labs((long)(*TimeValuePntr2 - *TimeValuePntr1));
       }
      if(MinDeltaTimeForMeasBd1 > labs((long)(*TimeValuePntr2 - *TimeValuePntr1)))
       {
        MinDeltaTimeForMeasBd1  = labs((long)(*TimeValuePntr2 - *TimeValuePntr1));
       }
        TimeValuePntr1 += 2;
        TimeValuePntr2 += 2;
      if(MaxDeltaTimeForMeasBd2 < labs((long)(*TimeValuePntr2 - *TimeValuePntr1)))
       {
        MaxDeltaTimeForMeasBd2  = labs((long)(*TimeValuePntr2 - *TimeValuePntr1));
       }
      if(MinDeltaTimeForMeasBd2 > labs((long)(*TimeValuePntr2 - *TimeValuePntr1)))
       {
        MinDeltaTimeForMeasBd2  = labs((long)(*TimeValuePntr2 - *TimeValuePntr1));
       }
        TimeValuePntr1 += 2;
        TimeValuePntr2 += 2;
      if(MaxDeltaTimeForMeasBd3 < labs((long)(*TimeValuePntr2 - *TimeValuePntr1)))
       {
        MaxDeltaTimeForMeasBd3  = labs((long)(*TimeValuePntr2 - *TimeValuePntr1));
       }
      if(MinDeltaTimeForMeasBd3 > labs((long)(*TimeValuePntr2 - *TimeValuePntr1)))
       {
        MinDeltaTimeForMeasBd3  = labs((long)(*TimeValuePntr2 - *TimeValuePntr1));
       }
        TimeValuePntr1 += 2;
        TimeValuePntr2 += 2;
     }
   }
  else
   {
    printf("Error: Did not receive '#'.\n");
   }
 }
```

```
//---------------------------------------------------------------------
// Main Routine
//---------------------------------------------------------------------
void main(void)
{
unsigned short GpibLines;

ErrorFlag = 0;
printf ("\nZMI-1000 Example External Sample Program\n");
TotalNumberOfZmiSamplesReceived = 0;
MaxDeltaTimeForMeasBd1 = 0;
MinDeltaTimeForMeasBd1 = 100000000;
MaxDeltaTimeForMeasBd2 = 0;
MinDeltaTimeForMeasBd2 = 100000000;
MaxDeltaTimeForMeasBd3 = 0;
MinDeltaTimeForMeasBd3 = 100000000;

// Initialize the Nation Instruments GPIB board
Zmi1000 = ibfind("DEV1");
printf("ZMI-1000 descriptor = %d\n",Zmi1000);
GpibBoard = ibfind("GPIB0");
printf("GPIB board descriptor = %d\n",GpibBoard);
if(Zmi1000<0)
 {
  printf("Error: did not find the ZMI-1000 system.\n");
  return;
 }
if(GpibBoard<0)
 {
  printf("Error: did not find the GPIB board.\n");
  return;
 }

// Setup the SRQ interrupt service routine
ibsrq(GetExsampleDataInFormatE);

// Clear the ZMI-1000 and start External Sampling
ibclr(Zmi1000);
ibwrt(Zmi1000, "*CLS\n*RST\n", 10);
ibwrt(Zmi1000, "*SRE 4\n", 7);
ibwrt(Zmi1000, "FORMAT E\n", 9);
printf("Initiating external sample...\n");
ibwrt(Zmi1000, "EXSAM 3,1,2,3,T\n", 16);
```

```
//Wait for SRQ interrupt. End program if a key is pressed.
printf("Press any key to end. Waiting for an SRQ...\n");
while (!(_bios_keybrd(_KEYBRD_READY)) && !ErrorFlag)
 {
  ibsta = iblines(Zmi1000,&GpibLines);
 }
if(!ErrorFlag)
 {
  GetExsampleDataInFormatE();
  ibwrt(Zmi1000, "EXEND\n", 6);
  ibwrt(Zmi1000, "*CLS\n", 5);
 }
printf("\nAxis 1  max delta time = %ld, min delta time = %ld\n",
MaxDeltaTimeForMeasBd1, MinDeltaTimeForMeasBd1);
printf("Axis 2  max delta time = %ld, min delta time = %ld\n",
MaxDeltaTimeForMeasBd2, MinDeltaTimeForMeasBd2);
printf("Axis 3  max delta time = %ld, min delta time = %ld\n",
MaxDeltaTimeForMeasBd3, MinDeltaTimeForMeasBd3);
printf("\n\nProgram complete\n");
}
//*****************   Program End   *****************
```

Appendix B

SYNTAX DRAWINGS

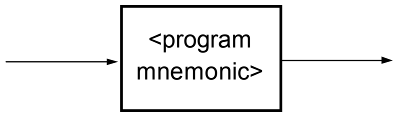
INTRODUCTION

This section provides illustrations of the data formats for the commands used when programming the ZMI-1000 System. The format for many of the commands is listed in either the Parameter or Response section of the command description (Chapter 4 of this manual).

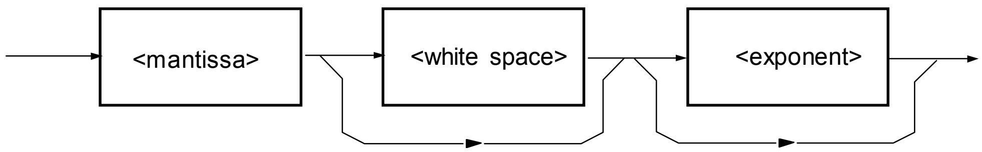
Note: Syntax elements are connected by lines with directional arrows to indicate the flow. Flow through the diagram proceeds from left-to-right. When an element is repeatable, a reverse right-to-left path is shown around and above the element. When an element can be by-passed, a left-to-right path is shown around and below the element. When there is a choice of elements, the path branches.

For additional information, consult the "IEEE Standard Codes, Formats, Protocols and Common Commands" guide available from IEEE. See Chapter 4 of this manual for the address for IEEE standards.

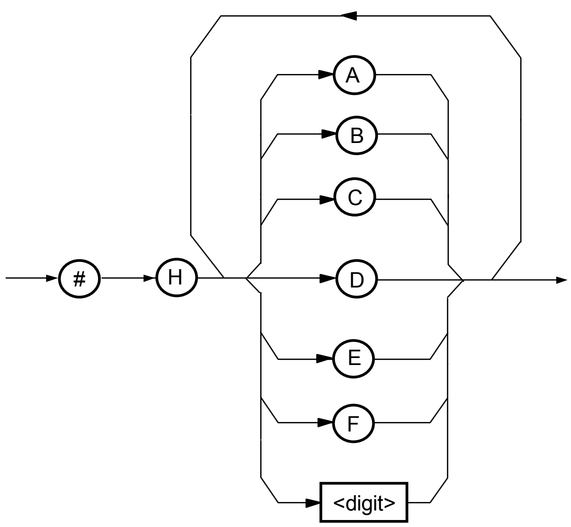
<CHARACTER PROGRAM DATA>



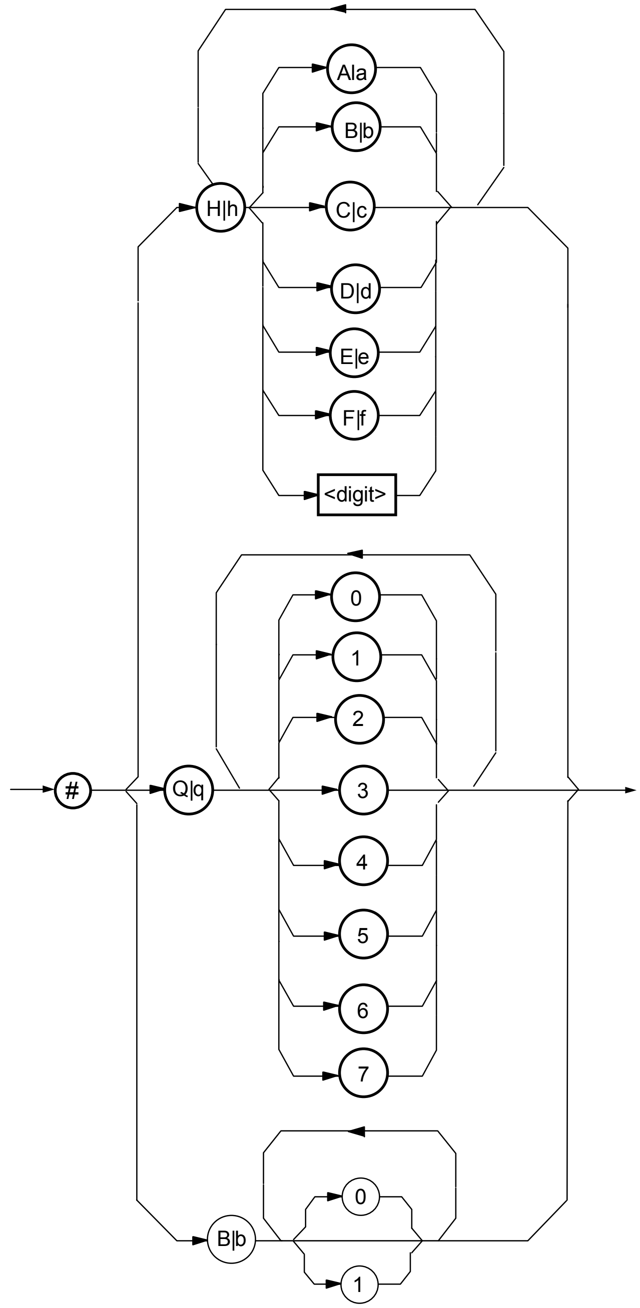
<DECIMAL NUMERIC PROGRAM DATA>



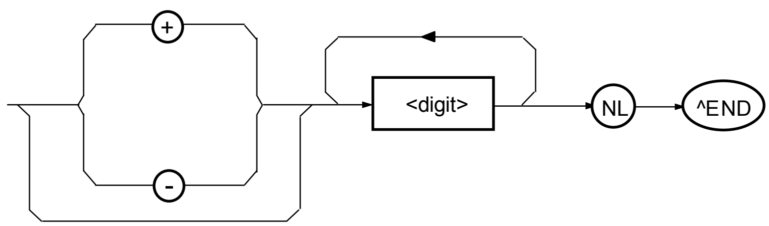
<HEXADECIMAL NUMERIC RESPONSE DATA>



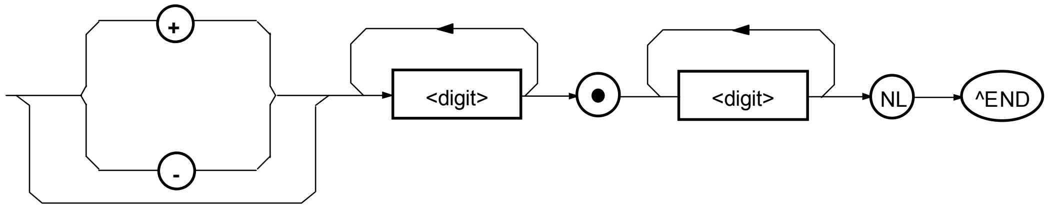
<NON DECIMAL NUMERIC PROGRAM DATA>



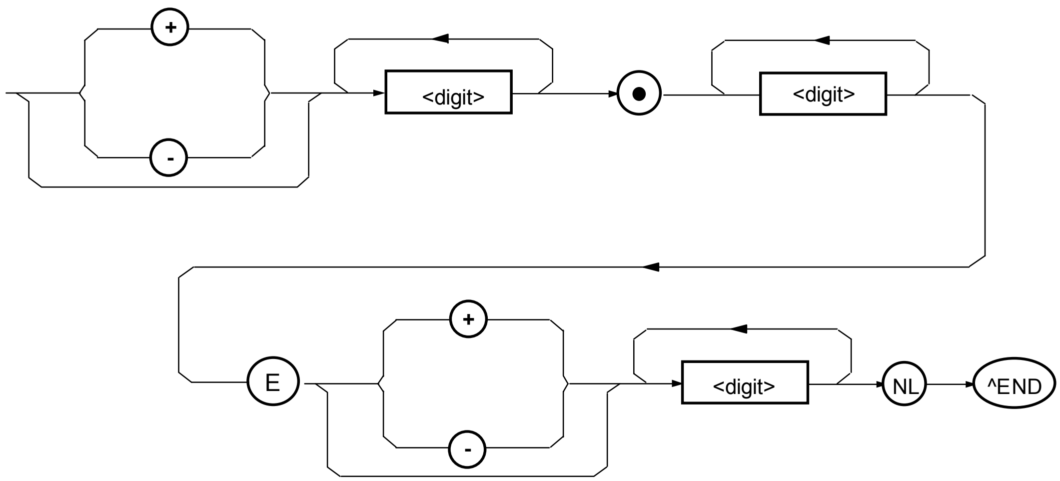
<NR1 NUMERIC RESPONSE DATA>



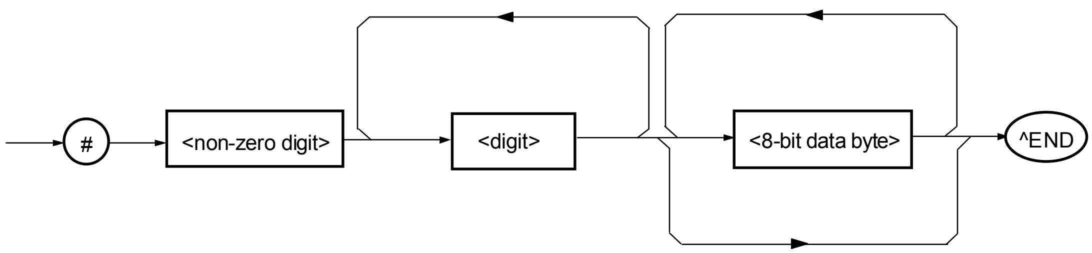
<NR2 NUMERIC RESPONSE DATA>



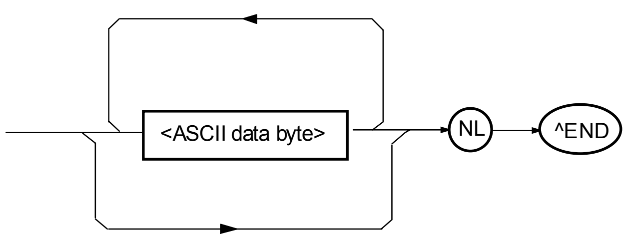
<NR3 NUMERIC RESPONSE DATA>



<DEFINITE LENGTH ARBITRARY BLOCK RESPONSE DATA>



<ARBITRARY ASCII RESPONSE DATA>



Appendix C
HP COMPATIBLE CABLE ASSEMBLY SIGNAL DIFFERENCES

The following table outlines the signal differences between HP and Zygo systems, as seen at the output of HP Compatible Cable Assembly 8020-0300-01.

HP 5507A	*ZMI-1000 Constant Data Rate*
Position Error (Sign, B30-B0) - two's complement representation of the difference between the position counter and the destination register. - forced to zero when Drive Enable Out- is false (high).	Position Data (P31-P0) - two's complement representation of the difference between the position accumulator and the offset register. - forced tri-state (high impedance) when Output Enable* is false (high).
Position Null - output is active (high) when Position Error is smaller than the Null Mask specifier. - Output transition occurs on rising edge of Error Clock, one cycle before position output state that caused it to occur.	Window* - output is active (low) when Position Data is within the range specified by the window mask register. - Output transition occurs coincident with the position data which caused it to occur.
Error Clock - used to synchronize external equipment to Position Error output transitions. - 75 % duty cycle. - frequency is 1.5 to 2.0 MHz or 1.9 to 2.4 MHz depending on the laser head used. - sampling of Position Error on the high to low transition is recommended.	Output Clock - used to synchronize external equipment to Position Data output transitions. - 50 % duty cycle. - frequency is 2.0, 4.0 or 8.0 MHz (software selectable). - sampling of Position Data on the high to low transition is recommended.
Drive Enable In- - this negative true input allows Drive Enable Out- to go true and activate the Position Error outputs. - Position Error is forced to zero when Drive Enable In- is false (high).	Output Enable* - this negative true input enables the Position Data outputs. - Position Data is forced tri-state when Output Enable* is false (high).
Position Reset- - this negative true input resets the position counter to zero within 2 microseconds. Normal counting resumes 2 microseconds after Position Reset- returns to the high state.	Position Reset* - the high to low transition of this input, on the next measurement signal transition, initiates: a. reset/preset position accumulator b. reset time accumulator c. reset error
Error Hold- - this negative true input freezes the Position Error outputs when low (true). - a false Drive Enable In- will not zero the position error outputs when Error Hold- is active low, although Drive Enable Out- will be forced false.	Position Hold* - the high to low transition allows one more measurement update of the P2 position register. This position is frozen as long as Position Hold* is true (low).

continued next page

<table>
<tr><th>HP 5507A</th><th>ZMI-1000 Constant Data Rate</th></tr>
<tr><td>External Sample-
- this signal samples the position counter. The hardware Position Error outputs are not affected, only the software position outputs.
- External Sample- flags the HP-IB board that a sample operation occurred.</td><td>External Sample*
- this signal samples the position accumulator. The P2 Position Data outputs are not affected, only the VME position register.
- External Sample* flags the CPU board that a sample operation occurred.</td></tr>
<tr><td>Drive Enable Out-
- may be used to disable the drive circuitry of the stage actuator to protect the stage in case of measurement errors.
- the following conditions force it high:
a. power-up or system BOOT command.
b. a Drive Off command.
c. measurement error.
d. position counter over/underflow.
e. in Error Mode 1, any other system or programming error.
f. Drive Enable In- is false.
- the only way to set Drive Enable Out- true (low) is with the *DRI command, provided none of the above conditions are true.</td><td>Error Out
- the following conditions force it high (true) if their corresponding enable bits are set true in control register 1
a. reference signal error (including laser head error).
b. measurement signal error.
c. position accumulator over/underflow.
d. excess velocity error.
- Error Out is enabled by an active Output Enable* input.
- if Output Enable* is false (high), Error Out is forced tri-state (high impedance).</td></tr>
</table>

ZMI
Cable Guide
OMP-0333G

Zygo Corporation
Laurel Brook Road
P.O. Box 448
Middlefield, Connecticut 06455-0448

Telephone: (860) 347-8506
Fax: (860) 346-4188
E-mail: inquire@zygo.com
Website: www.zygo.com

ZYGO CUSTOMER SUPPORT

For help within North America, 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 Monday - Friday, 8 a.m. - 5 p.m. (Eastern Standard Time)
(800) ZYGO NOW (800) 994-6669
or (860) 704-5191

FAX (860) 346-4188

INTERNET www.zygo.com
support@zygo.com

WRITE Zygo Corporation
Laurel Brook Road
P.O. Box 448
Middlefield, CT 06455-0448
Attn: Customer Support

MANUAL REVISION INFORMATION

The document (OMP) number and the applicable revision letter for this manual appear on the title page. The publication date appears below.

Revision	*Publication Date*	*Revision*	*Publication Date*
original	July 1992	F	August 1998
B	December 1993	G	May 2000
C	December 1994		
D	April 1997		
E	September 1997		

MANUAL NOTATIONS

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

Note: Provides helpful information.

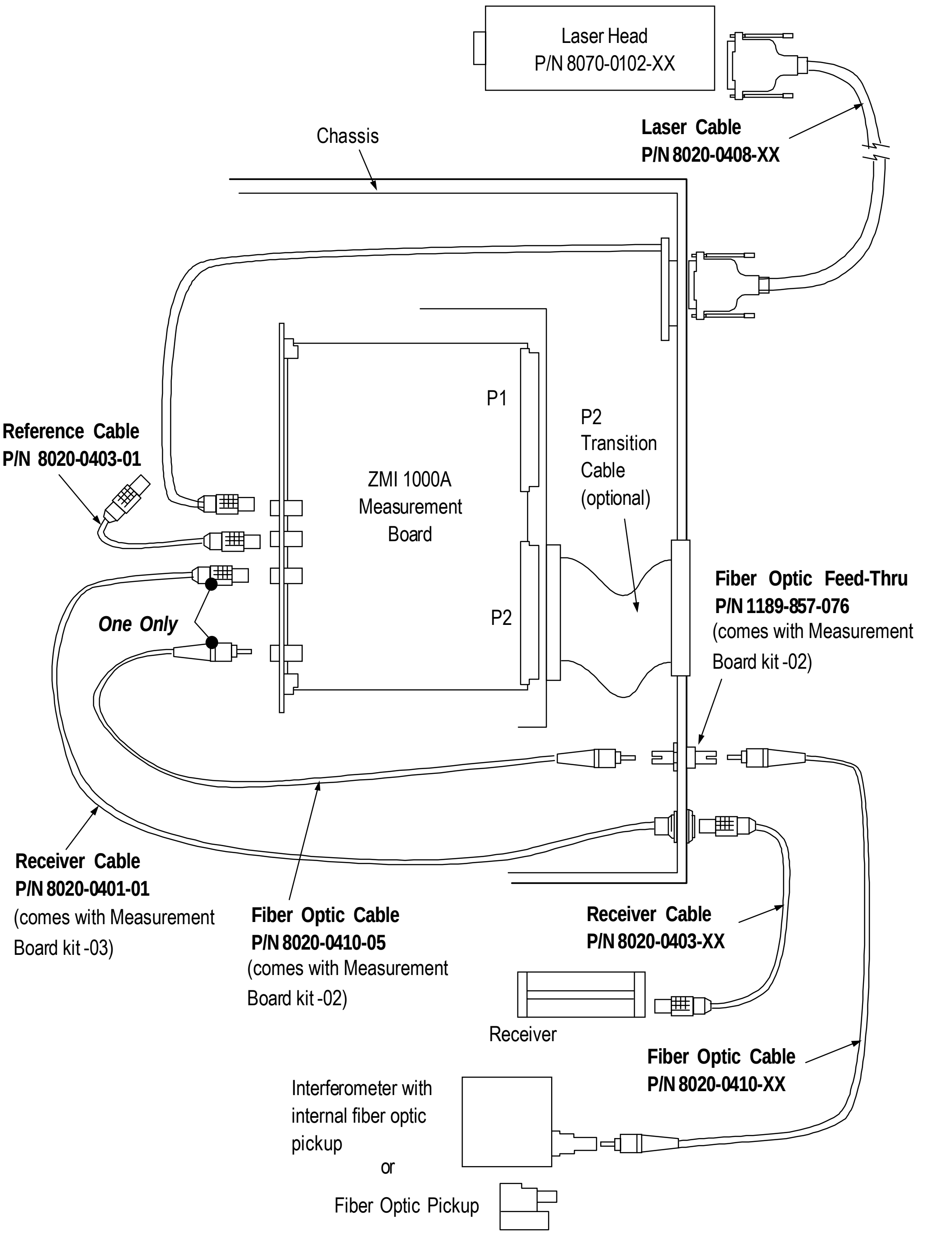
ZMI CABLE GUIDE

Zygo' s ZMI products are structured as "building-blocks". From the optical components to circuit boards, to the cables, products can be selected to suit your particular application.

In this cable guide, you' ll find overview drawings to help you select and identify the cables you need. For specific information about a particular cable refer to the detailed specification pages. If you have questions or additional cabling requirements please contact Zygo.

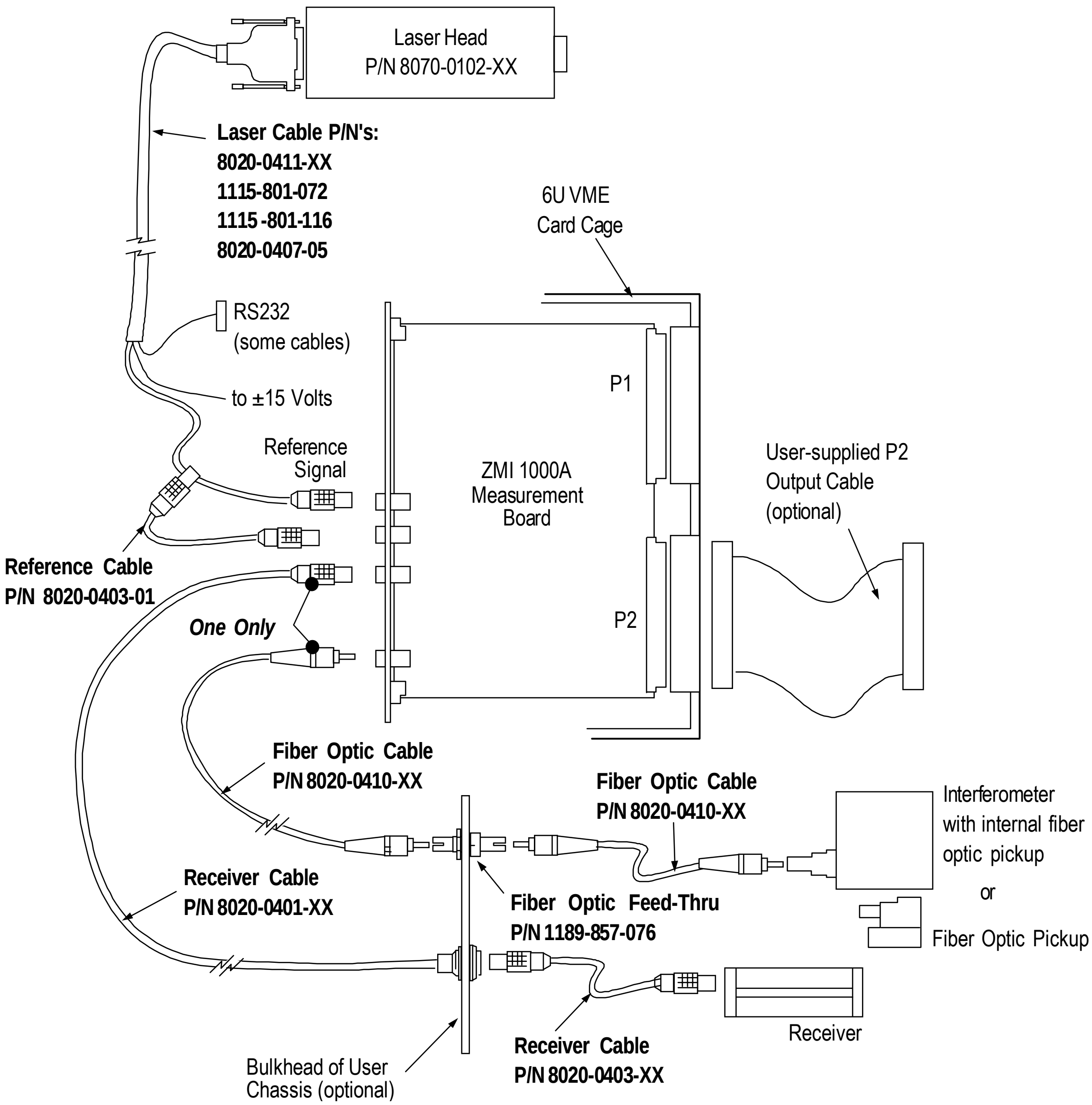
ZMI 1000 Chassis Based System Cables

For use with Zygo Chassis (P/N 8010-0100-02/-03) and ZMI 1000A Measurement Board Kits (P/N 8020-0100-02/-03).



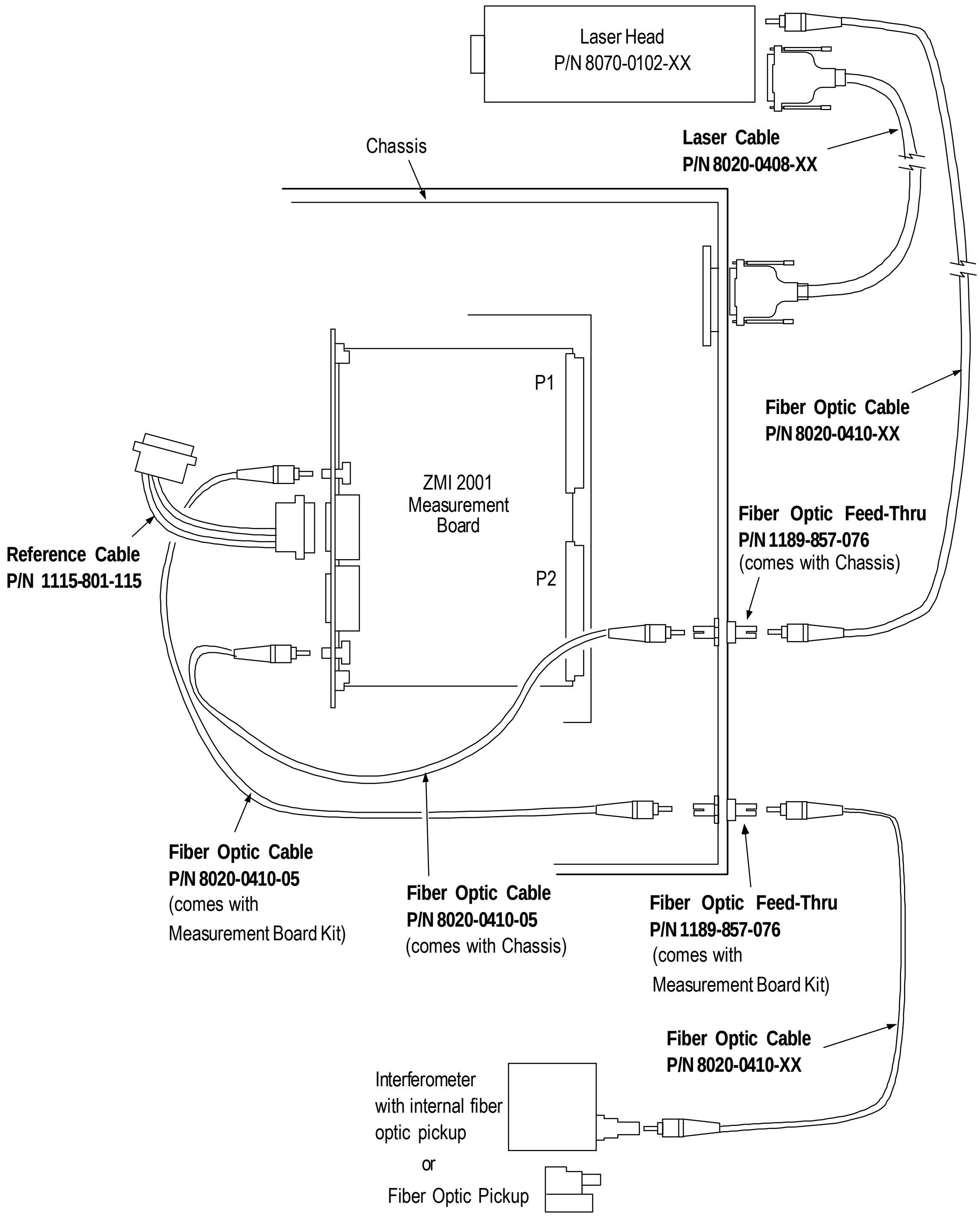
ZMI 1000 VME Backplane Based System Cables

For use with user-supplied VME backplane and ZMI 1000A Measurement Board Kit (P/N 8020-0100-07).



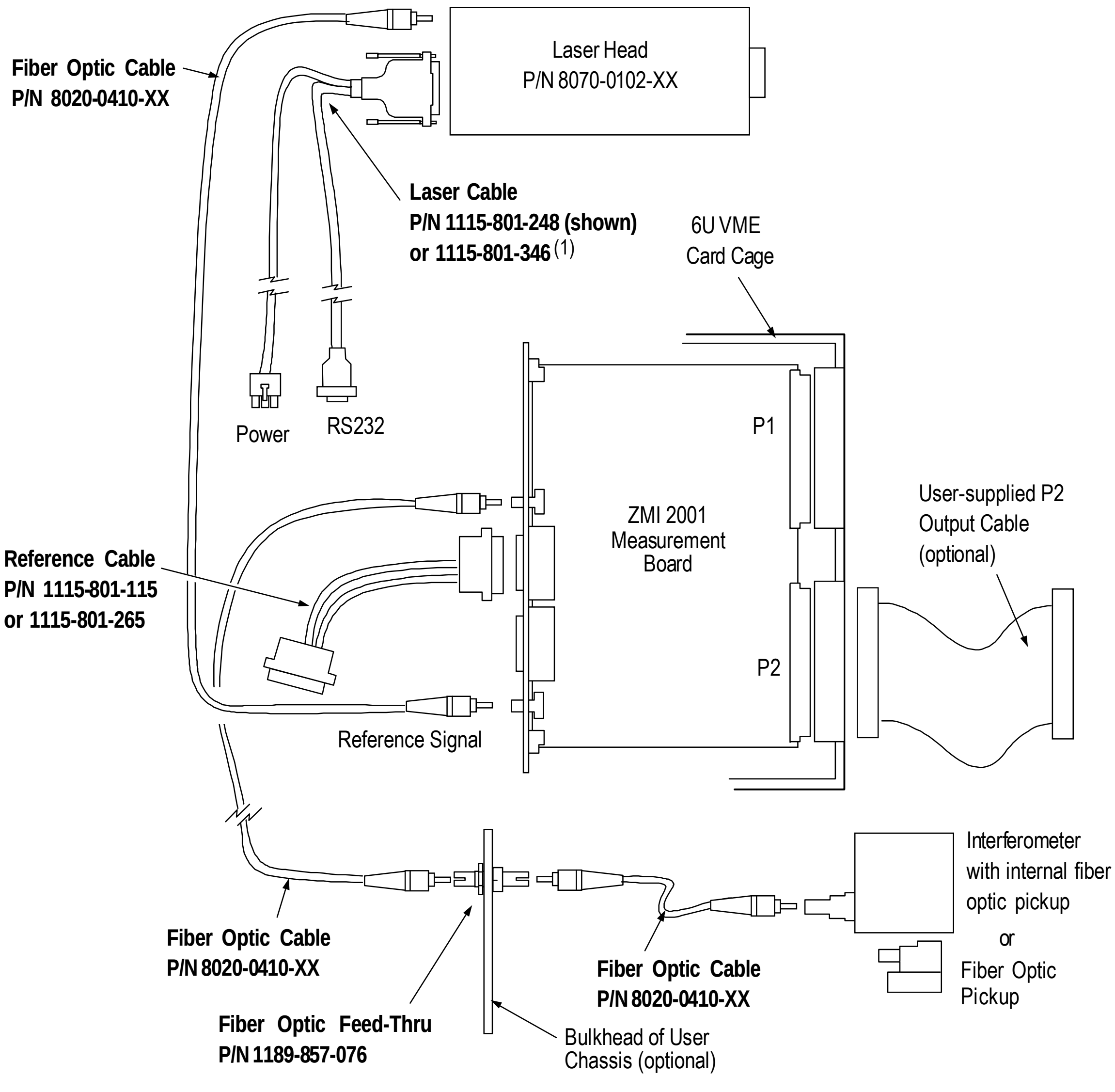
ZMI 2001 Chassis Based System Cables

For use with Zygo Chassis (P/N 8010-0100-04/-05) and ZMI 2001 Measurement Board Kit (P/N 8020-0101-06).



ZMI 2001 VME Backplane Based System Cables

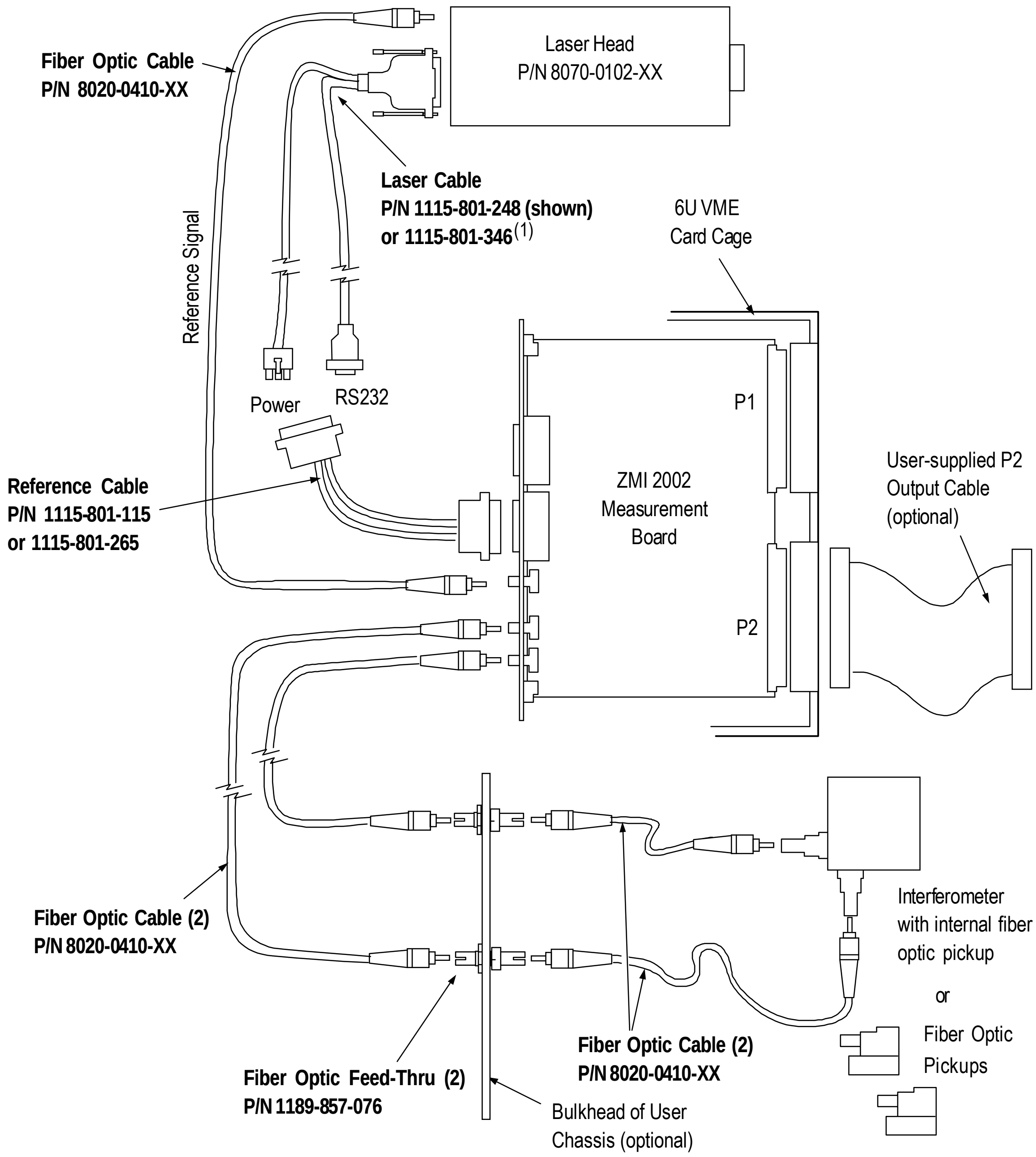
For use with user-supplied VME backplane and ZMI 2001 Measurement Board Kit (P/N 8020-0101-04).



(1) Laser Cable 1115-801-346 connects to the Laser Power Supply (P/N 8010-0104-XX).

ZMI 2002 VME Backplane Based System Cables

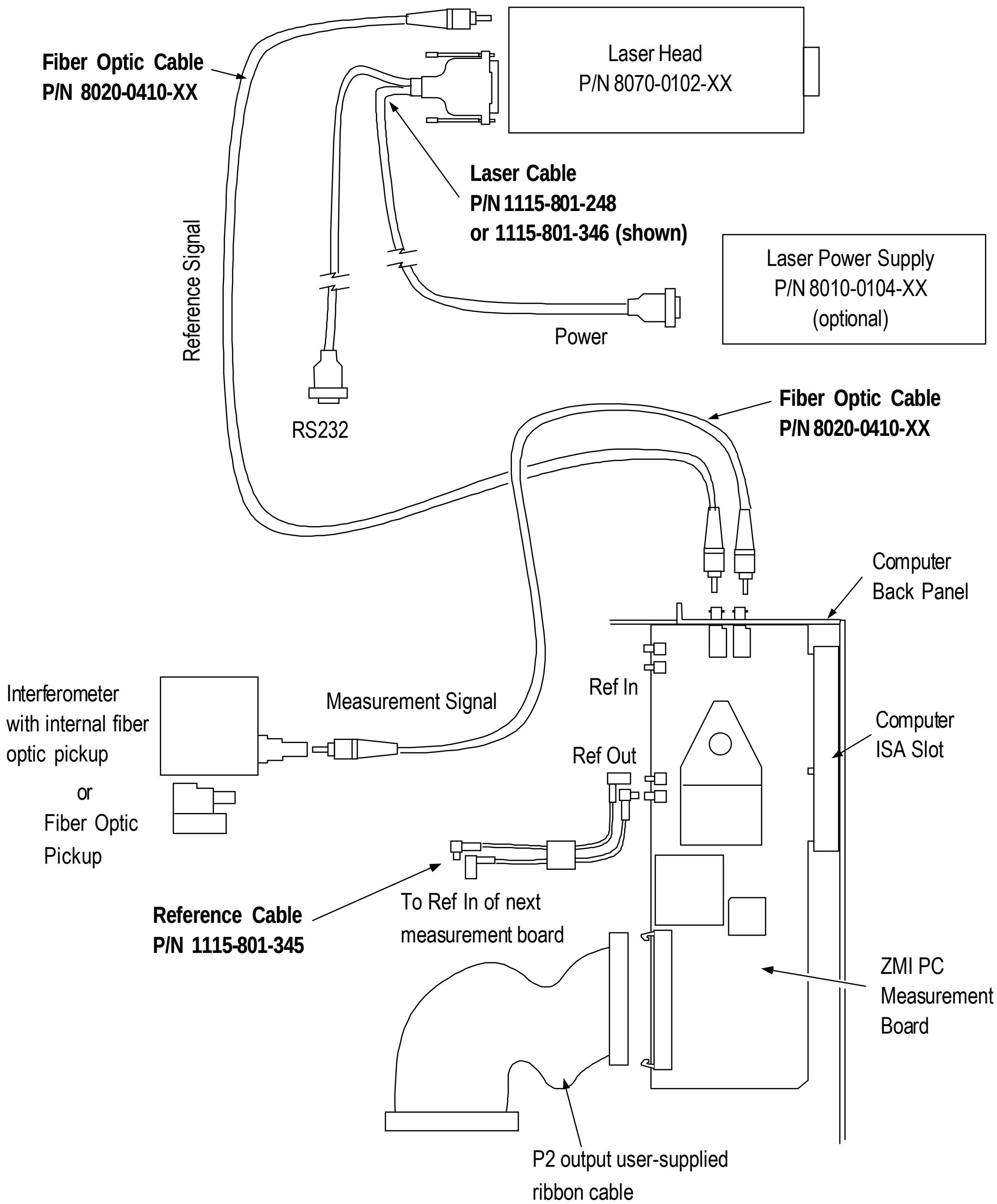
For use with user-supplied VME backplane and ZMI 2002 Measurement Board Kit (P/N 8020-0101-03).



(1) Laser Cable 1115-801-346 connects to the Laser Power Supply (P/N 8010-0104-XX).

ZMI PC ISA Based System Cables

For use with user-supplied computer ISA backplane and ZMI PC Measurement Board Kit (P/N 8020-0101-11).

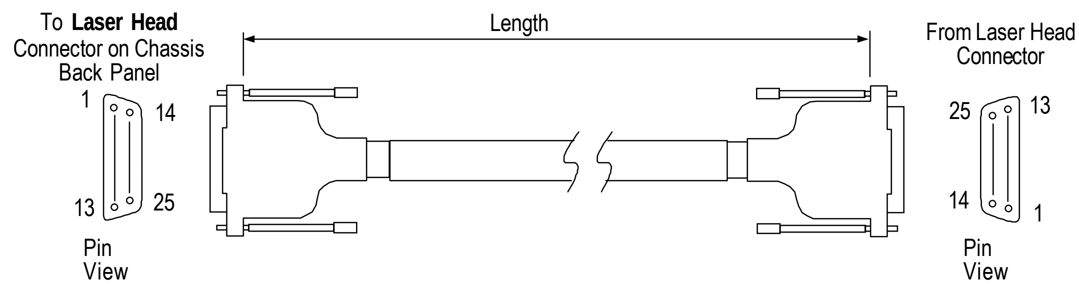


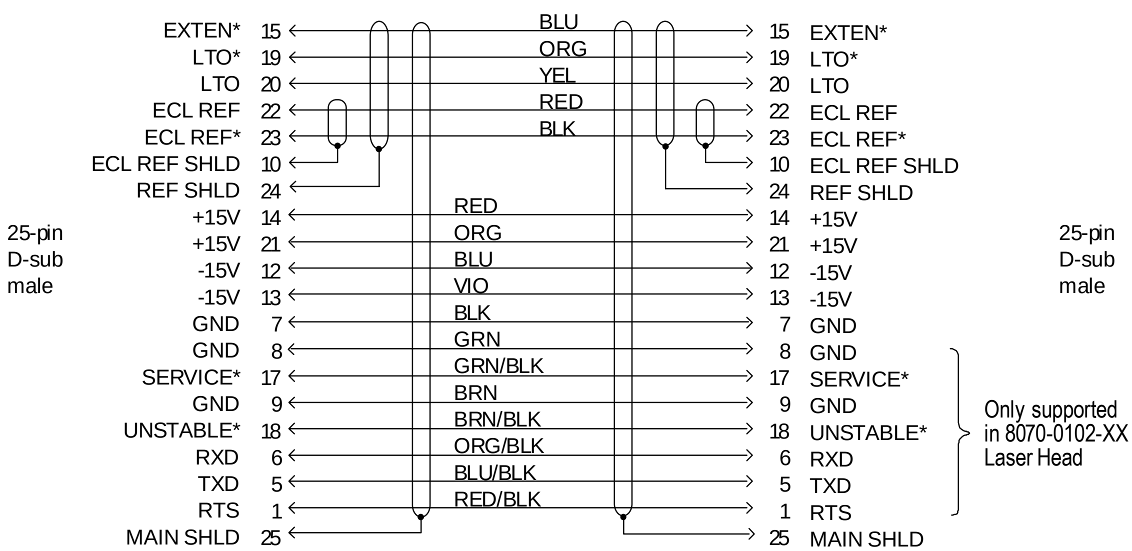
Laser Head Cable P/N 8020-0408-XX

For use with Zygo Laser Heads and the ZMI System Chassis.

XX	Length
01	3 meters
02	5 meters
03	10 meters
04	15 meters
05	0.5 meters

* Length tolerance is ±2%.



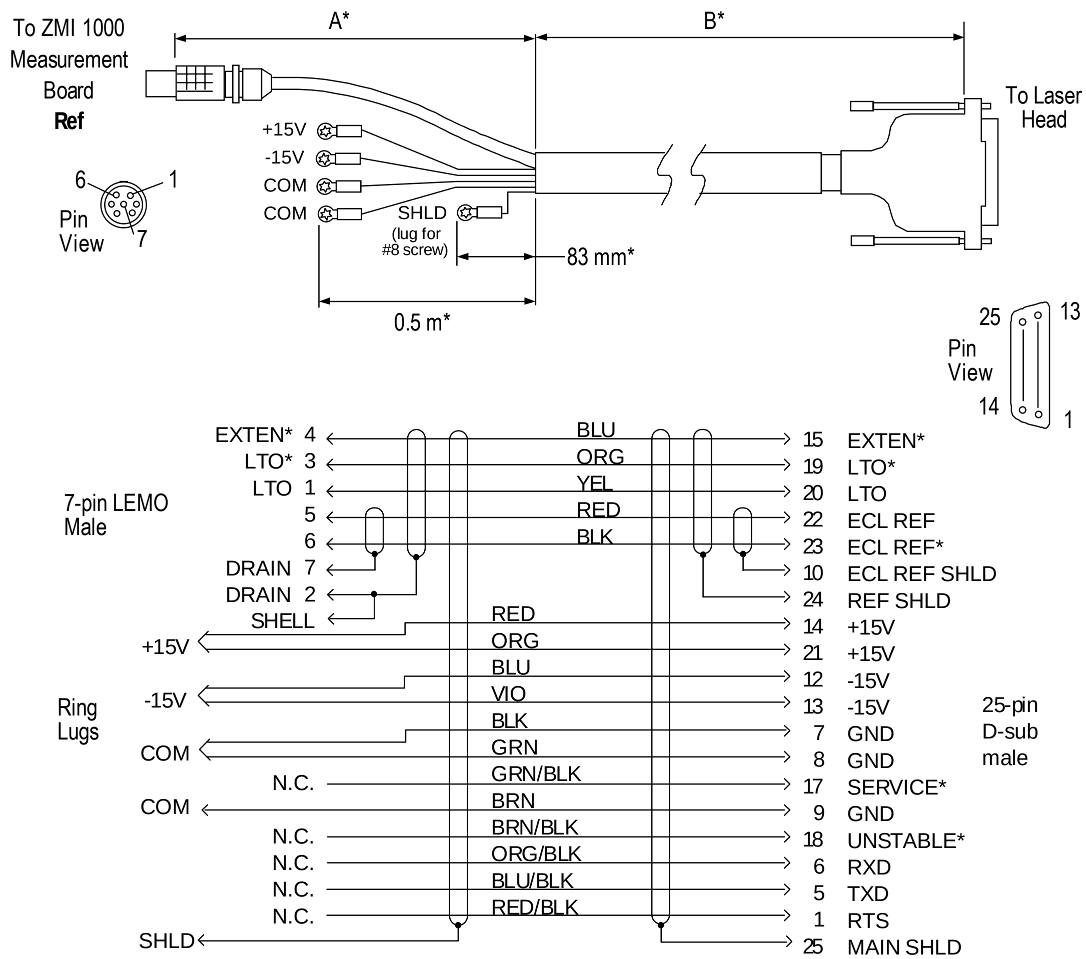


Laser Head Cable P/N 8020-0407-XX

For use with Zygo Laser Heads in a ZMI 1000 based system with a user-supplied backplane.

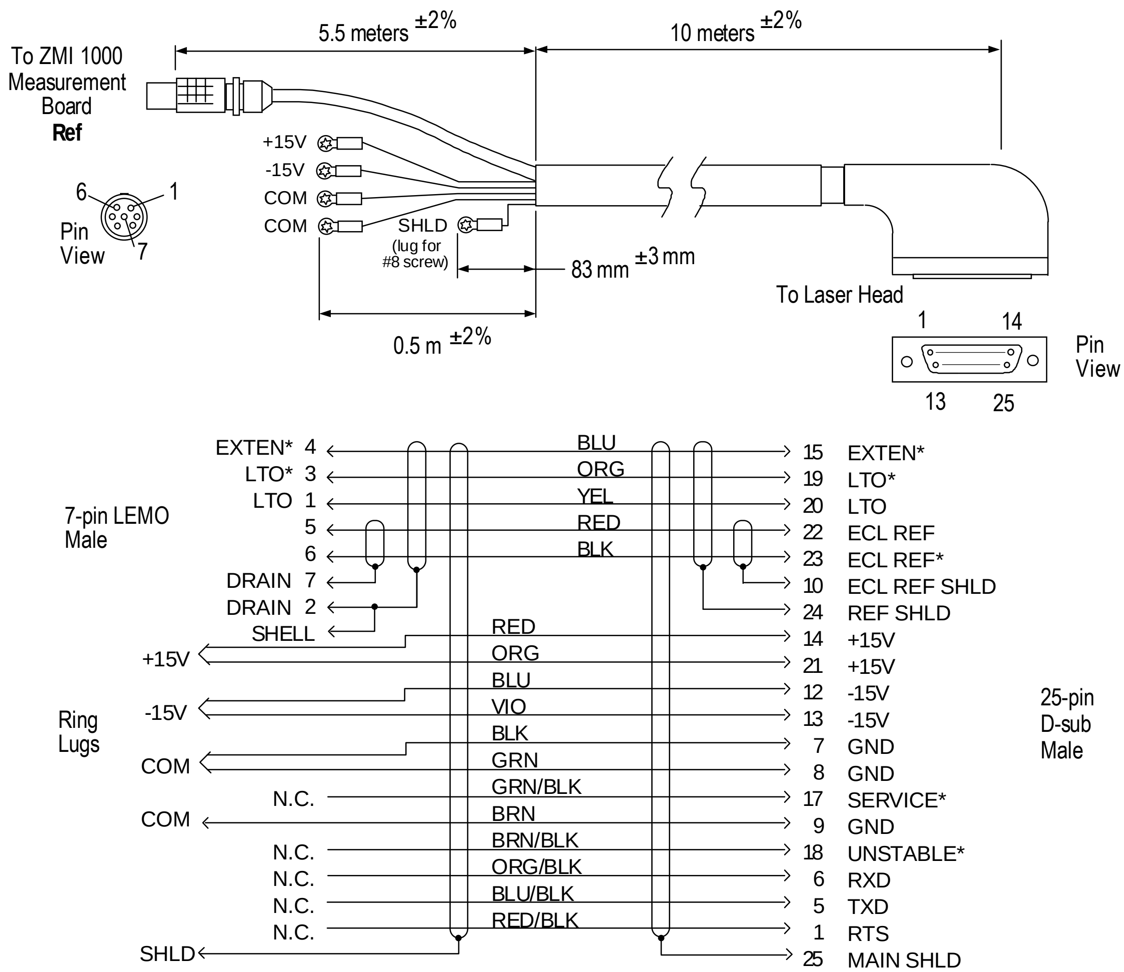
XX	A Length	B Length
01	3.5 meters	4 meters
02	5.5 meters	10 meters
03	5.5 meters	15 meters
04	1.7 meters	4.4 meters

* Length tolerance is ±2%.



Laser Head Cable P/N 8020-0407-05

Right-angle cable for use with Zygo Laser Heads in a ZMI 1000 based system with a user-supplied backplane. Note that in addition to the cable, a right angle adapter kit (P/N 8070-0108-01) is required for the Laser Head.

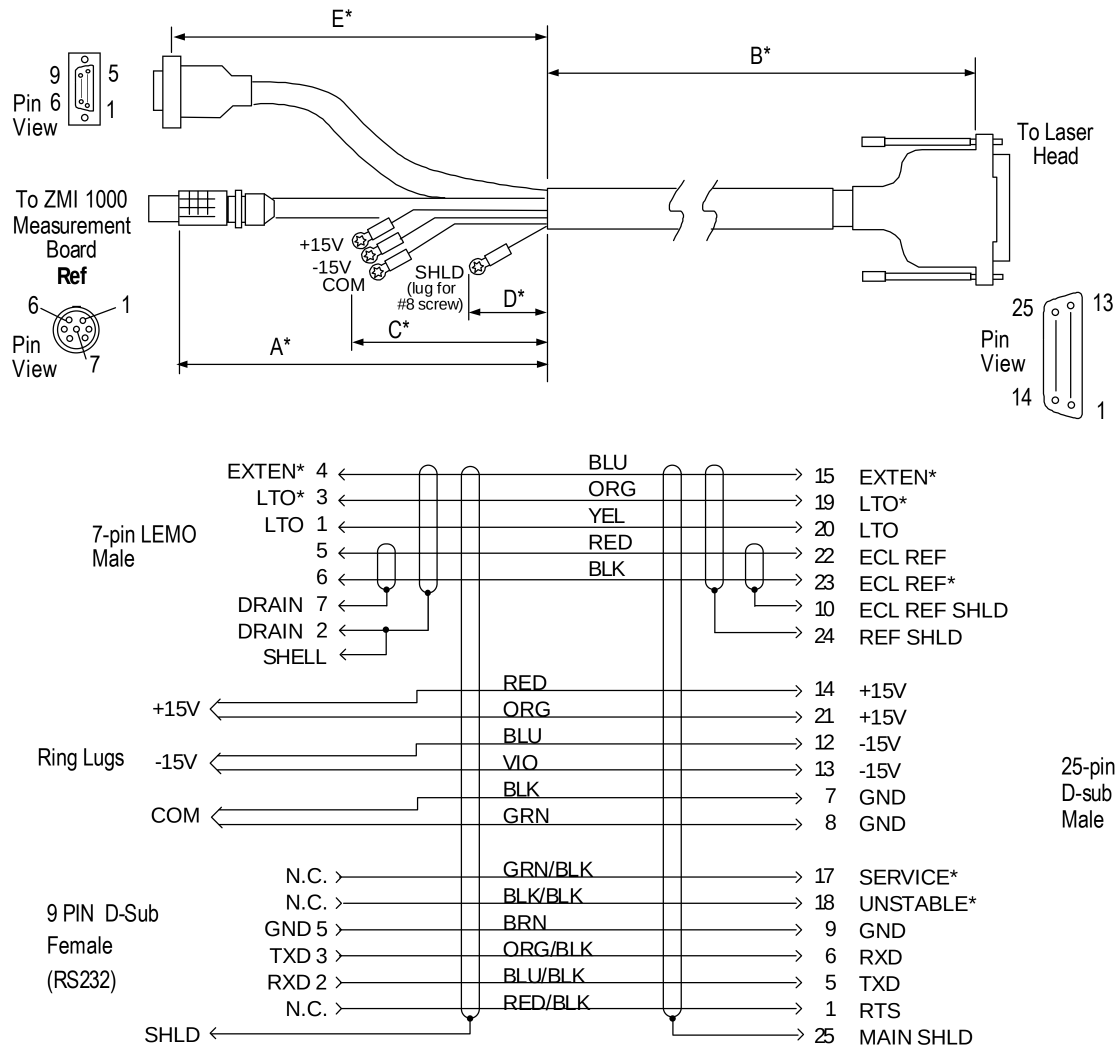


Laser Head Cable P/N 8020-0411-XX

For use with Zygo Laser Heads in a ZMI 1000 based system with a user-supplied backplane. RS232 diagnostics are supported when used with an 8070-0102-XX Laser Head.

XX	A Length	B Length	C Length	D Length	E Length
01	1 meter	2 meters	0.5 meter	0.5 meter	152 mm
02	1 meter	5 meters	0.5 meter	83 mm	102 mm
03	1 meter	10 meters	0.5 meter	83 mm	102 mm
04	1 meter	0.5 meters	0.5 meter	83 mm	102 mm

* Length tolerance is ±2%.

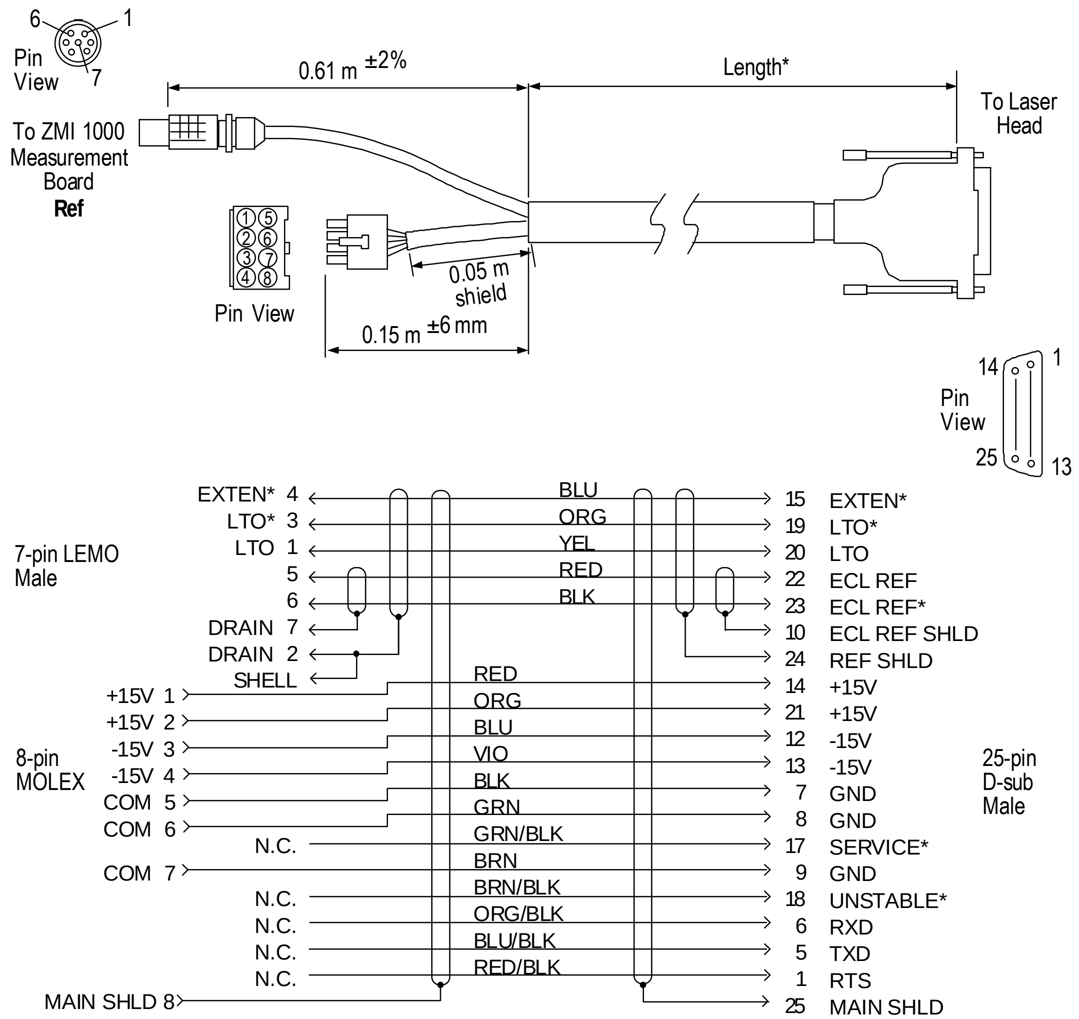


Laser Head Cable P/N 1115-801-072 and 1115-801-116

For use with Zygo Laser Heads in a ZMI 1000 based system with a user-supplied backplane.

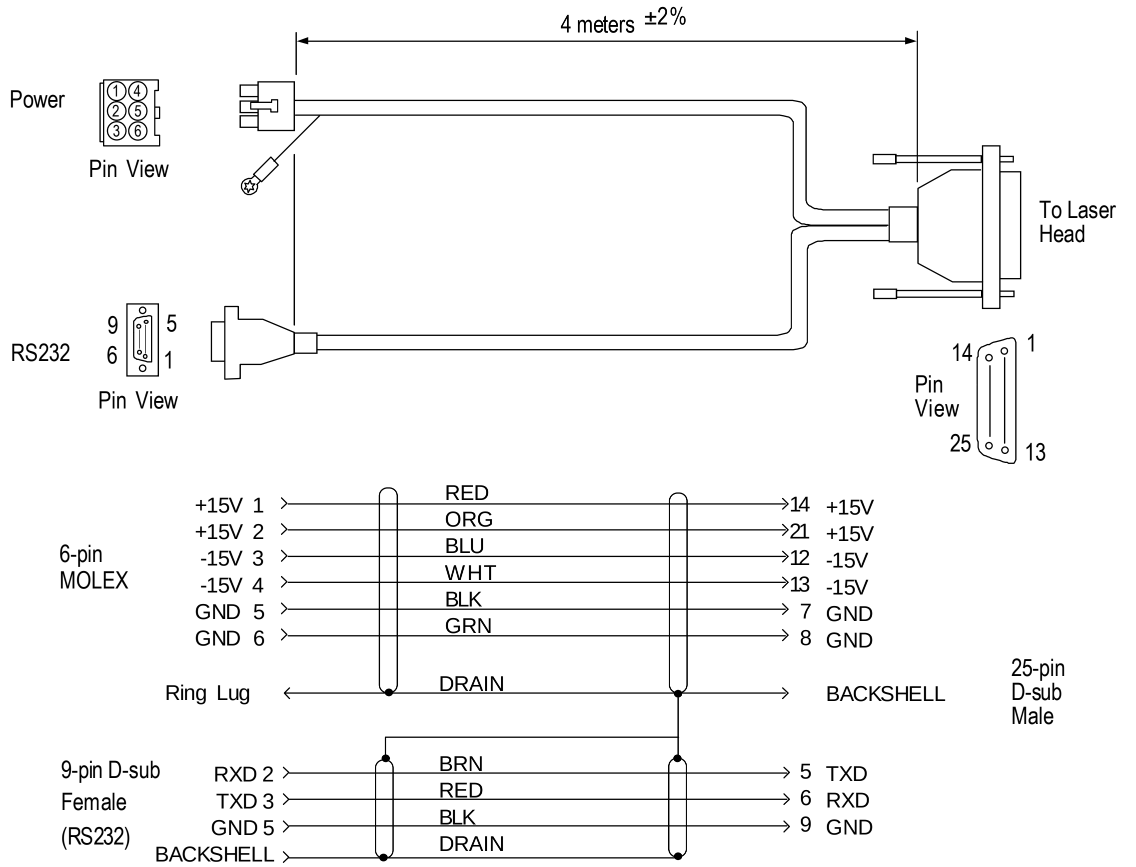
P/N	Length
1115-801-072	6 meters
1115-801-116	10 meters

* Length tolerance is ±2%.



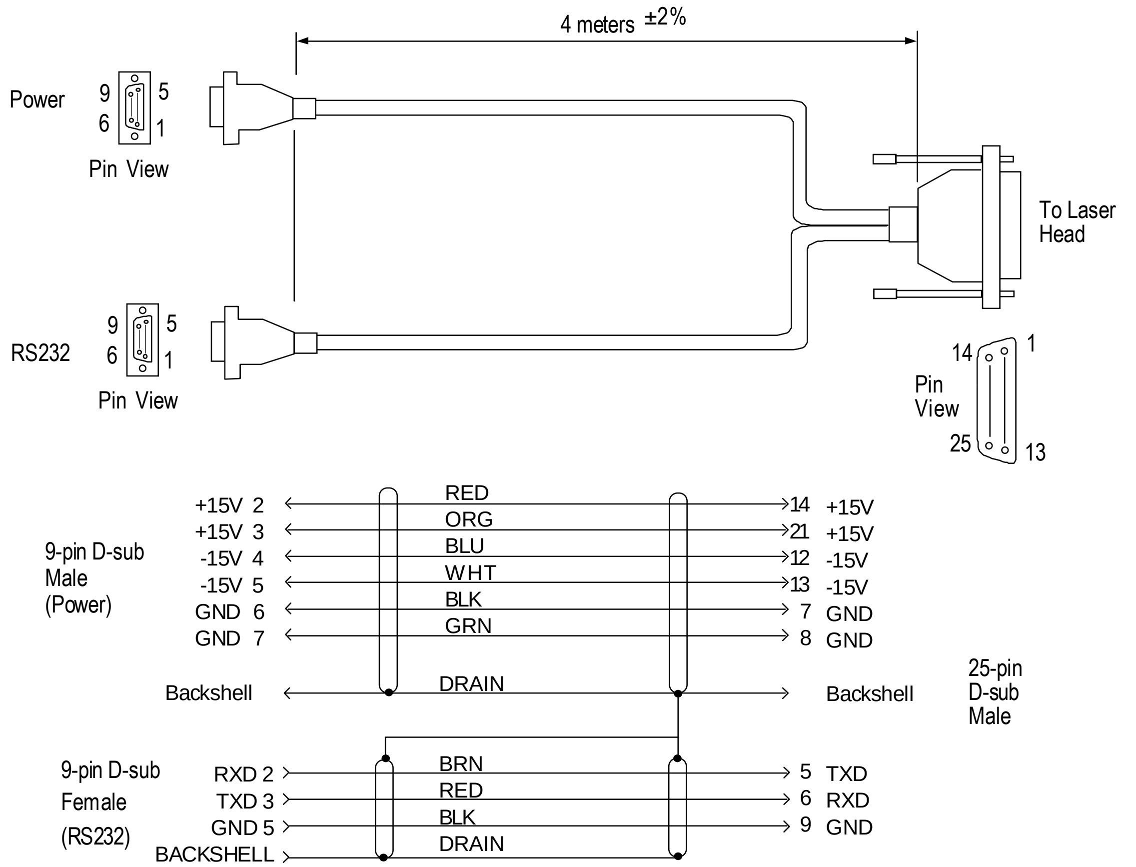
Laser Head Cable P/N 1115-801-248

For use with the Zygo 8070-0102-XX Laser Heads in a ZMI 2000 based system with a user-supplied backplane.



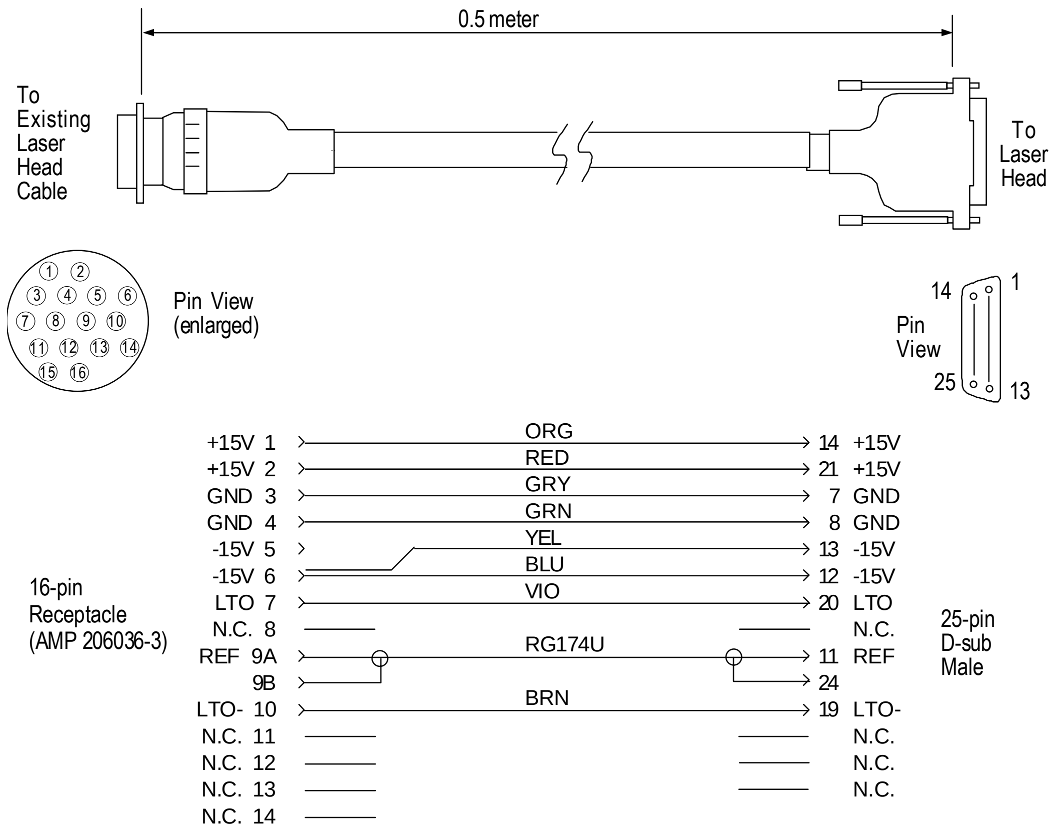
Laser Head Cable P/N 1115-801-346

For use with the Zygo 8070-0102-XX Laser Heads in a user-supplied backplane. The power connector mates to the Zygo Laser Power Supply (P/N 8010-0104-XX).



Laser Head Cable P/N 1115-801-333

For use with the Zygo 6191-0460-03 Laser Head in a Zygo 2/20 based system with a Controller or Coupler. This transition cable interfaces the 6191-0460-03 Laser Head to a Zygo 2/20 laser cable P/N 6191-0233-XX for backwards compatibility.



Fiber Optic Cable P/N 8020-0410-XX

For use with Zygo ZMI 1000 and ZMI 2000 Measurement Boards.

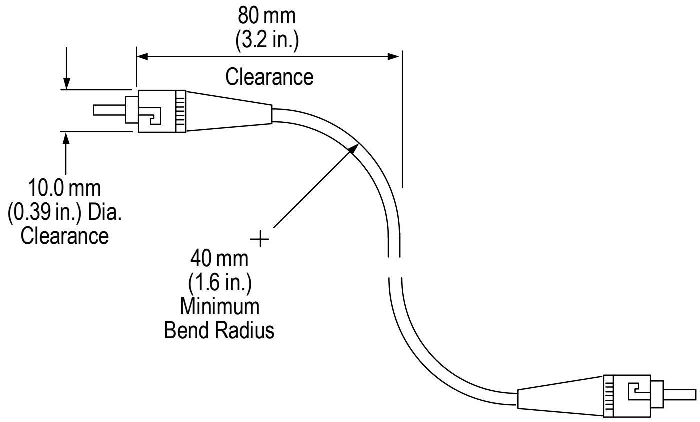
Size: 400 micron core, multi mode,
3.0 millimeter outside cable diameter.

Connectors: Male ST bayonet at both ends.

Cable Mechanical Specifications:
Maximum Tensile Load:
125 lb (500 N) short term
68 lb (300 N) long term
Crush Resistance: 428 lbs/in (750 N/cm)
Connector Pull Out Strength: 25 lb (225 N)

Environmental:
Operating Temperature: 0° to 70° C (32° to 158° F)
Non-operating Temperature: -20 to 80° C (-4° to 176° F)

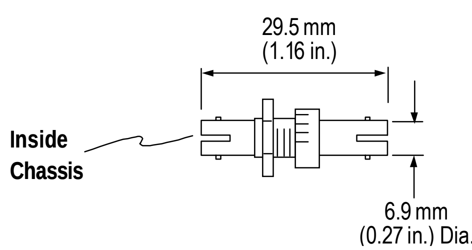
XX	Length	Tolerance
01	1 meters	-0%, +5%
02	3 meters	-0%, +5%
03	5 meters	±0.5%
04	10 meters	±0.5%
05	0.6 meters	-0%, +5%
06	20 meters	±0.5%
07	15 meters	±0.5%

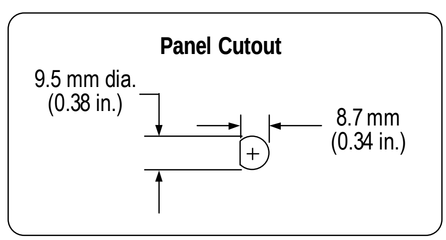


Chassis Fiber Optic Feed-Thru P/N 1189-857-076

Used to interface two fiber optic cables through a bulkhead panel.

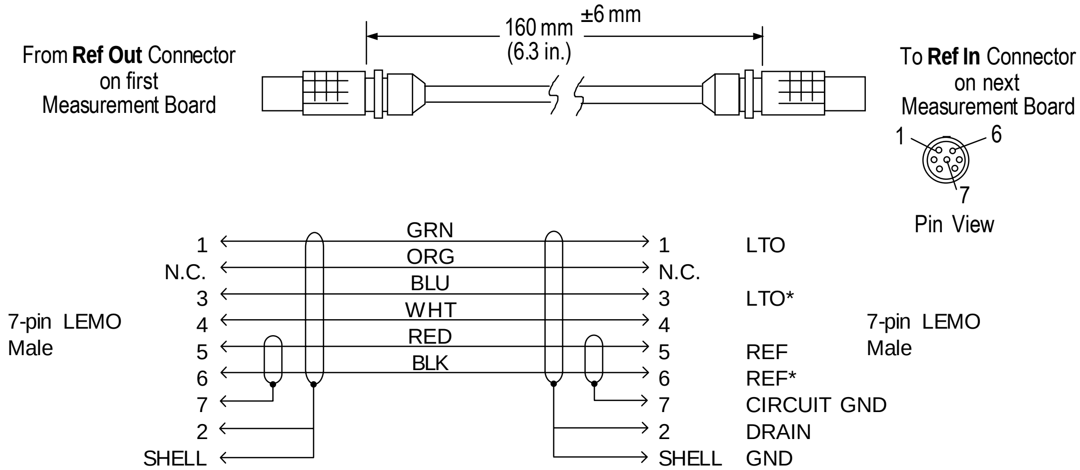
Efficiency: 80-90% typical





Measurement Board Reference Cable P/N 8020-0403-01

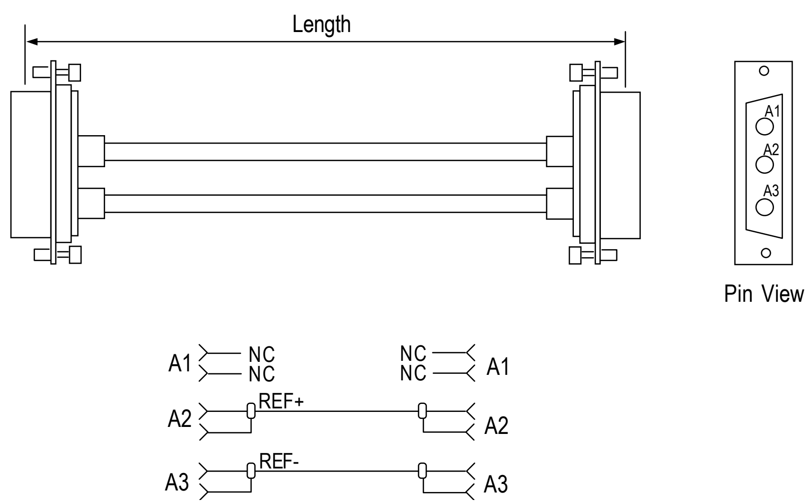
Used to daisy chain the reference signal between ZMI 1000 Measurement Boards.



Measurement Board Reference Cable P/N 1115-801-115 and 1115-801-265

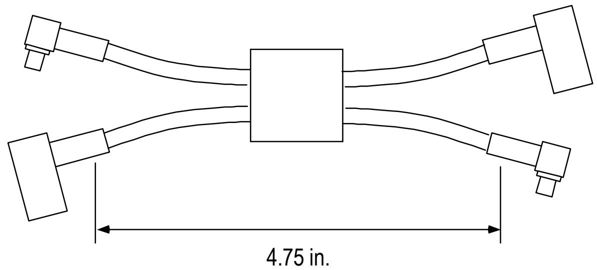
Used to daisy chain the reference signal between ZMI 2000 VME based Measurement Boards.

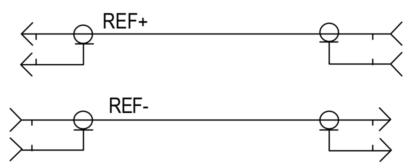
P/N	Length	Tolerance
1115-801-115	120 mm	±3 mm
1115-801-265	200 mm	±3 mm



Measurement Board Reference Cable
P/N 1115-801-345

Used to daisy chain the reference signal between ZMI PC Measurement Boards.

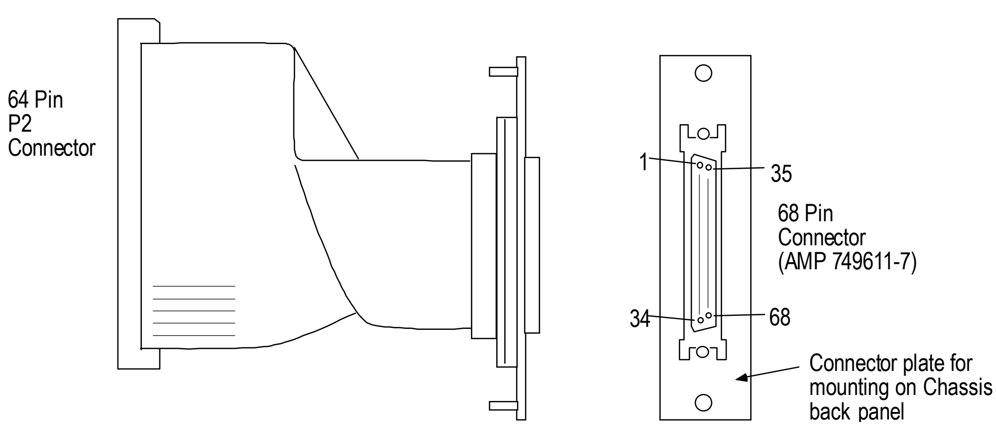




P2 Direct Output Cable P/N 8020-0304-01

For use with Zygo Chassis and ZMI 1000 and ZMI 2000 Measurement Boards.

Pin Out for ZMI 1000 Measurement Boards				Pin Out for ZMI 2000 Measurement Boards			
Pin	**Signal**	**Pin**	**Signal**	**Pin**	**Signal**	**Pin**	**Signal**
1	GND	35	P9	1	Reserved	35	P2_D26
2	64 MHz Ref	36	P10	2	P2_IDE*	36	P2_D18
3	GND	37	P11	3	GND	37	P2_D27
4	64 MHz Ref*	38	P12	4	GND	38	P2_D19
5	GND	39	GND	5	P2_A8	39	P2_D28
6	Error Out	40	P13	6	P2_A0	40	P2_D20
7	Ref Signal Error	41	P14	7	P2_A9	41	P2_D29
8	Meas Signal Error	42	P15	8	P2_A1	42	P2_D21
9	Overflow Error	43	P16	9	P2_A10	43	P2_D30
10	Window*	44	P17	10	P2_A2	44	P2_D22
11	GND	45	P18	11	P2_A11	45	P2_D31
12	Output H to L Enable*	46	P19	12	P2_A3	46	P2_D23
13	Ext Sample*	47	P20	13	P2_R/W*	47	P2_D8
14	Position Reset*	48	GND	14	P2_A4	48	P2_D0
15	Position Hold*	49	P21	15	P2_RESET*	49	P2_D9
16	Output Enable*	50	P22	16	P2_A5	50	P2_D1
17	GND	51	P23	17	GND	51	P2_D10
18	Output/Transfer Clock	52	P24	18	P2_A6	52	P2_D2
19	GND	53	P25	19	Reserved	53	P2_D11
20	Output/Transfer Clock*	54	P26	20	P2_A7	54	P2_D3
21	Time Reset Out*	55	P27	21	GND	55	P2_D12
22	Velocity Error	56	P28	22	GND	56	P2_D4
23	P0	57	GND	23	P2_INT1*	57	P2_D13
24	P1	58	P29	24	P2_INT0*	58	P2_D5
25	P2	59	P30	25	P2_INT3*	59	P2_D14
26	P3	60	P31	26	P2_INT2*	60	P2_D6
27	P4	61	Select Address 2	27	GND	61	P2_D15
28	GND	62	Time Reset*	28	GND	62	P2_D7
29	P5	63	Select Address 1	29	P2_D24	63	GND
30	P6	64	Sample*	30	P2_D16	64	GND
31	P7	65	Select Address 0	31	P2_D25	65	P2_SCLK1
32	P8	66	GND	32	P2_D17	66	P2_SCLK0
33	no connection	67	no connection	33	no connection	67	no connection
34	no connection	68	no connection	34	no connection	68	no connection



External Sample and Reset Cable
P/N 1115-801-071 and 1115-801-310

Used to synchronize the reset and clock signals on the P2 connector for ZMI Measurement Boards.

P/N 1115-801-071

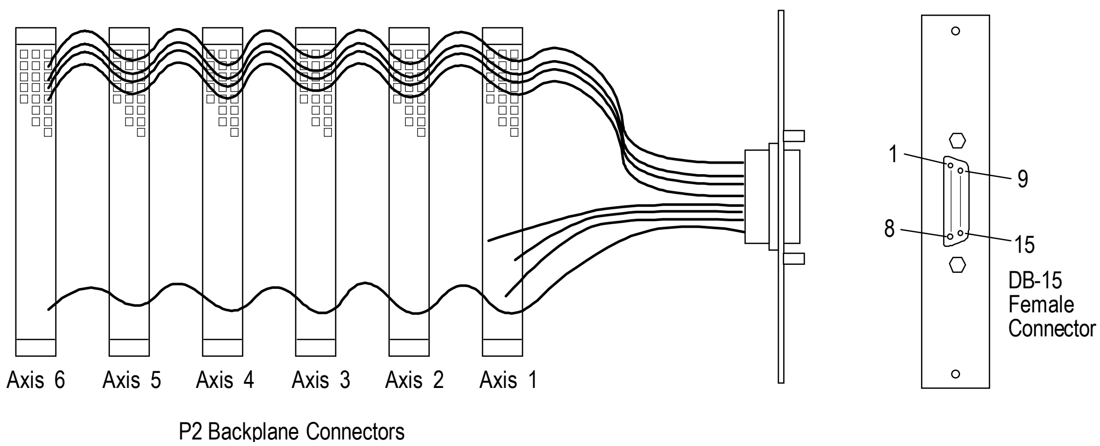
Pin Out for ZMI 1000 Measurement Boards

Pin	Signal
1	Error Out 5
2	Error Out 4
3	Error Out 3
4	Error Out 2
5	Error Out 1
6	Ext Sample*
7	Time Reset*
8	Position Reset*
9	Error Out 6
10	Output Enable*
11	GND
12	GND
13	GND
14	GND
15	GND

P/N 1115-801-310

Pin Out for ZMI 2000 Measurement Boards

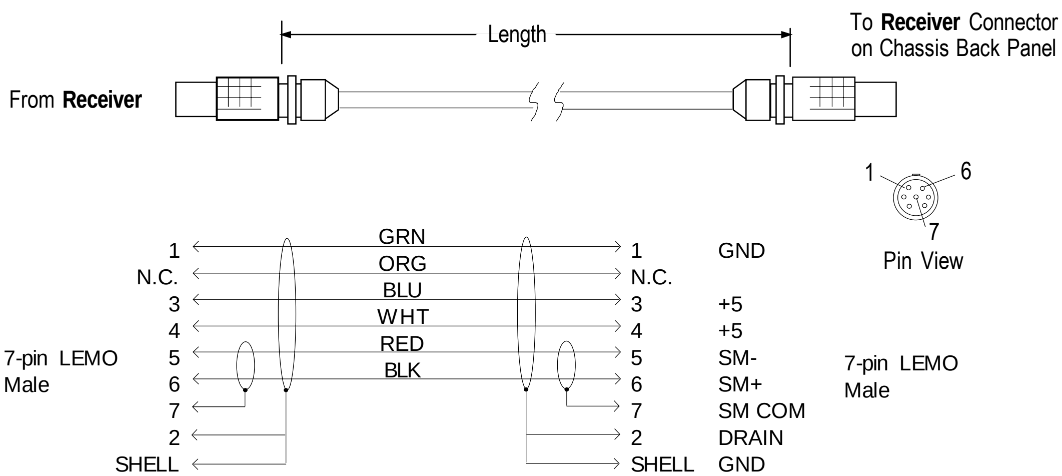
Pin	Signal
1	P2_INT5*
2	P2_INT4*
3	P2_INT3*
4	P2_INT2*
5	P2_INT1*
6	P2_SCLK0
7	P2_Reset*
8	P2_SCLK1
9	P2_INT6*
10	GND
11	GND
12	GND
13	GND
14	GND
15	GND



Receiver Cable P/N 8020-0403-XX

For use with Zygo 6191-0420-01 Receiver and ZMI 1000 Measurement Board. Note that P/N 8020-0403-01 cable is covered under "Measurement Board Reference Cable".

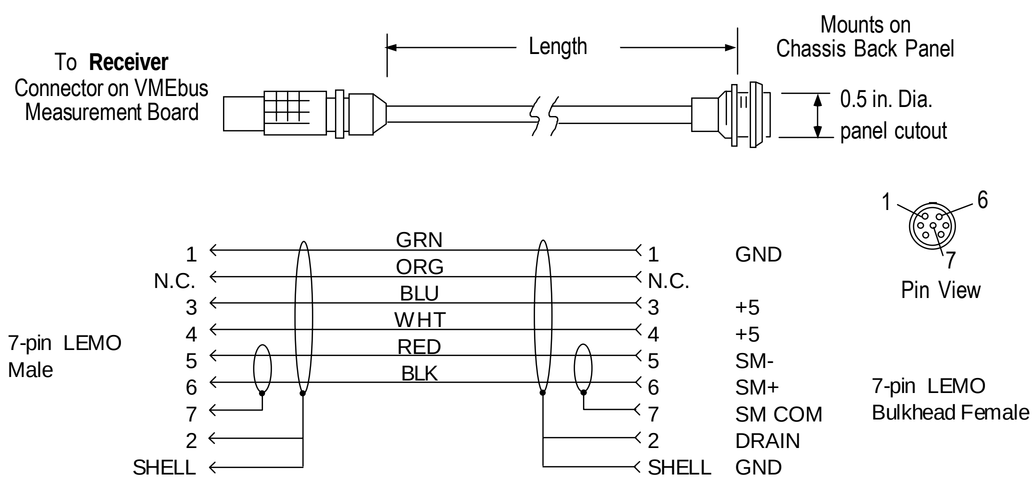
XX	Length	Tolerance
02	3 meters	±2%
03	6 meters	±2%
04	10 meters	±2%



Receiver Cable P/N 8020-0401-XX

Internal cable for use inside the Zygo Chassis; connects to ZMI 1000 Measurement Board and Receiver Cable P/N 8020-0403-XX.

XX	Length	Tolerance
01	28 in.	±2%
02	46 in.	±2%



ZMI
Optics Guide
OMP-0326M

Zygo Corporation
Laurel Brook Road
P.O. Box 448
Middlefield, Connecticut 06455-0448

Telephone: (860) 347-8506
Fax: (860) 346-4188
E-mail: inquire@zygo.com
Website: www.zygo.com

ZYGO CUSTOMER SUPPORT

For help within North America, 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 Monday - Friday, 8 a.m. - 8 p.m. (Eastern Standard Time)
(800) ZYGO NOW (800) 994-6669
or (860) 704-5191

FAX (860) 346-4188

INTERNET www.zygo.com
support@zygo.com

WRITE Zygo Corporation
Laurel Brook Road
P.O. Box 448
Middlefield, CT 06455-0448
Attn: Customer Support

MANUAL REVISION INFORMATION

The document (OMP) number and latest publication date for this manual appear on the title page. Any revision letter following the document number indicates that the manual has been revised. Revision letters also appear at the bottom of each revised page.

Revision	*Publication Date*	*Revision*	*Publication Date*
Original	August 1992	H	December 1997
B	March 1994	J	February 1999
C	March 1995	K	November 1999
D	September 1995	L	June 2000
E	March 1996	M	January 2002
F	February 1997		
G	May 1997		

MANUAL NOTATIONS

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

Note: Provides helpful information.

NOTICE: The descriptions, drawings, and specifications contained herein are subject to change. Zygo is not responsible for errors or omissions herein or for incidental damages in connection with the furnishing or use of this information. This document shall not be reproduced, photocopied, or duplicated, in whole or in part, without prior written approval of Zygo Corp.

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.

01/96

CONTENTS

CONTENTS

Introduction

Chapter 1

In This Chapter

- What This Manual Covers
- Caring for Optics
- The Role of Optics
- Beam Directing Optics
- Interferometers
- Miscellaneous Components
- Mounts
- Vacuum Applications

What This Manual Covers

This manual describes numerous Zygo optical components, and their installation and use. Optical components are an important part of a complete Zygo Motion Interferometer (ZMI) system. This chapter provides an overview of some of the optical components available. For details on many of Zygo's ZMI optical components, refer to Chapter 2.

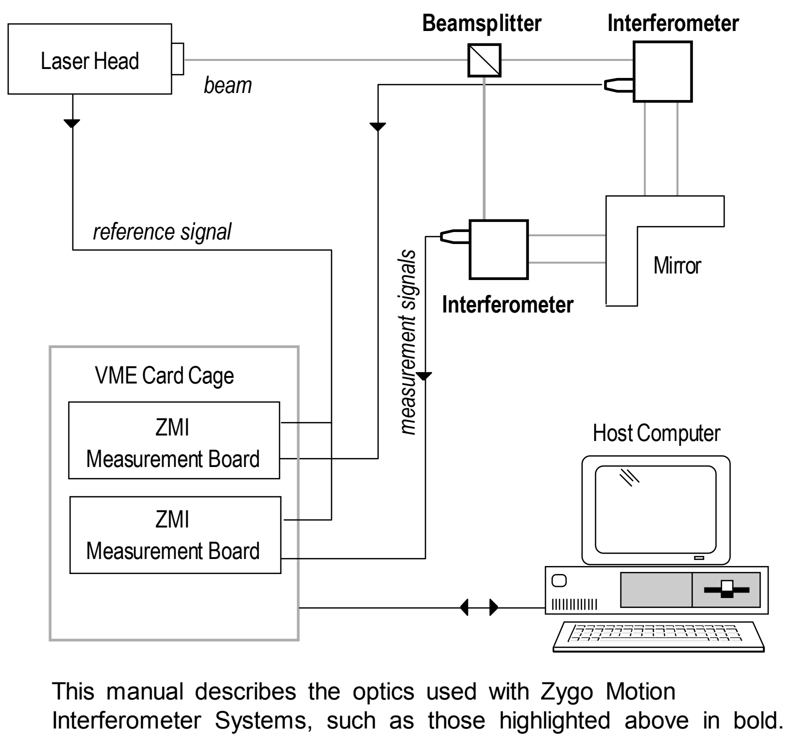


Figure 1-1 Typical ZMI System

Caring for Optics

- Handle optics with care; they are precision instruments.
- Do not touch the optical or glass surfaces.
- Store optical components in original plastic bags and product boxes.
- Should cleaning become necessary, follow the procedures in Chapter 6.

The Role of Optics

Optics divide and direct the beam from the Laser Head to the part whose motion is measured. Examples of optics used in an interferometry system are shown in Figure 1-2. By combining optics many configurations are possible.

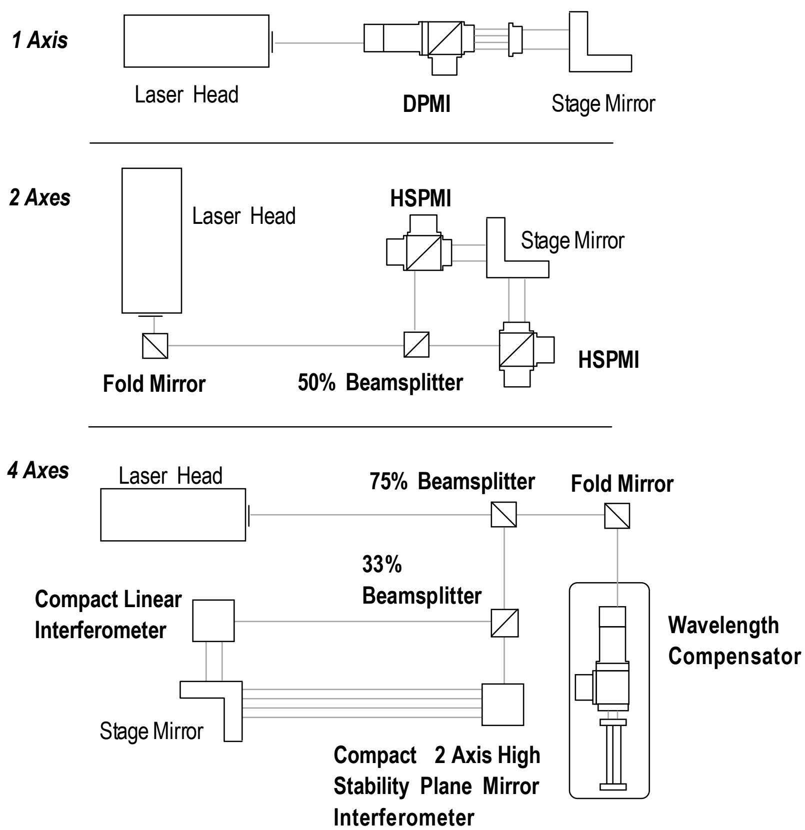
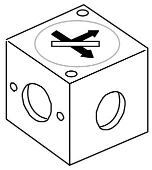


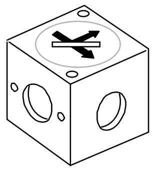
Figure 1-2 Example Uses of Optics

Beam Directing Optics

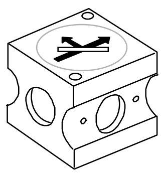
This category of optics divide and direct the laser beam into different paths. The beam is always directed parallel or perpendicular to the Laser Head's axes.



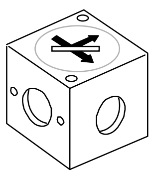
10% Beamsplitter
This 1-inch square cube splits an input laser beam into two perpendicular beams. It transmits the majority of the beam straight and reflects 10% of the beam at 90 degrees. An optional notched version is available.



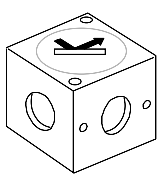
33% Beamsplitter
This 1-inch square cube splits an input laser beam into two perpendicular beams. It transmits 2/3 of the beam straight and reflects 1/3 of the beam at 90 degrees. An optional notched version is available.



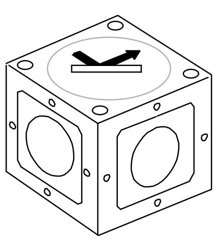
50% Beamsplitter
This 1-inch square cube splits an input laser beam into two perpendicular beams of equal power. An optional notched version of the beamsplitter cell is shown.



75% Beamsplitter
This 1-inch square cube splits an input laser beam into two perpendicular beams. It transmits 1/4 of the beam straight and reflects 3/4 of the beam at a 90-degree angle. An optional notched version is available.



Fold Mirror
This 1-inch square cube reflects an input laser beam at a right angle. An optional notched version is available.



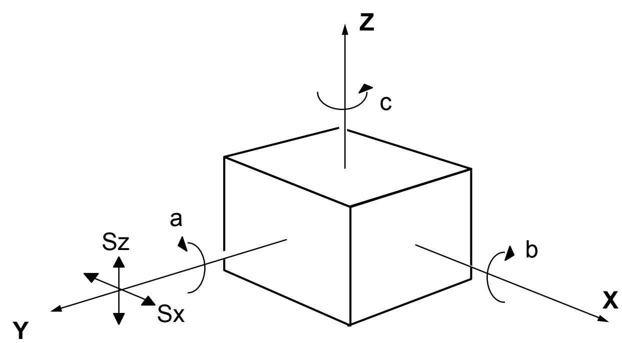
Fold Mirror, Large
This 1-1/2 inch square cube reflects two input laser beams, spaced 1/2 inch apart, at right angles.

Figure 1-3 Beam Directing Optics

Interferometers

An interferometer consists of various optical elements such as beamsplitters, mirrors, retroreflectors, and waveplates. The polarization beamsplitter in each interferometer selectively splits the laser beam into two separate frequencies. In a linear displacement application, the measurement frequency is sent to a moving reflector and the reference beam is passed to a stationary reflector. The two beams then recombine at the exit aperture of the interferometer to produce an optical reference signal.

In the ZMI system, interferometers are used to measure displacement, not absolute position. Displacement is how much an object moves from one location to the next. The types of measurement are illustrated in Figure 1-4.

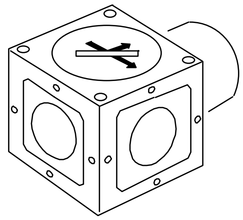


Linear Displacement	The difference from one point to the next point along a linear axis. Labeled as X, Y, and Z.
Angular Displacement	The rotation of an object about the X, Y, or Z axis. Labeled as a, b, and c.
Straightness of Travel	The deviation of an object from a straight line of travel. Labeled as Sx and Sz.

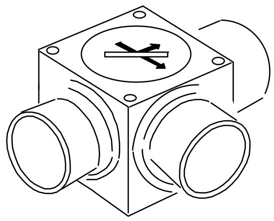
Figure 1-4 Types of Measurement

Except for Zygo's compact and custom interferometer designs, the interferometers are based on a building block concept. The building blocks are optical components, which are combined together to perform a specific function. By repositioning components, an interferometer can be changed from a straight-through to a right angle configuration. Straight-through or right-angle refers to the path of the measurement beam relative to the input beam.

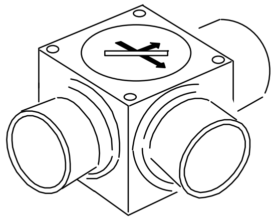
Many of Zygo's interferometers are described in Figure 1-5. These interferometers can be adapted to meet the requirements of most vacuum applications. In addition to standard components, Zygo designs and develops custom interferometers and stage mirrors. Contact Zygo to help you choose the interferometer configuration that best suits your metrology needs.



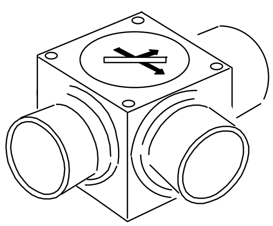
Linear Interferometer (LI)
This single pass interferometer is used to measure linear motion. It consists of a polarization beamsplitter and a retroreflector. A second retroreflector is required for the moving target.
Resolution: 0.62 nm (ZMI 2000) 0.31 nm (ZMI 4000)



Plane Mirror Interferometer (PMI)
This 2-pass design is used to measure linear motion. It consists of a polarization beamsplitter, two retroreflectors, and a quarter waveplate. A plane mirror is required for the moving target.
Resolution: 0.31 nm (ZMI 2000) 0.15 nm (ZMI 4000)

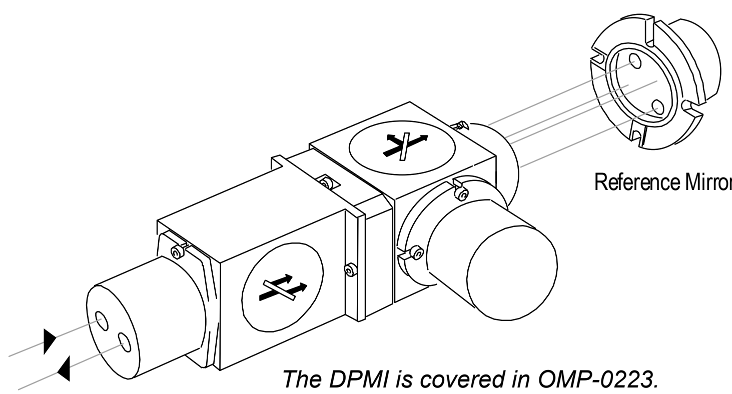


High Stability Plane Mirror Interferometer (HSPMI)
This 2-pass interferometer is less sensitive to environmental changes than the PMI. It consists of a polarization beamsplitter, retroreflector, quarter waveplate, and a quarter waveplate-plane mirror assembly. A plane mirror is required for the moving target.
Resolution: 0.31 nm (ZMI 2000) 0.15 nm (ZMI 4000)



4-Pass Plane Mirror Interferometer
This 4-pass PMI is used to measure linear motion of a plane mirror target. The interferometer includes a polarization beamsplitter, retroreflector, quarter waveplate, 4-passadapter, and a quarter waveplate plane mirror assembly.
Resolution: 0.15 nm (ZMI 2000) 0.08 nm (ZMI 4000)

Differential Plane Mirror Interferometer (DPMI)
By changing the reference mirror, this 2-pass interferometer can be used to measure linear or angular displacement. It has balanced optical paths for high accuracy applications. It consists of a beam translator, polarization shear plate, half waveplate, polarization beamsplitter, retroreflector, and quarter waveplate. A plane mirror is required for the moving target.

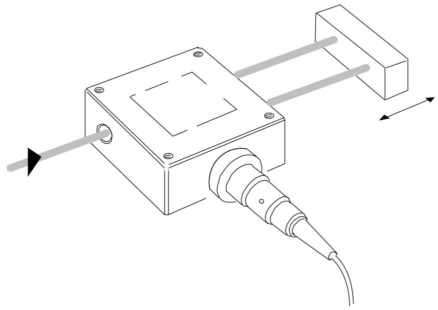


The DPMI is covered in OMP-0223.

Angular Resolution:
0.014 arc sec (ZMI 2000)
0.007 arc sec (ZMI 4000)

Linear Resolution:
0.31 nm (ZMI 2000)
0.15 nm (ZMI 4000)

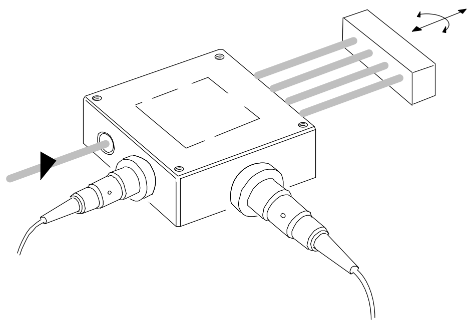
Figure 1-5 Interferometers (page 1 of 2)



Compact High Stability Plane Mirror Interferometer

A 2-pass interferometer used to measure linear motion. It has a built-in fiber optic pickup and is available in a straight-through or right-angle configuration. A plane mirror is required for the moving target.

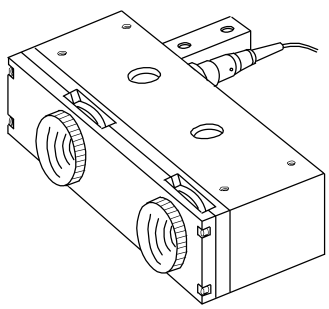
Resolution: 0.31 nm (ZMI 2000)
0.15 nm (ZMI 4000)



Compact 2 Axis High Stability Plane Mirror Interferometer

Provides linear and angular displacement measurements, simultaneously. It has two built-in fiber optic pickups and is available in a straight-through or right-angle configuration. A plane mirror is required for the moving target.

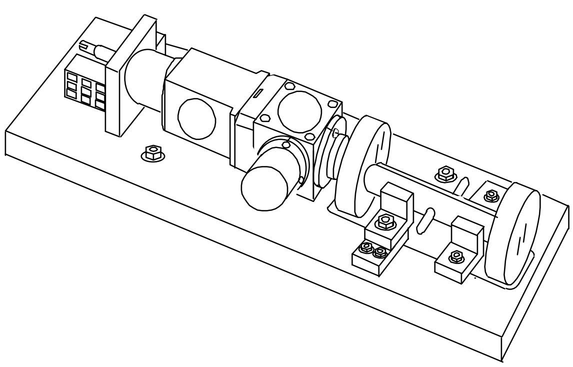
Angular Resolution: 0.005 arc second (ZMI 2000)
0.003 arc second (ZMI 4000)
Linear Resolution: 0.31 nm (ZMI 2000)
0.15 nm (ZMI 4000)



Column Reference Interferometers

A column reference design allows for the measurement of the relative displacement between two active mirrors, while reducing a system's dead path error. The interferometer shown is a 2-pass design that has a fiber optic pickup mounted to the interferometer cell. A single mirror or two separate plane mirrors can be used as the target(s) for this interferometer. (Other column reference designs are available.)

Resolution: 0.31 nm (ZMI 2000)
0.15 nm (ZMI 4000)



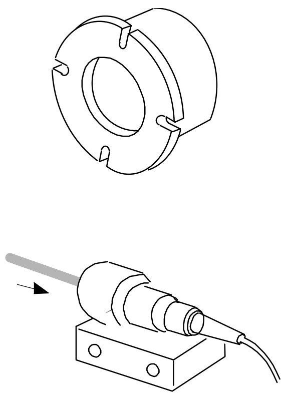
Optical Wavelength Compensator

Measures the effect the air environment has on the wavelength of the light beams. Contains all optics to directly measure changes in the refractive index of air.

Figure 1-5 Interferometers (page 2 of 2)

Miscellaneous Components

Zygo offers other components that compliment the interferometers.



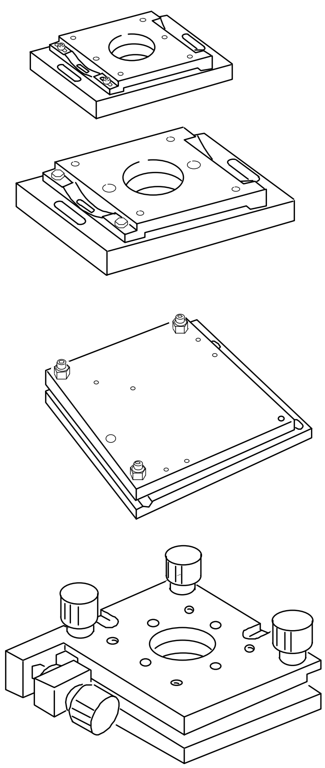
Retroreflector
This cube corner reflector reflects a beam back parallel to the incident light beam, regardless of the angular alignment. The standard size retroreflector is used as a moving target for the linear interferometer. The small retroreflector is used as the target for a single beam interferometer.

Fiber Optic Pickup
Receives the optical signal from an interferometer and couples the signal through a Fiber Optic Cable to the Zygo ZMI Measurement Board. The pickup can be mounted to a 1-1/2 inch interferometer cell, or positioned external to the interferometer.

Figure 1-6 Miscellaneous Components

Mounts

Zygo offers a variety of mounts that can be used in conjunction with the beam directing optics and interferometers.



Mirror/Beamsplitter Mount
Secures all 1-inch cube components and provides for fine-position adjustment.

Interferometer Mount
Secures all 1-1/2 inch cube components and provides for fine-position adjustment.

Compact Interferometer Mounts
Secures compact interferometers and provides for fine-position adjustment. Two versions of this mount are available. The larger version interfaces with the single and dual axis compact interferometers; the smaller version can be used only with the compact linear interferometer.

Precision Adjustable Mount
Secures all 1-1/2 inch cube components and provides for fine-adjustment in four planes: tilt in x and y, yaw, and height. Adapter plates convert the mount to accept other optical components.

Figure 1-7 Mounts

Vacuum Applications

Zygo offers low outgassing versions of most ZMI optical components for applications that require displacement measurements to be performed in a vacuum environment. The laser beams pass through an optical quality vacuum window to the vacuum compatible beam steering optics and interferometers inside the chamber. It should be noted that dead path errors are reduced substantially in most vacuum applications.

Most of Zygo's optical components are available in versions that are vacuum compatible. Contact Zygo for more information.

> **Note:** The laser head is *not* designed for use in a vacuum environment.

Window Requirements

The following are suggested specifications for a vacuum window:

Specification	*Description*
Aperture, Clear	The clear aperture should be based on the interferometer used. Refer to the interferometer specification pages in Chapter 2.
Transmitted and Reflected Wavefront Distortion	< λ/8 over the clear aperture
Surface Quality	60-40 per Mil-0-13830
Antireflection Coating	R < 0.25%

Vacuum Application Example

The accompanying figure shows an application where the X-Y stage and optical components are installed in a vacuum chamber. The laser beam enters and exits the chamber through one window. This places only the vacuum compatible optical components inside the vacuum chamber.

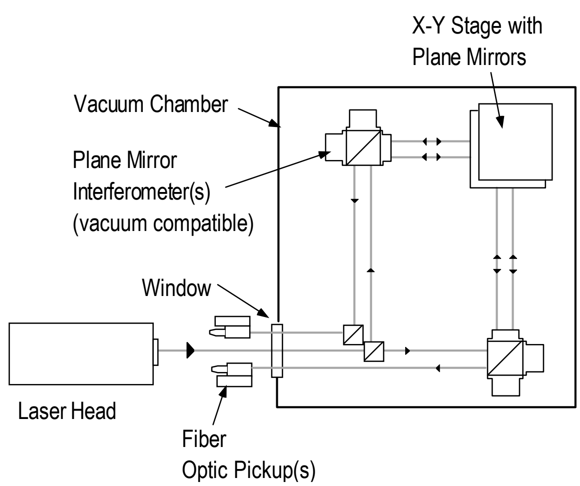


Figure 1-8 Typical Vacuum Application

Specifications

Chapter 2

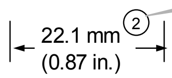
In This Chapter ***see page***

(continued)

Notes Regarding Specifications

- Some dimensions are labeled with tolerance numbers as shown below.

Tolerance Labeling



Number	Millimeters	Inches
1	± 0.13	± 0.005
2	± 0.25	± 0.010
3	± 0.38	± 0.015
4	± 0.51	± 0.020
5	± 0.64	± 0.025
6	± 0.79	± 0.030
7	±1.02	± 0.040

- Dimension drawings are not equally scaled.
- The term “Optical Signal Efficiency” is defined as the ratio of the AC signal at the output beam of the device to the AC signal at the input beam of that device as measured by a detector.

Beamsplitters, 10%, 33%, 50% & 75%

Configuration	Zygo Part Number	Model
10% standard	6191-0138-09	7025
33% standard	6191-0138-01	7000
33% notched	6191-0302-01	7000A
50% standard	6191-0138-02	7001
50% notched	6191-0302-02	7001A
75% standard	6191-0138-07	7027

Dimensions: See Figure.

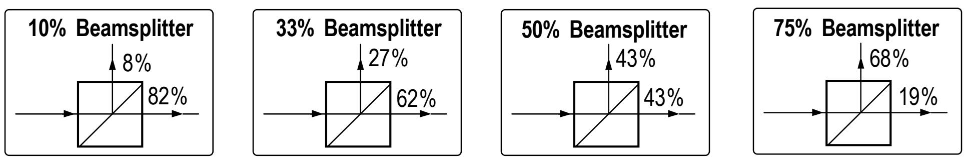
Weight: ≈70 grams (2.5 oz)

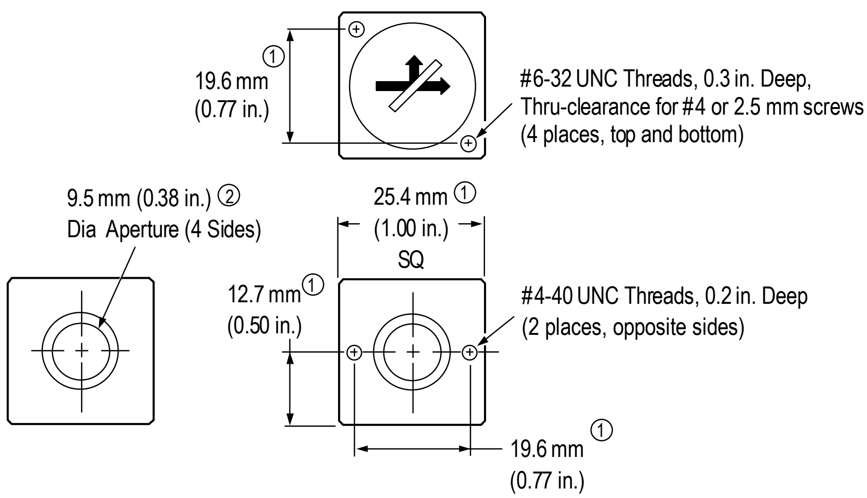
Materials:
Housing: Magnetic Stainless Steel
Optics: Fused Silica
Adhesives: Vacuum Grade -- low volatility

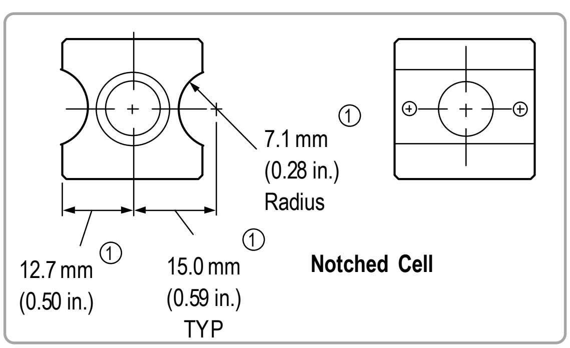
Optical: See Inset.
Out-of-parallelism of transmitted beam to input beam: 1 ± 0.5 arc min

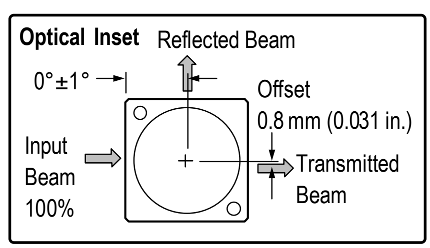
Optical Signal Efficiency (minimum):

Beamsplitter	*Reflection*	*Transmission*
10%	8%	82%
33%	27%	62%
50%	43%	43%
75%	68%	19%









Fold Mirror

Configuration	Zygo Part Number	Model
standard	6191-0138-03	7007
notched	6191-0302-03	7007A

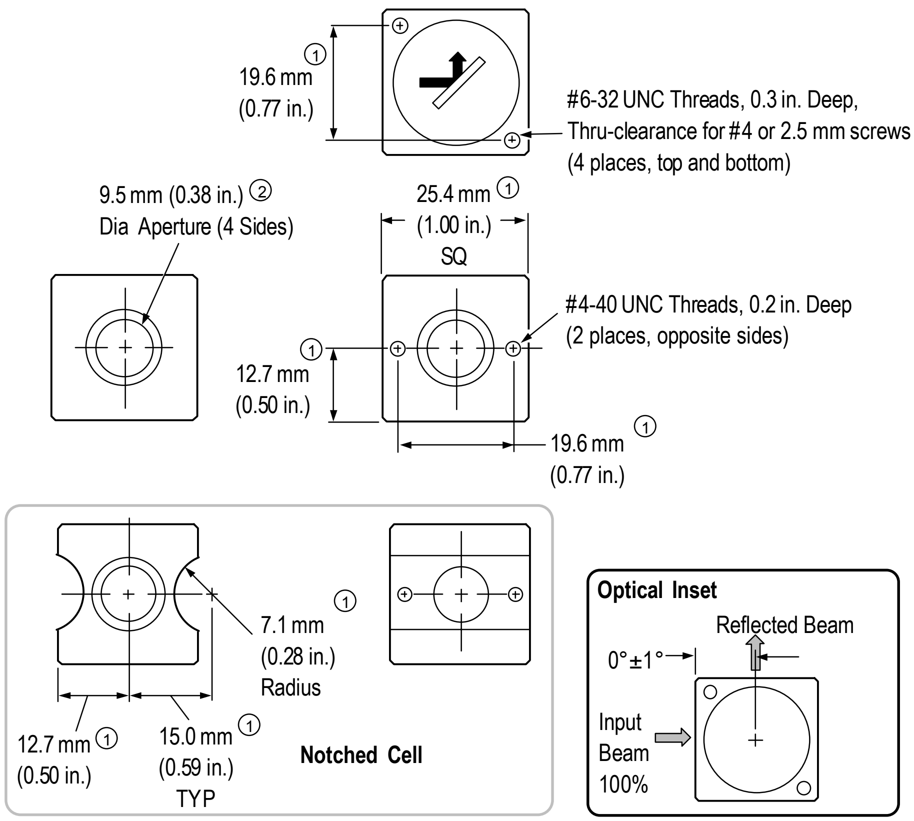
Dimensions: See Figure.

Weight: 74 grams (2.6 oz)

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

Optical: See Inset.

Optical Signal Efficiency (minimum): 98%



Fold Mirror, Large

Zygo Part Number: 6191-0301-01

Model: 7009

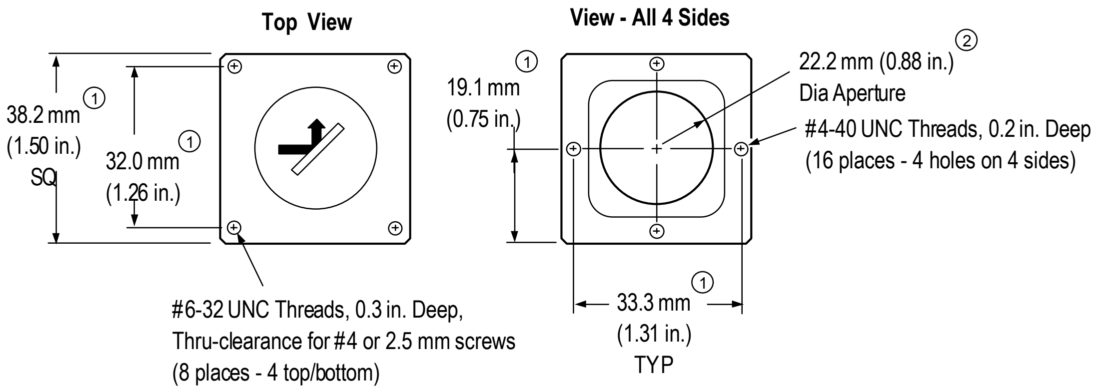
Dimensions: See Figure.

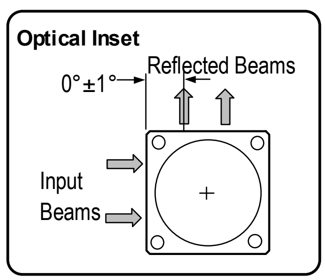
Weight: 169 grams (5.9 oz)

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

Optical: See Inset.

Optical Signal Efficiency (minimum): 97%





Linear Interferometer (LI)

Zygo Part Number: 6191-0135-01

Model: 7002

Dimensions: See Figure.

Weight: 215 grams (7.6 oz)

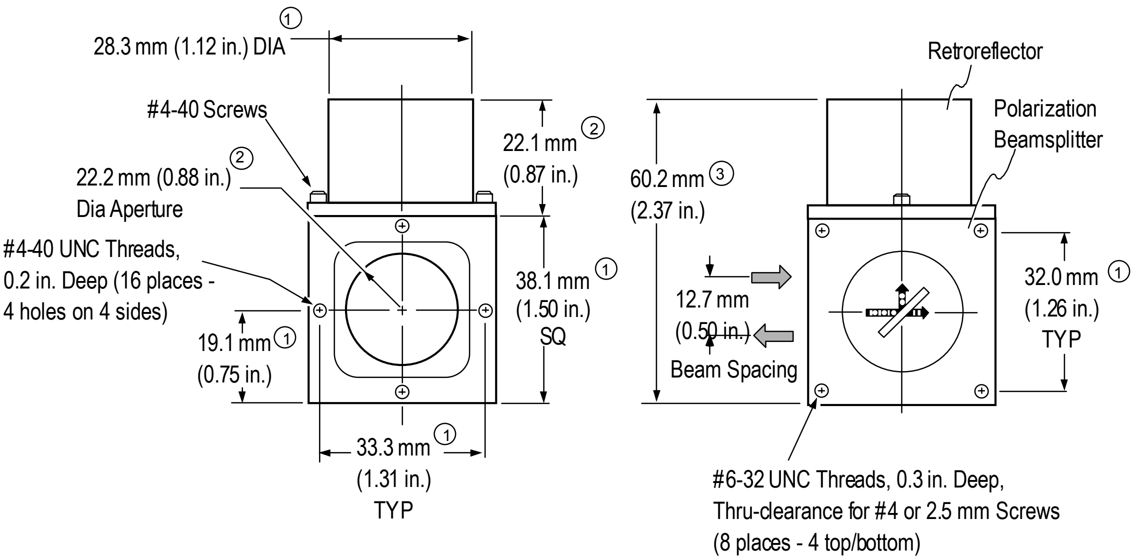
Components Included:
Polarization Beamsplitter, Retroreflector

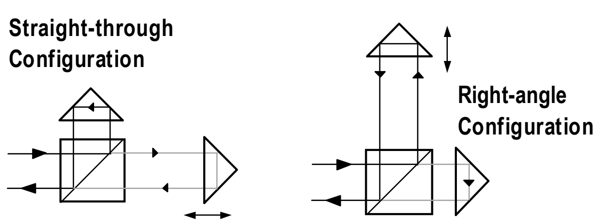
Additional Components Required:
Retroreflector

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

Optical:
Linear Displacement Resolution (nominal):
0.62 nm (ZMI 2000)
0.31 nm (ZMI 4000)
Out-of-parallelism of transmitted beam to input beam:
≤10 arc min
Maximum error due to tolerances in polarizing optical elements: ± 0.8 nm (0.03 µin)
Maximum offset of retroreflector: ± 0.4 mm
Maximum tilt of retroreflector: ± 4°
Thermal drift coefficient (change of indicated distance per degree C temperature change) (typical):
< 0.022 micrometer/degree C
(< 0.854 microinch/degree C)

Optical Signal Efficiency:
74% Typical, including target retroreflector
70% Minimum, including target retroreflector





Plane Mirror Interferometer (PMI)

Zygo Part Number: 6191-0131-01

Model: 7006

Dimensions: See Figure.

Weight: 286 grams (10.0 oz)

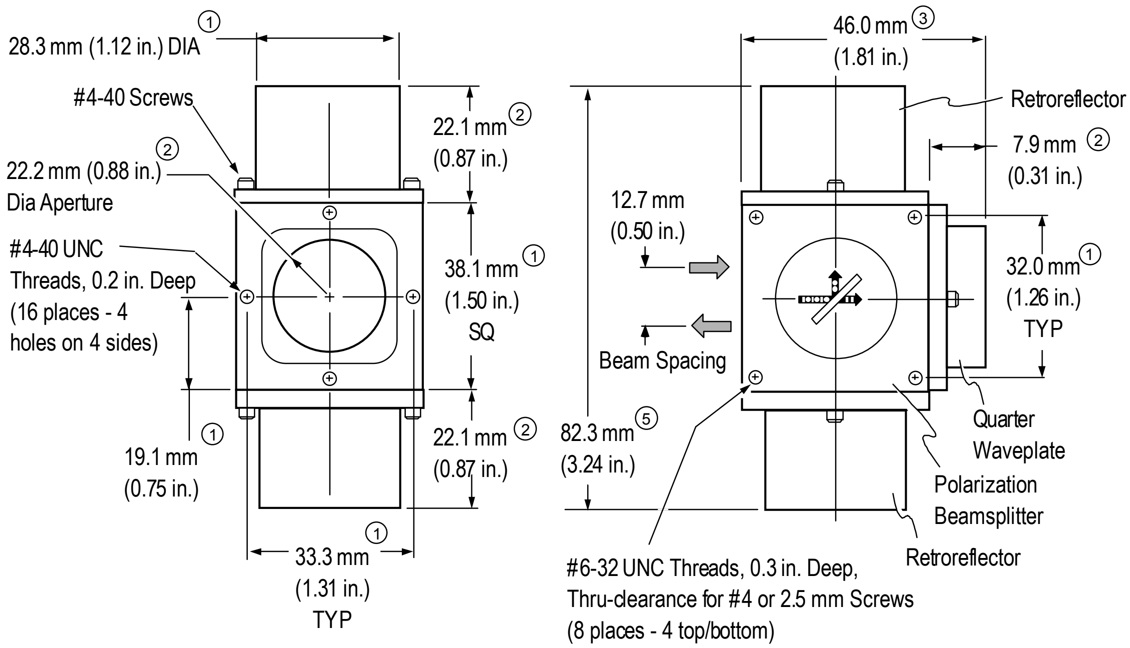
Components Included:
Polarization Beamsplitter, Quarter Waveplate, Retroreflectors (2)

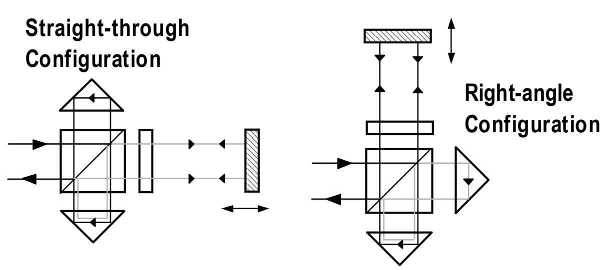
Additional Components Required:
Plane Mirror

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

Optical:
Linear Displacement Resolution (nominal):
0.31 nm (ZMI 2000)
0.15 nm (ZMI 4000)
Out-of-parallelism of transmitted beam to input beam:
≤10 arc min
Maximum error due to tolerances in polarizing optical elements: ± 1 nm (0.04 µin)
Thermal drift coefficient (change of indicated distance per degree C temperature change) (typical):
< 0.306 micrometer/degree C
(< 12.0 microinch/degree C)

Optical Signal Efficiency:
> 67% with a plane mirror having 99% reflectance at 633 nm at normal incidence.





High Stability Plane Mirror Interferometer (HSPMI)

Zygo Part Number: 6191-0318-02

Model: 7006A

Dimensions: See Figure.

Weight: 305 grams (10.6 oz)

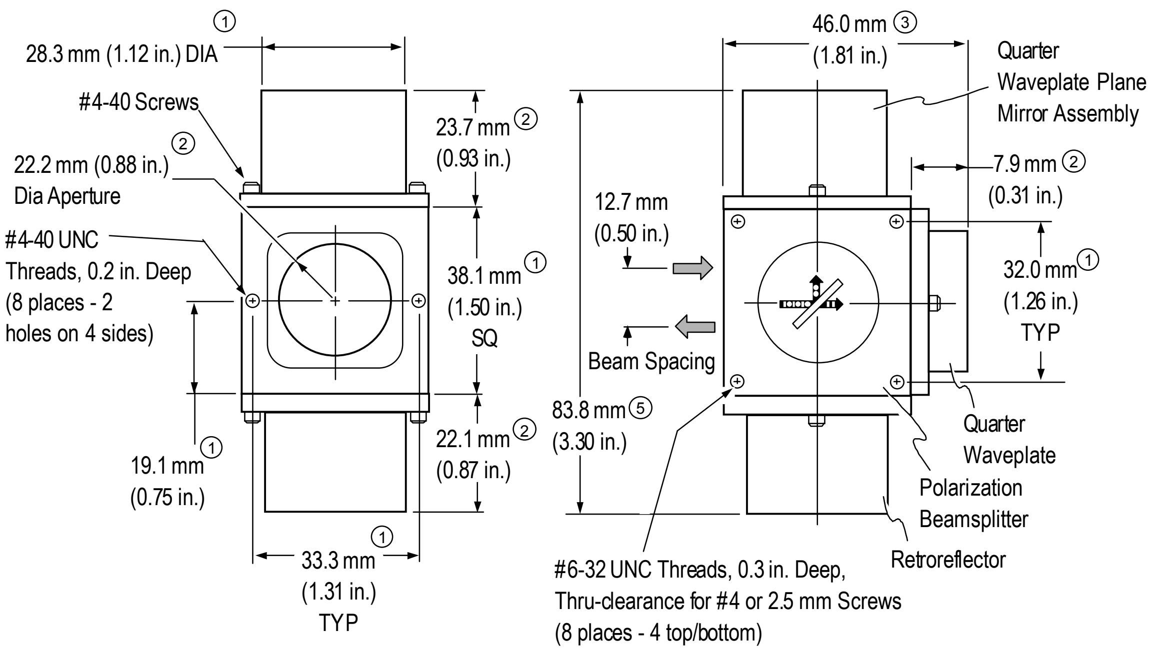
Components Included:
Polarization Beamsplitter, Retroreflector, Quarter Waveplate, Quarter Waveplate Plane Mirror Assembly

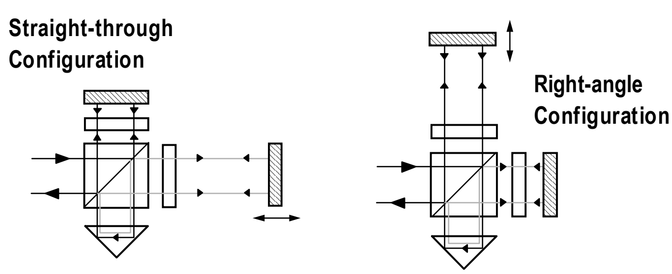
Additional Components Required:
Plane Mirror

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

Optical:
Linear Displacement Resolution (nominal):
0.31 nm (ZMI 2000)
0.15 nm (ZMI 4000)
Out-of-parallelism of transmitted beam to input beam:
≤10 arc min
Maximum error due to tolerances in polarizing optical elements: ± 1 nm (0.04 μin)
Thermal drift coefficient (change of indicated distance per degree C temperature change) (typical):
< 0.018 micrometer/degree C
(< 0.724 microinch/degree C)

Optical Signal Efficiency:
60% with a plane mirror having 99% reflectance at 633 nm at normal incidence.





4-Pass Plane Mirror Interferometer

Zygo Part Number: 6191-0104-01

Model: 7014

Dimensions: See Figure.

Weight: 350 grams (12.3 oz)

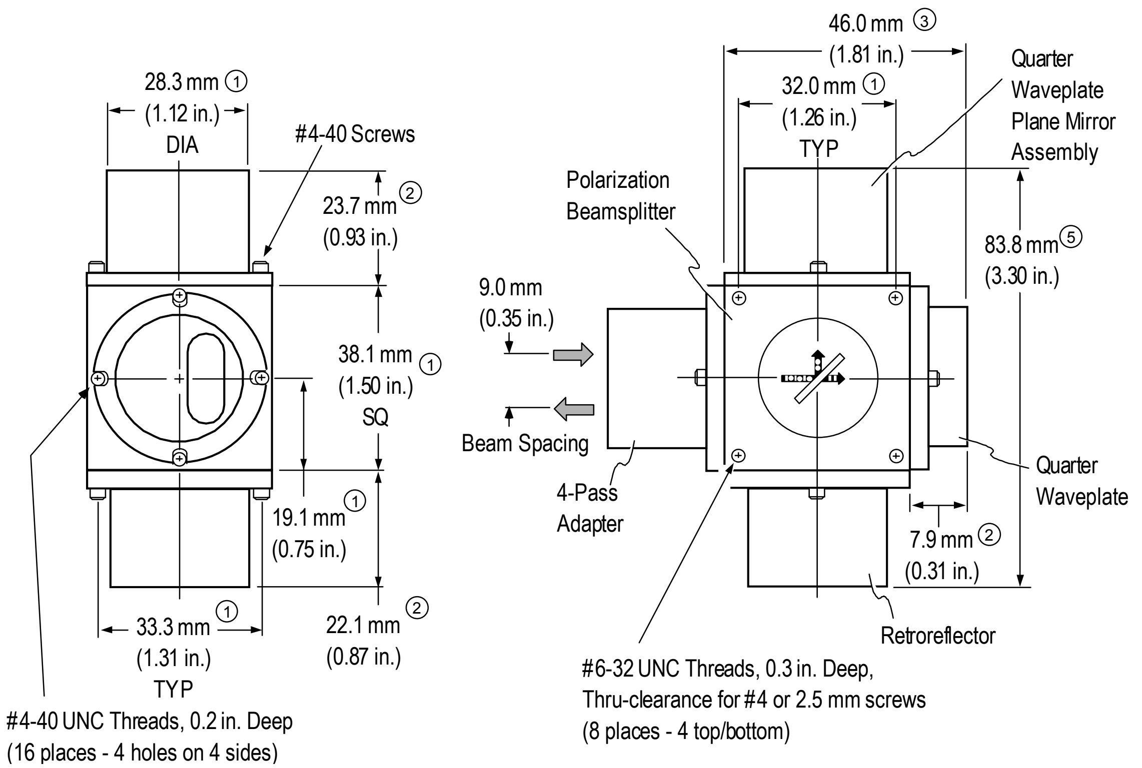
Components Included:
Polarization Beamsplitter, Retroreflector, Quarter Waveplate, Quarter Waveplate Plane Mirror Assembly, 4-PassAdapter

Additional Components Required:
Plane Mirror

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

Optical:
Linear Displacement Resolution (nominal):
0.15 nm (ZMI 2000)
0.08 nm (ZMI 4000)
Out-of-parallelism of transmitted beam to input beam: ≤10 arc min
Maximum error due to tolerances in polarizing optical elements: ± 1 nm (0.04 µin)
Thermal drift coefficient (change of indicated distance per degree C temperature change) (typical):
< 0.018 micrometer/degree C
(< 0.724 microinch/degree C)

Optical Signal Efficiency:
25% with a plane mirror having 99% reflectance at 633 nm at normal incidence.



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

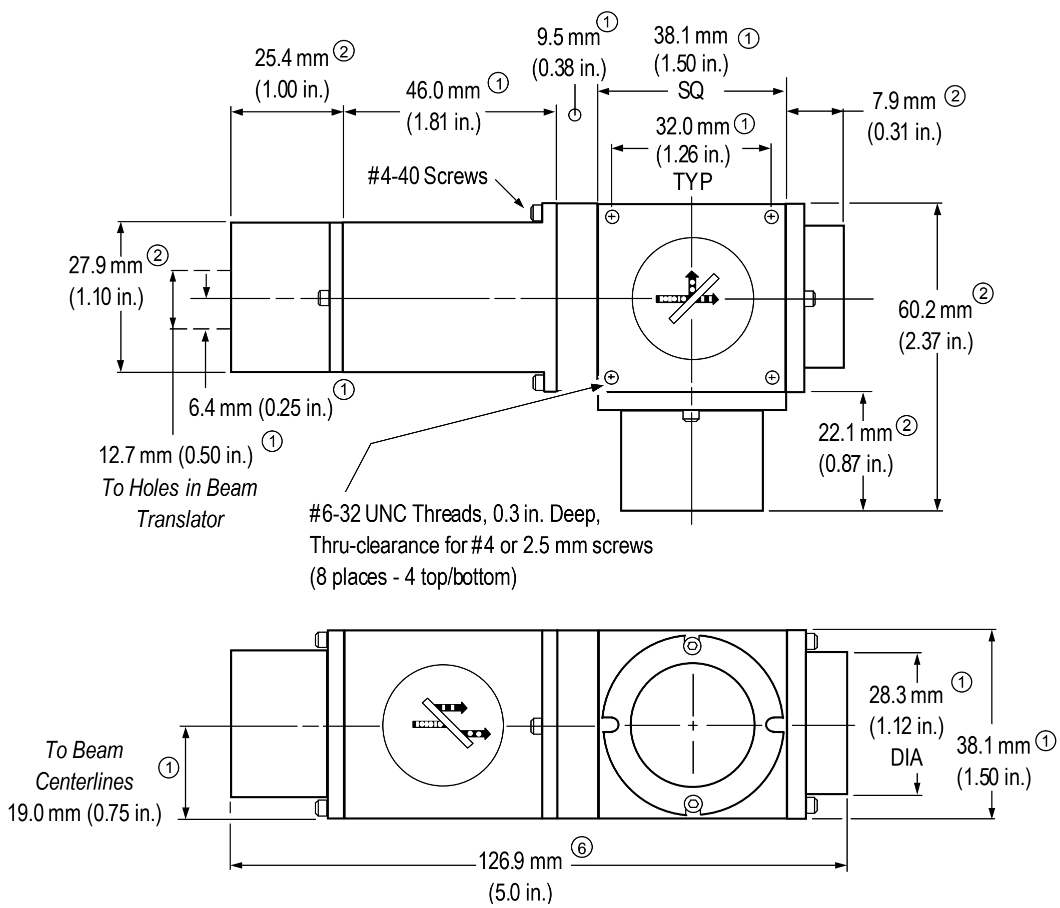
Additional Components Required:
Reference Mirror, Plane Mirror or Target Mirror

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

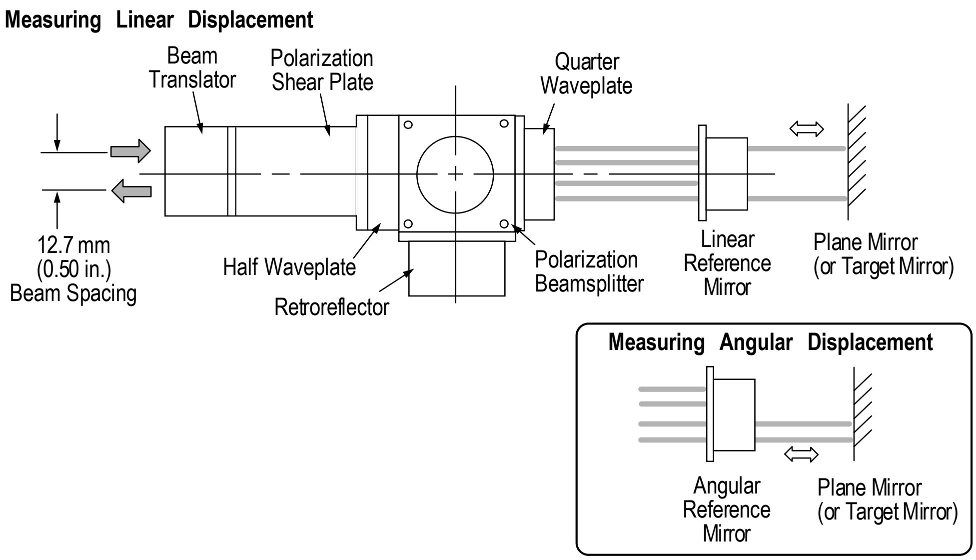
Optical:
Linear Displacement Resolution (nominal):
0.31 nm (ZMI 2000)
0.15 nm (ZMI 4000)
Angular Displacement Resolution (nominal):
0.014 arc sec (ZMI 2000)
0.007 arc sec (ZMI 4000)
Out-of-parallelism of transmitted beam to input beam: ≤11 arc min
Maximum error due to tolerances in polarizing optical 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.

Note: This interferometer does not perform optical differencing.



DPMI (continued)



DPMI Mirrors

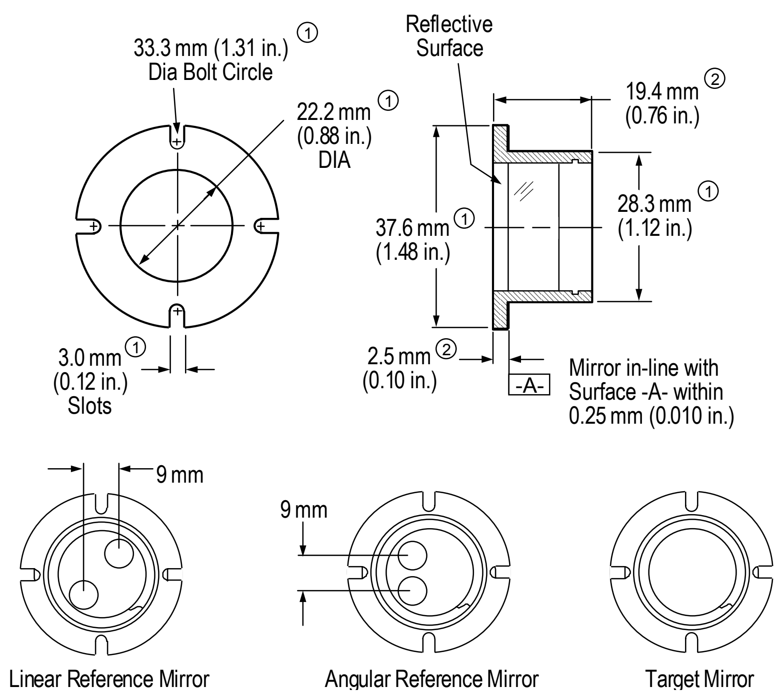
Configuration	Zygo Part Number	Model
Linear Reference Mirror	6191-0437-01	7017A
Angular Reference Mirror	6191-0437-02	7018A
Target Mirror	6191-0437-03	7019A
Reverse Linear Ref Mirror	6191-0437-04	7017AR
Reverse Target Mirror	6191-0437-05	7019AR

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%



Compact High Stability Plane Mirror Interferometer (CHSPMI)

Configuration	Zygo Part Number	Model
Straight-through	6191-0362-01	2002-01
Right-angle	6191-0362-02	2002-02

Dimensions: See Figure.

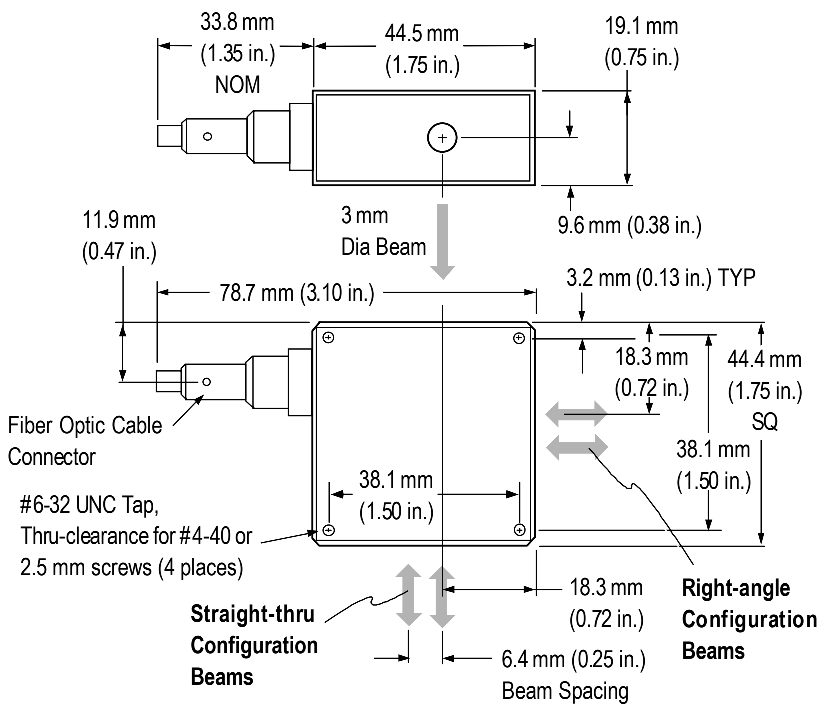
Weight: 149 grams (5.3 oz)

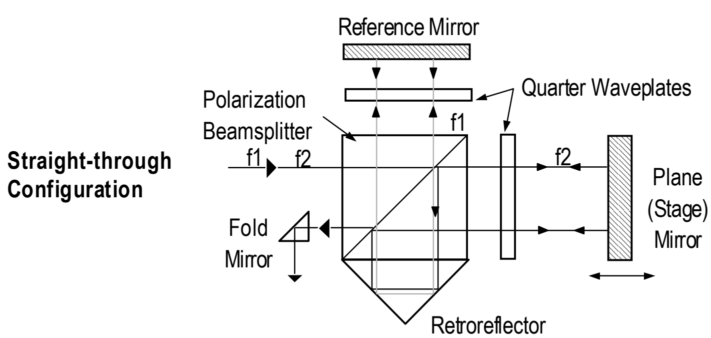
Additional Components Required:
Plane Mirror

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

Optical:
Linear Displacement Resolution (nominal):
0.31 nm (ZMI 2000)
0.15 nm (ZMI 4000)
Linear Displacement Range (typical): 0 to 1000 mm
Maximum deviation of transmitted beam: ≤ 2 arc min
Incoming Beam Diameter: 3 mm
Measurement Beam Spacing (center-to-center):
6.35 mm

Optical Signal Efficiency:
> 60% with a plane mirror having 99% reflectance at 633 nm at normal incidence.





Compact 2 Axis High Stability Plane Mirror Interferometer

Configuration	Zygo Part Number	Model
Straight-through	6191-0366-01	2001-01
Right-angle	6191-0366-02	2001-02

Dimensions: See Figure.

Weight: 242 grams (8.5 oz)

Additional Components Required:
Plane Mirror

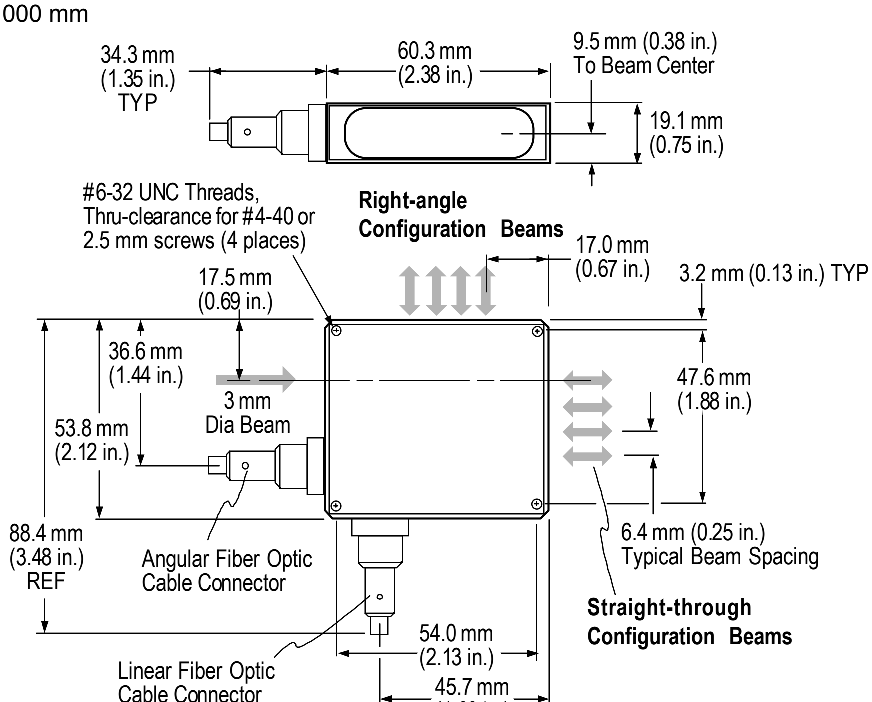
Materials:
Housing: Magnetic Stainless Steel
Optics: BK-7, Crystalline Quartz, and Zerodur
Adhesives: Vacuum Grade -- low volatility

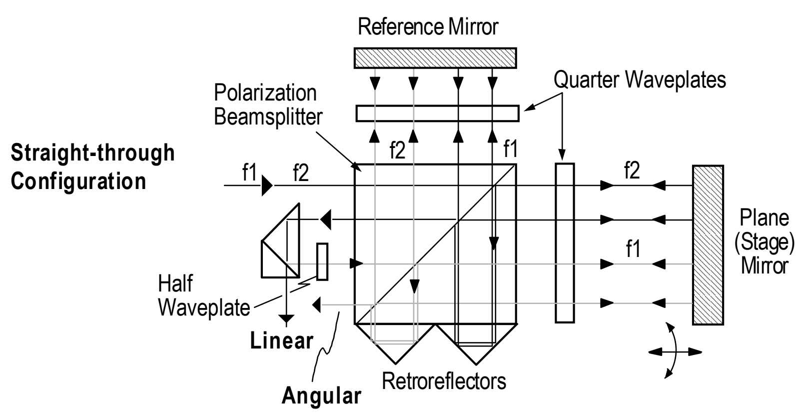
Optical:
Linear Displacement Resolution (nominal):
0.31 nm (ZMI 2000)
0.15 nm (ZMI 4000)
Linear Displacement Range (typical):
0 to 1000 mm

Optical: (continued)
Angular Displacement Resolution:
0.005 arc sec (ZMI 2000)
0.003 arc sec (ZMI 4000)
Angular Displacement Range (maximum):
± 150 arc sec @ 250 mm (typical)
± 40 arc sec @ 1000 mm (typical)
Maximum deviation of transmitted beam: ≤ 2 arc min
Incoming Beam Diameter: 3 mm
Measurement Beam Spacing (center-to-center):
6.35 mm

Optical Signal Efficiency:
> 21% per axis with a plane mirror having 99% reflectance at 633 nm at normal incidence.

Note: This interferometer performs optical differencing.





LC Compact High Stability Plane Mirror Interferometer

Configuration	Zygo Part Number	Model
Straight-through	6191-0541-01	2002-01LC
Right-angle	6191-0541-02	2002-02LC

Dimensions: See Figure.

Weight: 65 grams (2.3 oz)

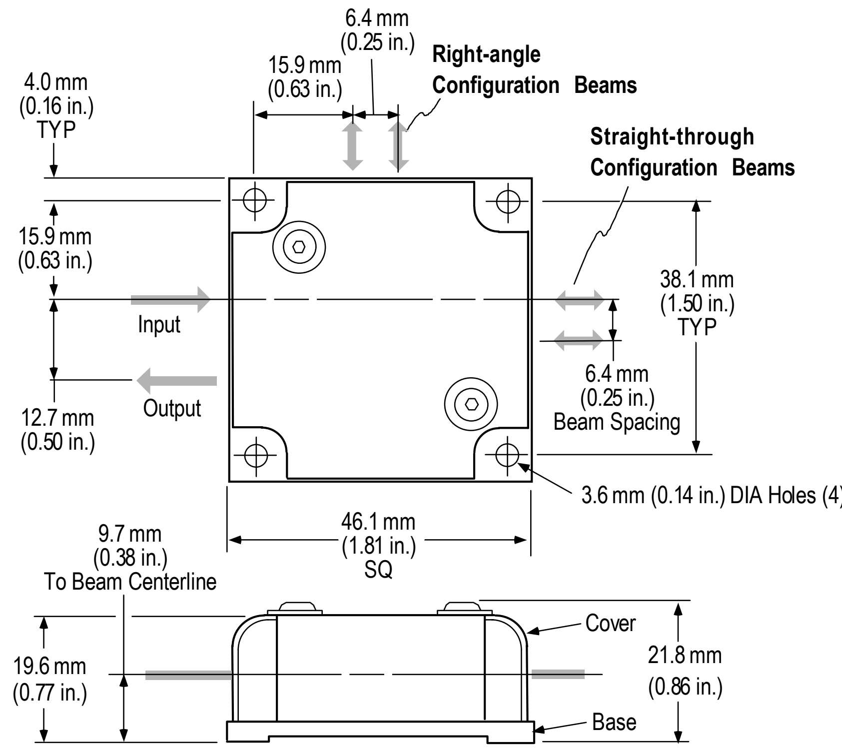
Additional Components Required:
Plane Mirror

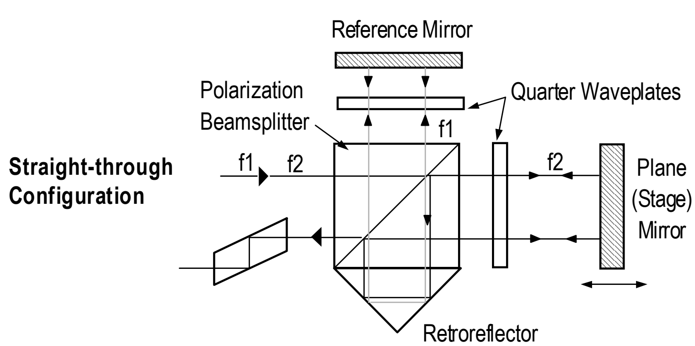
Materials:
Base: Non Magnetic Stainless Steel
Cover: Aluminum
Optics: BK-7, Crystalline Quartz, and Zerodur
Adhesives: Vacuum Grade -- low volatility

Note: Available with low outgassing adhesives for high vacuum applications.

Optical:
Linear Displacement Resolution (nominal):
0.31 nm (ZMI 2000)
0.15 nm (ZMI 4000)
Linear Displacement Range (typical):
0 to 1000 mm
Maximum deviation of transmitted beam:
≤ 2 arc min
Incoming Beam Diameter: 3 mm
Measurement Beam Spacing (center-to-center):
6.35 mm

Optical Signal Efficiency:
> 60% with a plane mirror having 99% reflectance at 633 nm at normal incidence.





LC Compact 2 Axis High Stability Plane Mirror Interferometer

Configuration	Zygo Part Num.	Model
Straight-through	6191-0542-01	2001-01LC
Right-angle	6191-0542-02	2001-02LC

Dimensions: See Figure.

Weight: 113 grams (4.0 oz)

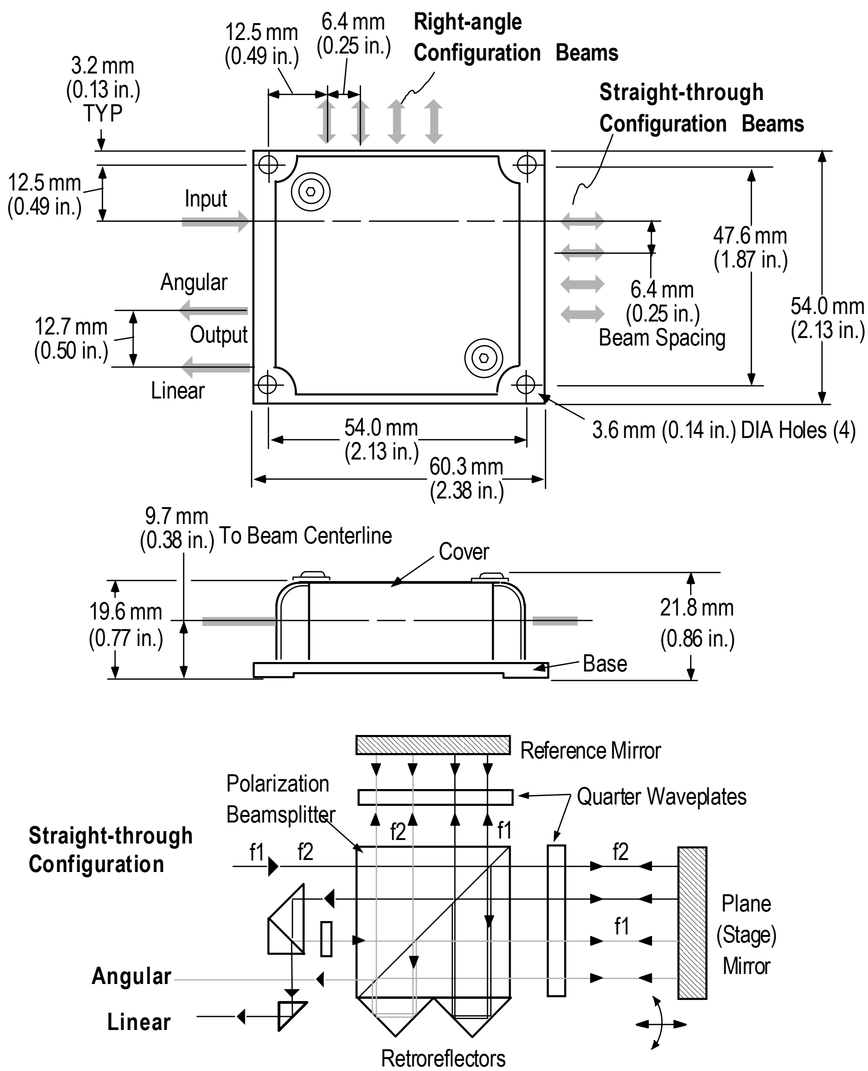
Additional Components Required:
Plane Mirror

Materials:
Base: Non Magnetic Stainless Steel
Cover: Aluminum
Optics: BK-7, Crystalline Quartz, and Zerodur
Adhesives: Vacuum Grade -- low volatility

Notes:
Available with low outgassing adhesives for high vacuum applications.
This interferometer performs optical differencing.

Optical:
Linear Displacement Resolution (nominal):
0.31 nm (ZMI 2000)
0.15 nm (ZMI 4000)
Linear Displacement Range (typical):
0 to 1000 mm
Angular Displacement Resolution:
0.005 arc sec (ZMI 2000)
0.003 arc sec (ZMI 4000)
Angular Displacement Range (maximum):
± 150 arc sec @ 250 mm (typical)
± 40 arc sec @ 1000 mm (typical)
Maximum deviation of transmitted beam:
≤ 2 arc min
Incoming Beam Diameter: 3 mm
Measurement Beam Spacing (center-to-center):
6.35 mm

Optical Signal Efficiency:
> 21% per axis with a plane mirror having 99% reflectance at 633 nm at normal incidence.



Compact 3 Axis High Stability Plane Mirror Interferometer

Configuration	Zygo Part Number	Model
Straight-through	6191-0624-01	2006-01
Right-angle	6191-0624-02	2006-02
Left-angle	6191-0624-03	2006-03

Dimensions: See Figure.

Weight: 619 grams (21.8 oz)

Components Included: Polarization Beamsplitter, Retroreflector Assembly, Quarter Waveplate, Quarter Waveplate Plane Mirror Assembly, Rhomboid Assembly, Fiber Optic Assembly

Additional Components Required:
Plane Mirror

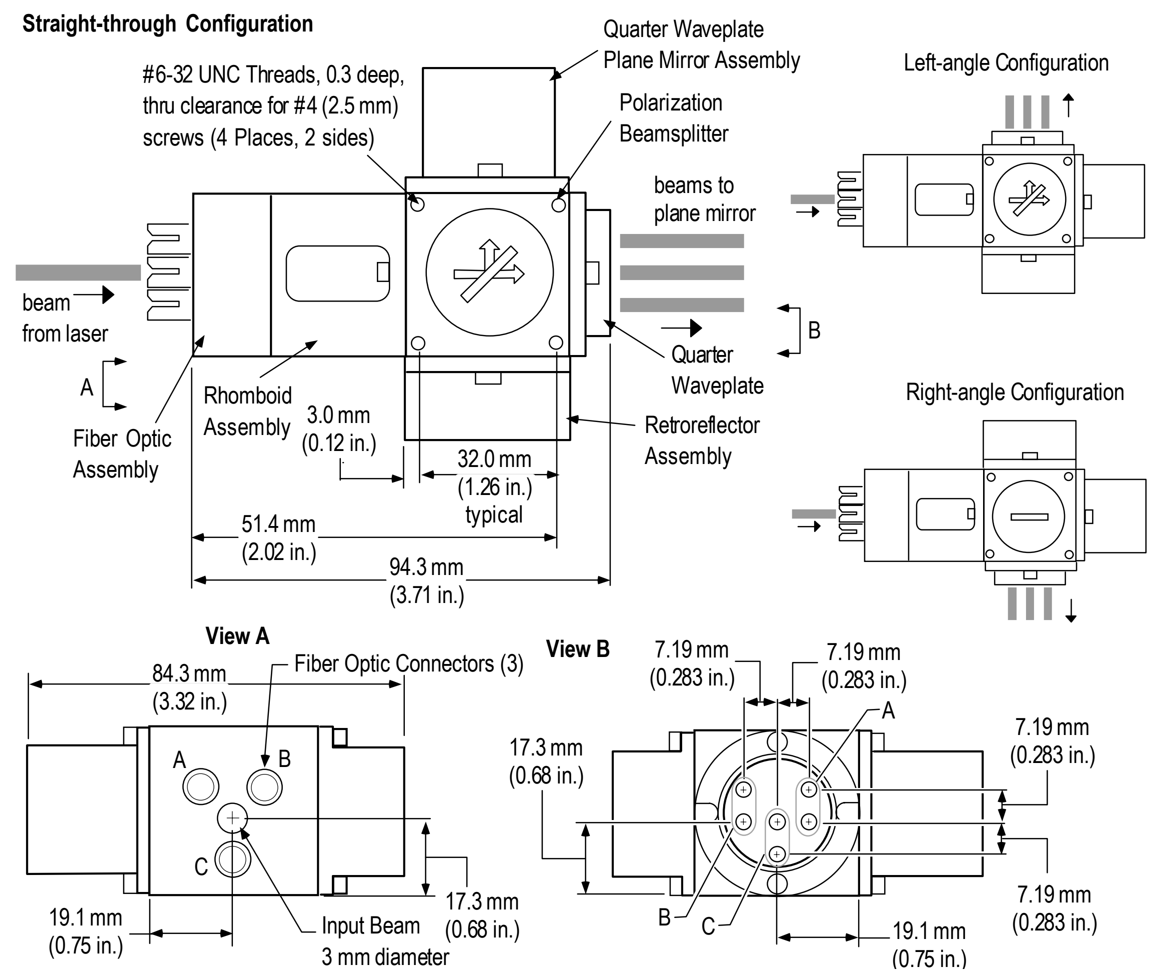
Materials:
Housing: Magnetic Stainless Steel
Optics: BK-7, Crystalline Quartz, and Zerodur
Adhesives: Vacuum Grade -- low volatility

Note: This interferometer does not perform optical differencing.

Measure	Beams	Resolution
Linear	A, B, or C	0.31 nm (ZMI 2000)
		0.15 nm (ZMI 4000)
Pitch	C:$\frac{A+B}{2}$	0.0088 arc sec (ZMI 2000)
		0.0044 arc sec (ZMI 4000)
Yaw	A:B	0.0044 arc sec (ZMI 2000)
		0.0022 arc sec (ZMI 4000)

Optical:
Incoming Beam Diameter: 3 mm
Measurement Beam Spacing (center-to-center):
7.19 mm [linear, pitch, and yaw (beams C:B or C:A)]
14.38 mm (yaw, beams A:B)

Optical Signal Efficiency:
> 18% per axis with a plane mirror having 99% reflectance at 633 nm at normal incidence.



Column Reference Plane Mirror Interferometer with Steering Wedges

Zygo Part Number: 6191-0539-01

Model: 2005

Dimensions: See Figure.

Weight: 3.2 Kg (112 oz)

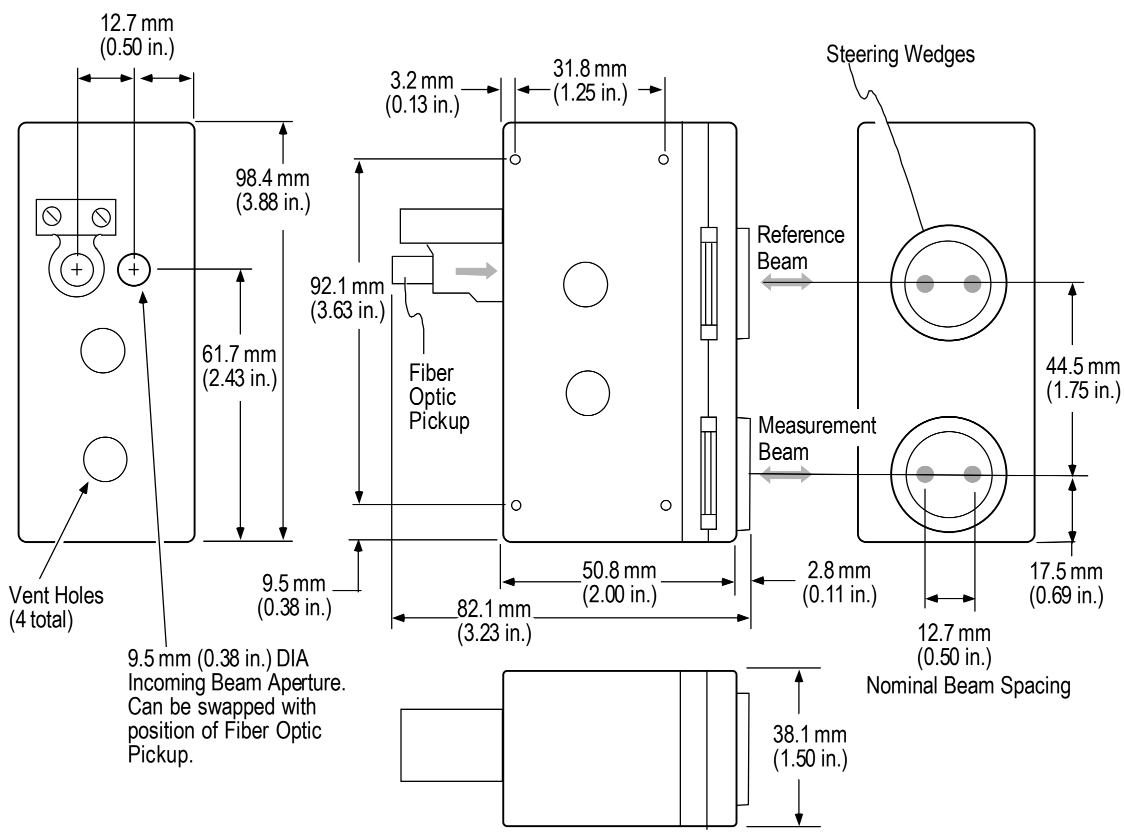
Additional Components Required:
Plane Mirror(s)

Materials:
Housing: Magnetic Stainless Steel
with Electroless Nickel Plating
Optics: BK-7, Crystalline Quartz, and Zerodur
Adhesives: Vacuum Grade -- low volatility

Beam:
Incoming Beam Diameter: 6 mm
Measurement Beam Spacing
(vertical center-to-center): 44.5 mm
Measurement Beam Spacing
(horizontal center-to-center): 12.7 mm

Optical:
Linear Displacement Resolution (nominal):
0.31 nm (ZMI 2000)
0.15 nm (ZMI 4000)
Linear Displacement Range (typical): 0 to 1000 mm
Maximum error due to tolerances in polarizing optical elements: ± 2 nm
Thermal drift coefficient (change of indicated distance per degree C temperature change) (typical):
< 0.03 micrometer/degree C

Optical Signal Efficiency:
> 60% with a plane mirror having 99% reflectance at 633 nm at normal incidence.



Optical Probe Interferometer (OPI)

Configuration	Zygo Part Number	Model
50 mm Focal Length	6191-0476-01	7028-01
120 mm Focal Length	6191-0476-02	7028-02
160 mm Focal Length	6191-0476-03	7028-03

Dimensions: See Figure.

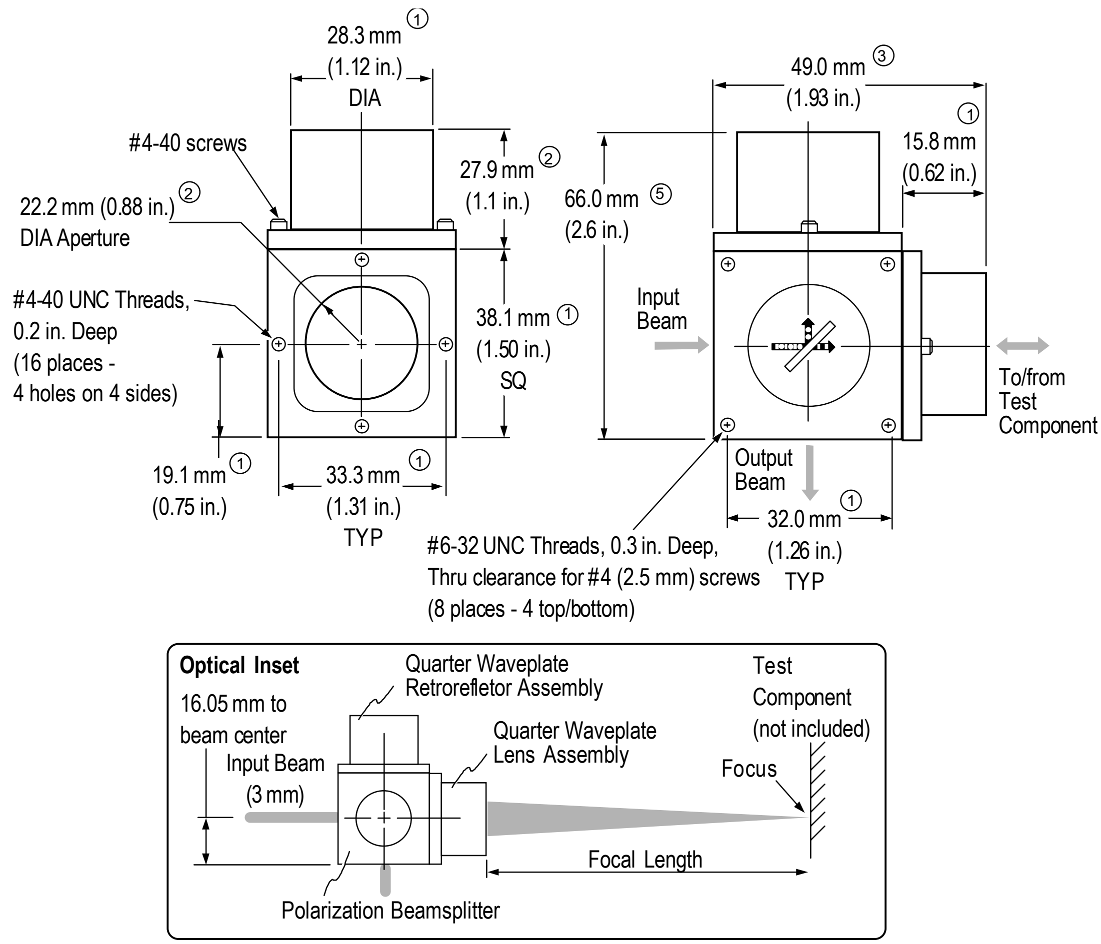
Weight: 301 grams (10.6 oz)

Components Included:
Polarization Beamsplitter, Quarter Waveplate Retroreflector Assembly, Quarter Waveplate Lens Assembly

Materials:
Housing: Magnetic Stainless Steel with Nickel Plating
Aperture: Plastic
Optics: BK-7, Crystalline Quartz, Zerodur, and Crown & Flint Glass
Adhesives: Vacuum Grade -- low volatility

Optical:
Incoming Beam Diameter: 3 mm
Linear Displacement Resolution (nominal):
0.62 nm (ZMI 2000)
0.31 nm (ZMI 4000)
Linear Displacement Range:
±0.25 mm about focus

Optical Signal Efficiency:
At Focus: 60%
At Range Limits: 10%



Straightness Interferometer (SI)

Configuration	Zygo Part Number	Model
Standard	6191-0331-01	7020
DPMI Conversion Kit	6191-0331-02	7020K

Dimensions: See Figure.

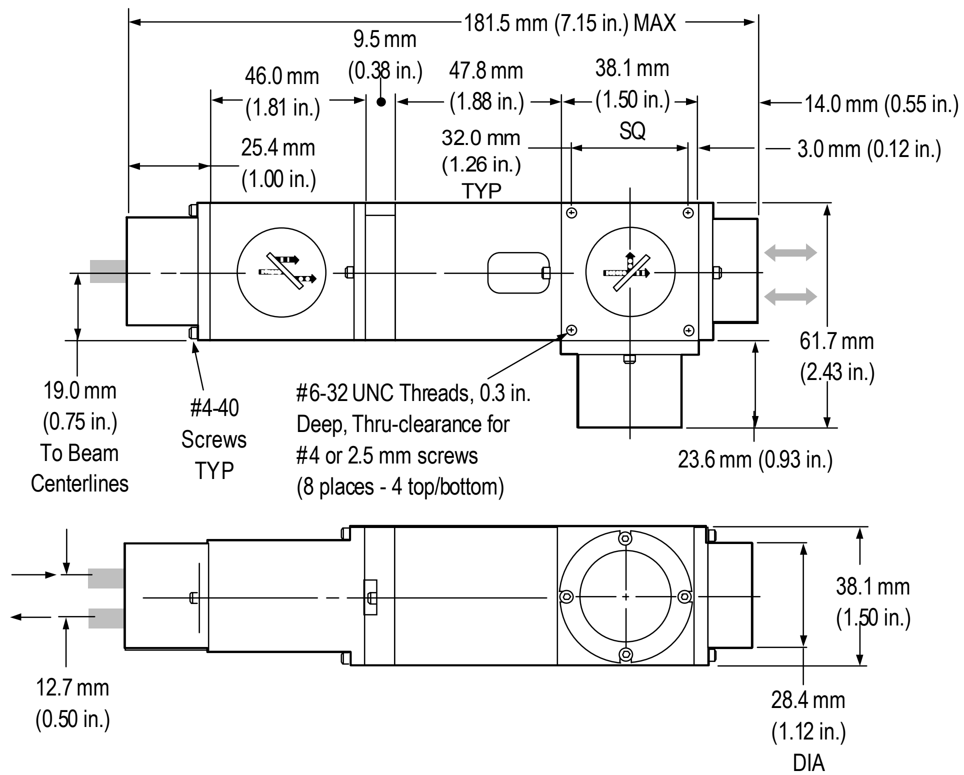
Weight: 825 grams (29.1 oz)

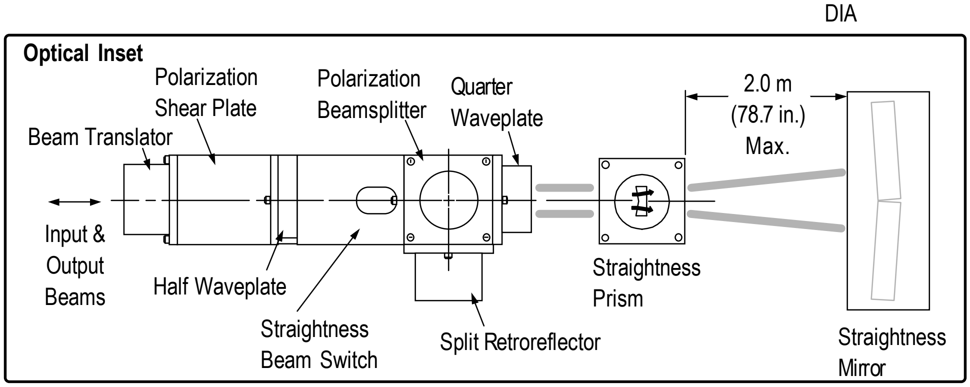
Components Included:
Polarization Beamsplitter, Half Waveplate, Quarter Waveplate, Polarization Shear Plate, Beam Translator, Split Retroreflector, Beam Switch Prism, Straightness Prism, Straightness Mirror

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

Optical: See Inset.
Incoming Beam Diameter: 6 mm
Measurement Range: ± 1 mm
Straightness Resolution (nominal):
0.01 µm (ZMI 2000)
0.005 µm (ZMI 4000)
Maximum distance between Straightness Prism and Straightness Mirror: 2.0 m (78.1 in.)

Optical Signal Efficiency: ≥ 30%





Straightness Interferometer (continued)

Straightness Prism and Mirror

Component	Zygo Part Number	Model
Prism	6191-0315-01	7020A
Mirror	6191-0264-01	7020D

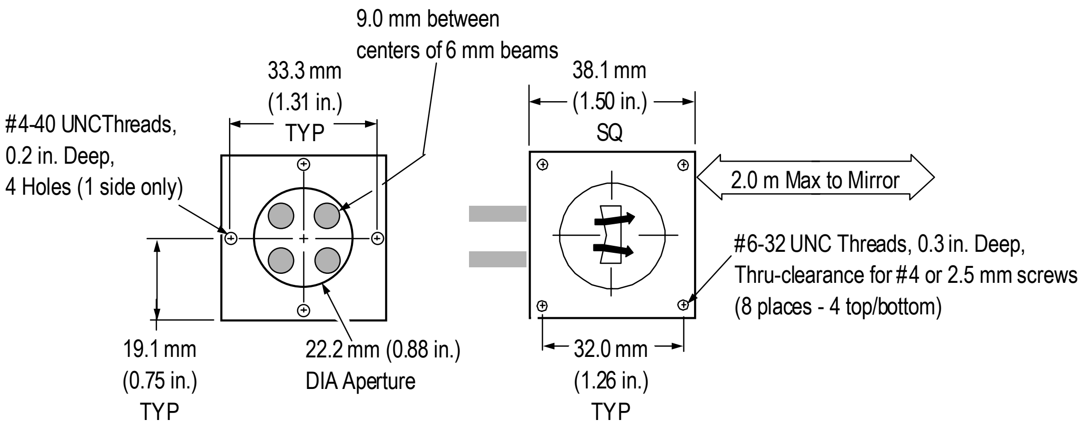
Dimensions: See Figure.

Weights: 238 grams (8.4 oz) Prism
755 grams (26.6 oz) Mirror

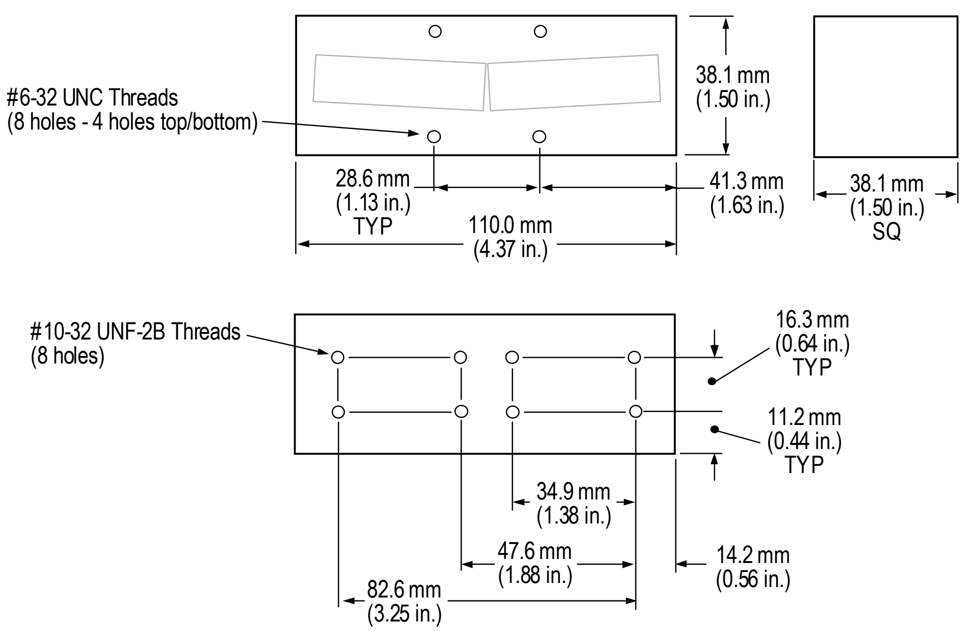
Materials:
Housing: Magnetic Stainless Steel
Optics: BK-7 (Prism),
Zerodur or Fused Silica (Mirror)
Adhesives: Vacuum Grade -- low volatility

Note: The Straightness Prism and Straightness Mirror are a "matched" set.

Prism



Mirror



Compact Optical Wavelength Compensator

Zygo Part Number: 6191-0584-01

Model: 7057

Dimensions: See Figure.

Weight: 1.3 kilograms (44 oz)

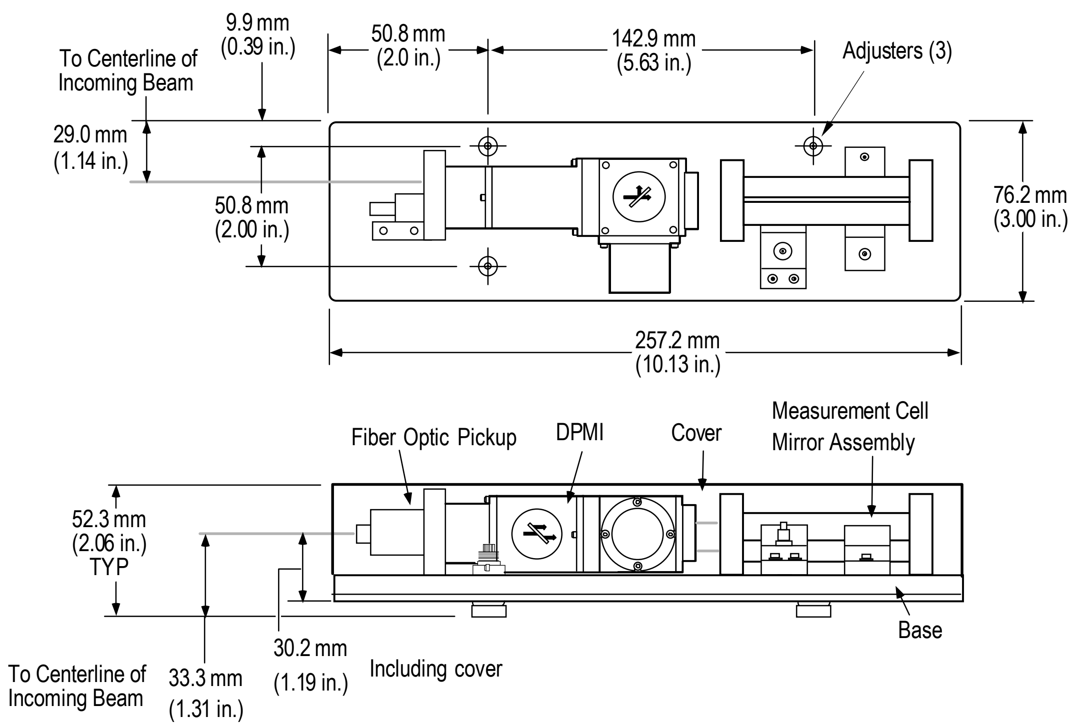
Components Included: Polarization Beamsplitter, Half Waveplate, Retroreflector, Polarization Shear Plate, Beam Translator, Quarter Waveplate, Measurement Cell Mirror Assembly, Fiber Optic Pickup

Materials:
- Base: Aluminum Alloy
- Measurement Cell Mirror Assembly: INVAR and Zerodur

Optical:
- Measurement Resolution (nominal):
  - 4.4×10^{-9} (ZMI 2000)
  - 2.2×10^{-9} (ZMI 4000)
- Range Accuracy: ± 0.1 ppm

Optical Signal Efficiency: > 50%

Operating Environment Temperature: 10°-30 ° C



Fiber Optic Pickup

Zygo Part Number: 8040-0104-01

Dimensions: See Figure.

Weight: 6 g (0.2 oz)

Components Included: Fiber Optic Adapter

Materials: connector – Rython R-4,
housing – Thermocomp DF-1002 BK8-115

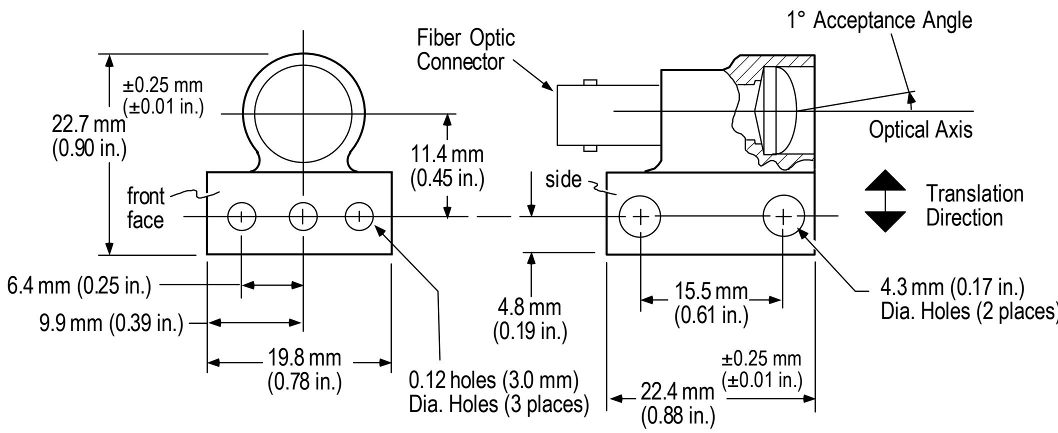
Typical Translation Range: ±1 mm

Mounting Surfaces (front face and sides):
Flatness: 0.013 mm (0.0005 in.)
Perpendicular and parallel to optical axis:
0.025 mm (0.001 in.)

Recommended Minimum Operating Optical Power:
10 μW (ZMI 1000) 5 μW (ZMI 2000)

Environmental:
Operating Temperature: 0° to 50° C (32° to 122° F)
Non-operating Temperature:
-40° to 75° C (-40° to 167° F)
Operating Humidity: 0 to 90% (non-condensing)
Non-operating Humidity: 0 to 90% (non-condensing)

Specification Definitions
Acceptance Angle - angle range where relative efficiency is greater than 0.5.
Translation Range - lateral range across input beam where relative efficiency is greater than 0.5.



All dimensions ±0.13 mm (±0.005 in.) except as noted.

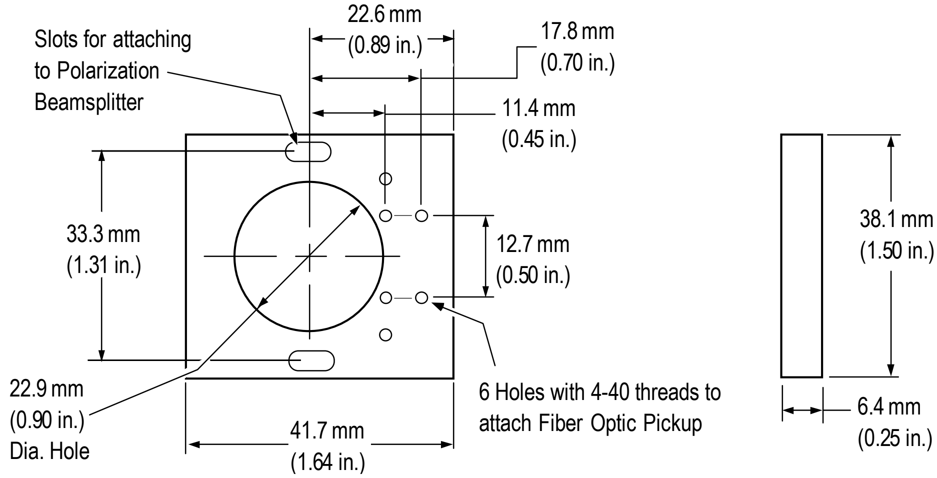
Fiber Optic Pickup and Adapter Plate Options

Assembly P/N includes…	*Fiber Optic Pickup*	*Adapter Plate*	*For Interferometer(s)*
8040-0103-01	8040-0104-01	8040-1007-01	LI, PMI, HSPMI
8040-0103-02	8040-0104-01	none	user defined
8040-0103-03	8040-0104-01	6191-2104-01	DPMI
8040-0103-04	8040-0104-01	6191-2228-01	4-Pass PMI
8040-0103-05	8040-0104-01	6191-2229-01	SBI

Fiber Optic Adapter Plates

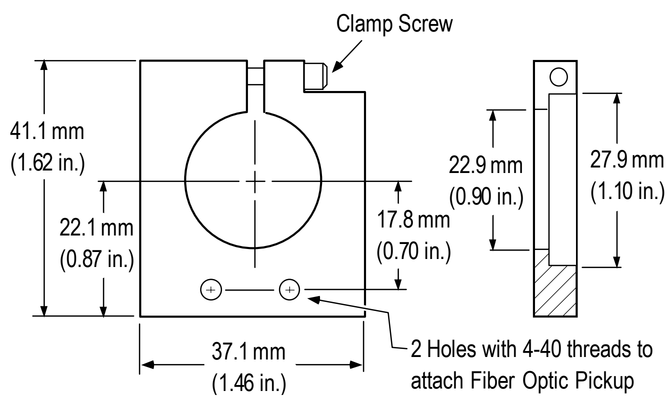
Zygo Part Number: 8040-1007-01

Description: For mounting the Fiber Optic Pickup to a Linear Interferometer, PMI, or HSPMI Interferometer. This adapter plate attaches to the Polarized Beamsplitter cell with two #4-40 threaded screws.



Zygo Part Number: 6191-2104-01

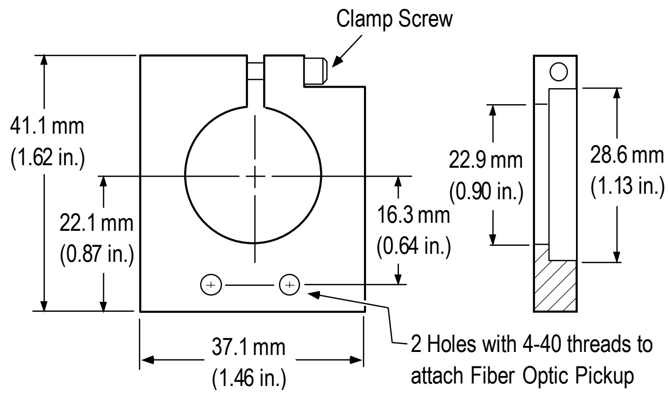
Description: For mounting the Fiber Optic Pickup to a DPMI. This adapter plate clamps to the beam translator.



Fiber Optic Adapter Plates (continued)

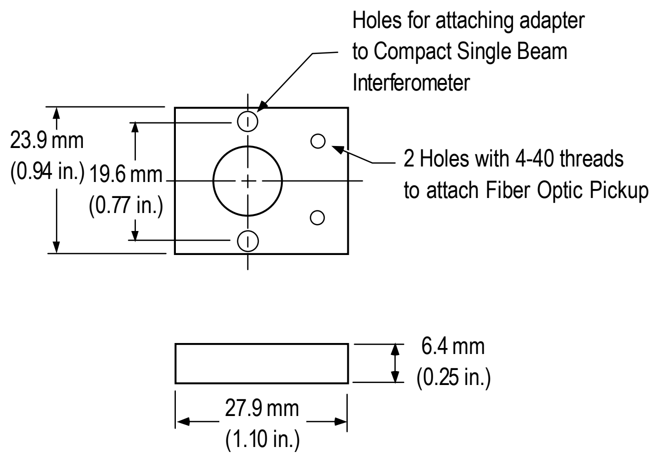
Zygo Part Number: 6191-2228-01

Description: For mounting the Fiber Optic Pickup to a 4-Pass PMI. This adapter plate clamps to the 4-Pass adapter.



Zygo Part Number: 6191-2229-01

Description: For mounting the Fiber Optic Pickup to a Single Beam Interferometer. This adapter plate attaches to the compact polarization beamsplitter cell with two #2-56 threaded screws.



Retroreflector, Standard & Small

Configuration	Zygo Part Number	Model
standard	6191-0438-02	7003
small	6191-0550-01	7004

Dimensions: See Figures.

Weight: standard, 47 grams (1.7 oz)
small, 11 grams (0.4 oz)

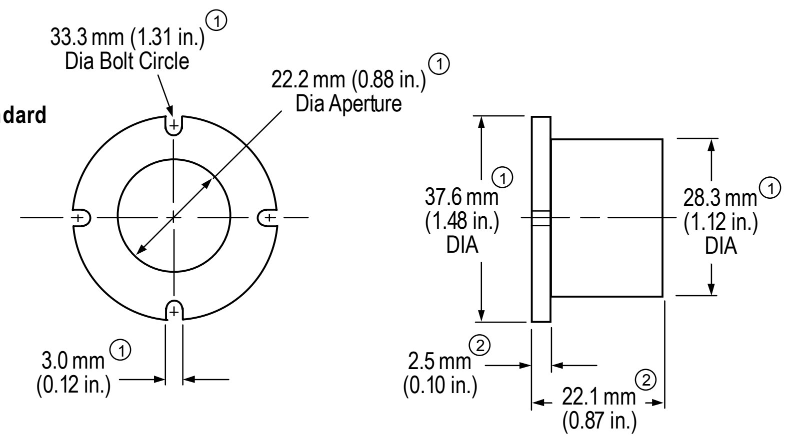
Materials:
Housing: Magnetic Stainless Steel
End Cap: Metal
Optics: BK-7
Adhesives: Vacuum Grade -- low volatility

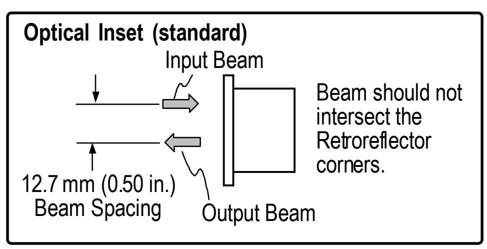
Optical: See Inset.
Out-of-parallelism between output beam and input beam: ≤1.5 arc sec

Optical Signal Efficiency (typical): 86%

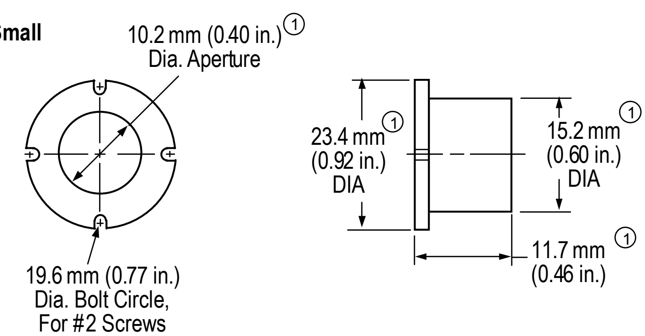
Note: the small retroreflector is used as a target mirror with the single beam interferometer.

Standard





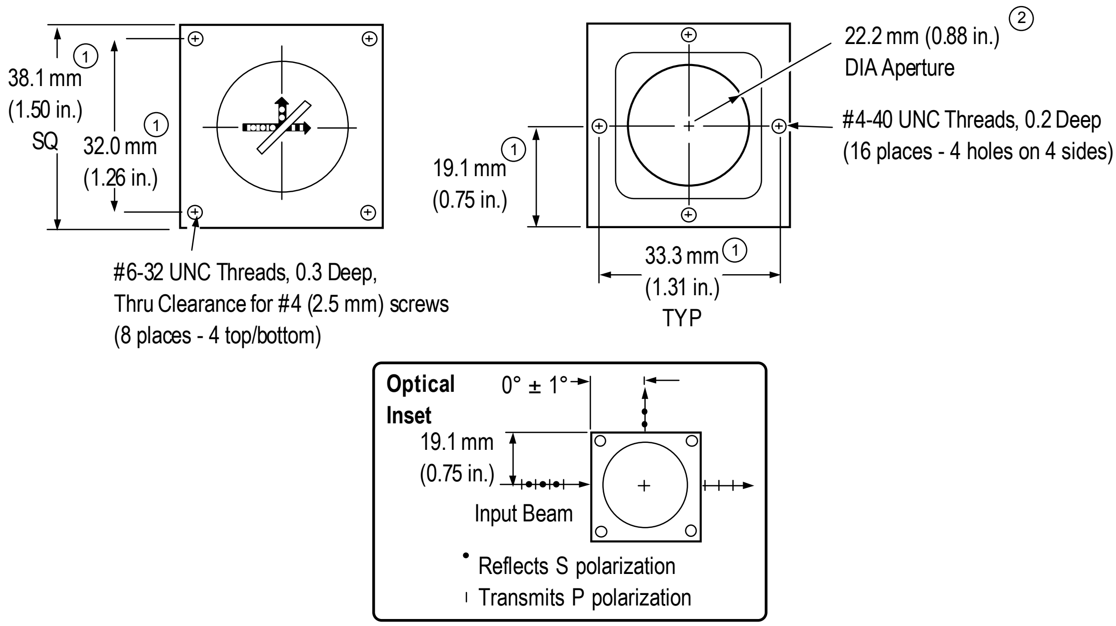
Small



Polarization Beamsplitter

Zygo Part Number: 6191-0134-01
Model: 7008
Dimensions: See Figure.
Weight: 170 grams (6.0 oz)
Optical: See Inset.
Out-of-parallelism of transmitted beam to input beam: ≤ 10 arc min

Materials:
Housing: Magnetic Stainless Steel with Electroless Nickel Plating
Apertures: Plastic
Optics: BK-7
Adhesives: Vacuum Grade -- low volatility



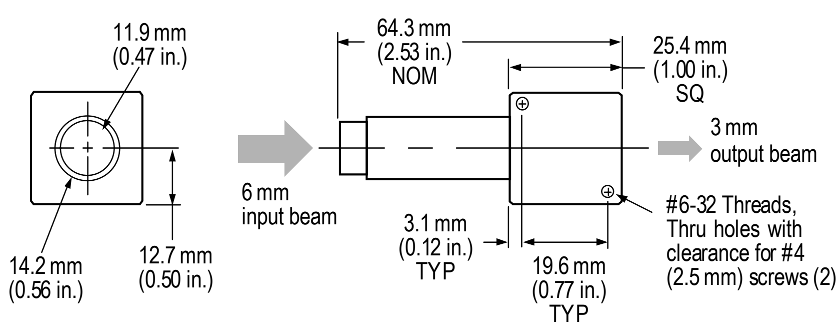
Beam Reducing Telescope

Zygo Part Number: 6191-0372-01
Model: 2010
Dimensions: See Figure.
Weight: 137 grams (4.8 oz)
Function: reduce 6 mm (0.24 in.) beam diameter to 3 mm (0.12 in.)

Materials:
Housing: Magnetic Stainless Steel with Electroless Nickel Plating
Optics: BK-7
Adhesives: Vacuum Grade -- low volatility

Optical: Out-of-parallelism of transmitted beam to input beam: < 5 arc min

Optical Signal Efficiency: 98% Typical



Quarter Waveplate

Zygo Part Number: 6191-0441-01

Model: 7022A

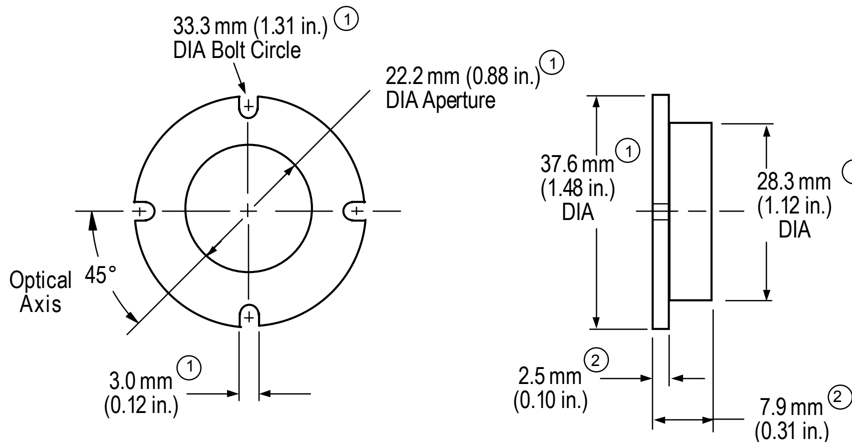
Dimensions: See Figure.

Weight: 25 grams (0.9 oz)

Materials:
Housing: Magnetic Stainless Steel with Electroless Nickel Plating
Optics: Crystalline Quartz
Adhesives: Vacuum Grade -- low volatility

Optical:
Angular deviation of transmitted beam to input beam: ≤ 1 arc min

Optical Signal Efficiency: > 99% (typical)



Half Waveplate

Zygo Part Number: 6191-0178-01

Model: 7021

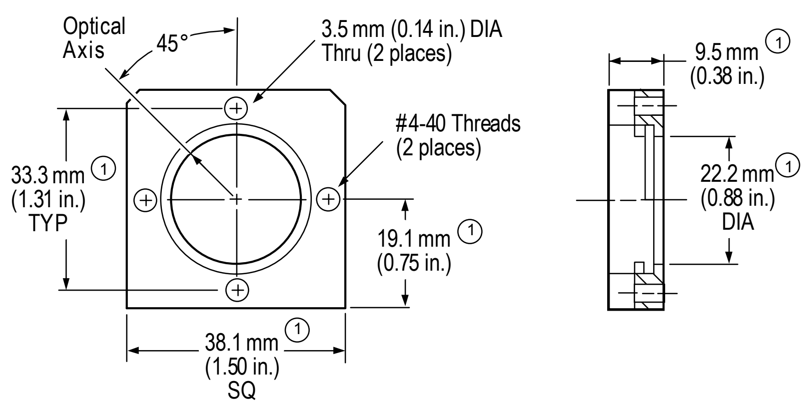
Dimensions: See Figure.

Weight: 69 grams (2.3 oz)

Materials:
Housing: Magnetic Stainless Steel with Electroless Nickel Plating
Optics: Crystalline Quartz
Adhesives: Vacuum Grade -- low volatility

Optical:
Angular deviation of transmitted beam to input beam: ≤ 1.0 arc sec

Optical Signal Efficiency: > 99% (typical)



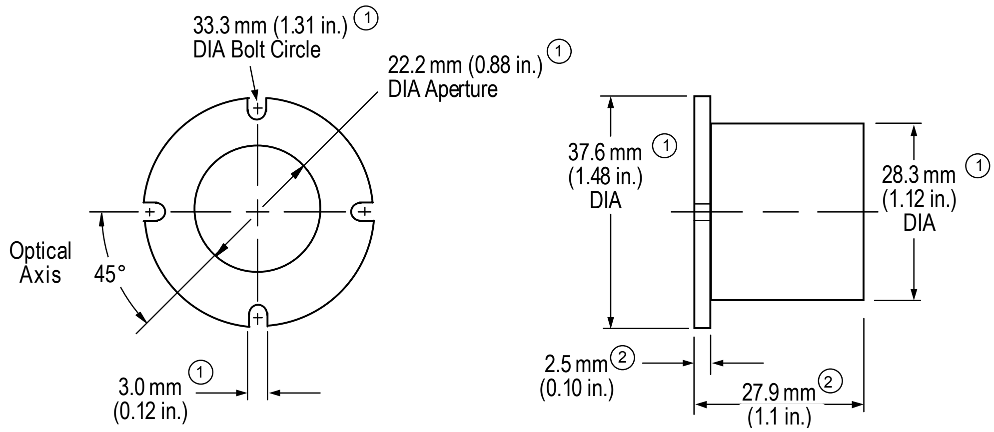
Quarter Waveplate Retroreflector Assembly

Zygo Part Number: 6191-0439-01
Model: 7023A
Dimensions: See Figure.
Weight: 59 grams (2.1 oz)

Materials:
Housing: Magnetic Stainless Steel
with Electroless Nickel Plating
End Cap: Metal
Optics: BK-7 and Crystalline Quartz
Adhesives: Vacuum Grade -- low volatility

Optical:
Out-of-parallelism between output beam to input beam:
≤ 1.5 arc sec

Optical Signal Efficiency: > 86% (typical)

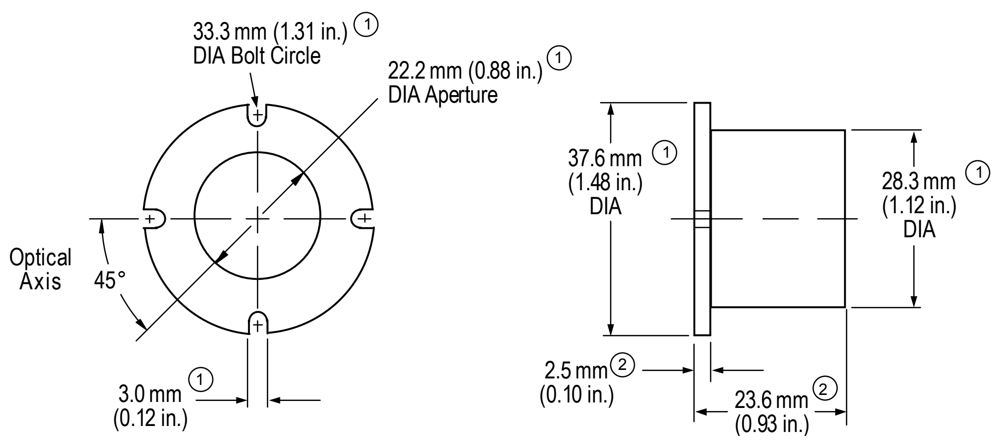


Quarter Waveplate Plane Mirror Assembly

Zygo Part Number: 6191-0440-01
Model: 7024A
Dimensions: See Figure.
Weight: 66 grams (2.3 oz)

Materials:
Housing: Magnetic Stainless Steel
with Electroless Nickel Plating
Optics: Crystalline Quartz and Zerodur
Adhesives: Vacuum Grade -- low volatility

Optical Signal Efficiency: > 99% (typical)



Angle Prism

Configuration	Zygo Part Number	Model
Angle Prism only	6191-0416-01	7026-01
Mounted Angle Prism	6191-0416-02	7026-02

Dimensions: See Figure.

Weight: 136 grams (4.8 oz)
(26 grams (0.9 oz) Non-mounted Prism)

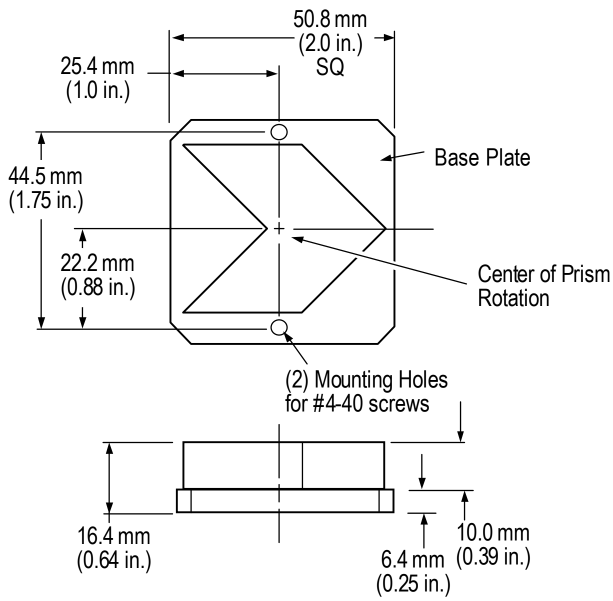
Additional Components Required:
DPMI and Stationary Plane Mirror

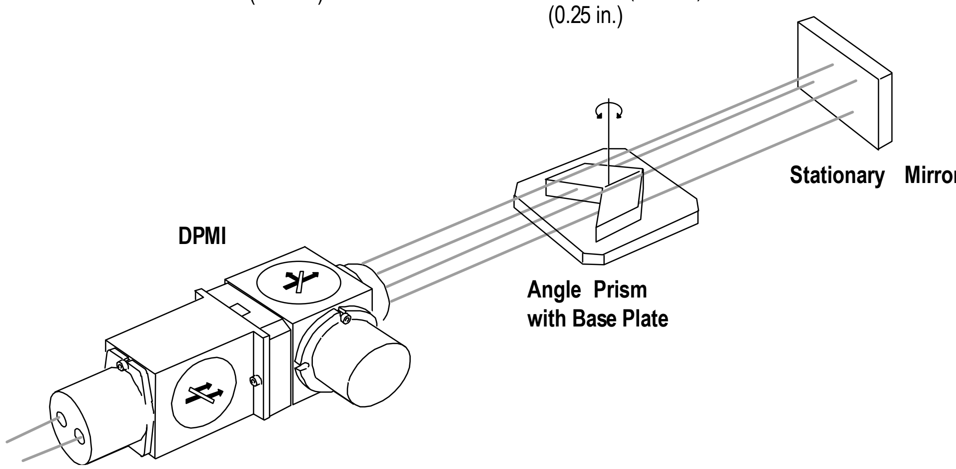
Materials:
Base: Magnetic Stainless Steel with Nickel Plating
Optics: BK-7
Adhesives: Vacuum Grade -- low volatility

Minimum Stationary Mirror Size:
20 x 40 mm (0.8 x 1.6 in.)

Optical:
Angular Displacement Resolution (nominal):
0.011 arc sec (ZMI 2000)
0.005 arc sec (ZMI 4000)
Angular Displacement Range:
± 20 degrees unvignetted,
± 30 degrees vignetted
Maximum Angular Velocity:
31,200 deg/sec (ZMI 2000)
62,400 deg/sec (ZMI 4000)

Optical Signal Efficiency (including DPMI):
43% unvignetted, 30% vignetted.
(Based on a stationary plane mirror having 99% reflectance at 633 nm at normal incidence.)

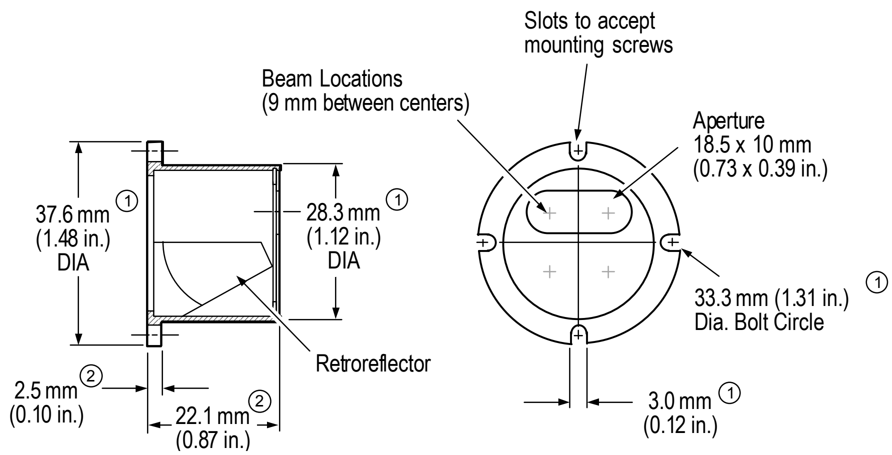




4-Pass Adapter

Zygo Part Number: 6191-0103-01
Model: 7034
Dimensions: See Figure.
Weight: 40 grams (1.4 oz)
Materials:
Housing: Magnetic Stainless Steel
End Cap: Metal
Optics: BK-7
Adhesives: Vacuum Grade -- low volatility

Optical:
Out-of-parallelism between output beam to input beam: ≤ 1.5 arc sec
Optical Signal Efficiency: 86% (typical)

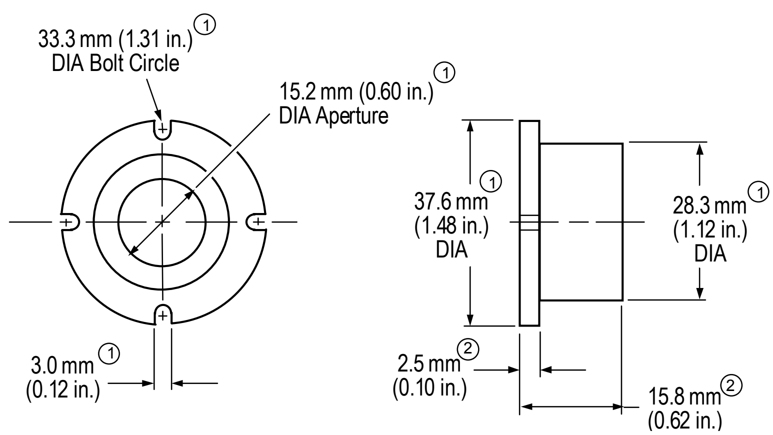


Optical Probe Lens

Configuration	Zygo Part Number	Model
50 mm focal length	6191-0374-01	7028-01L
120 mm focal length	6191-0374-02	7028-02L
160 mm focal length	6191-0374-03	7028-03L

Materials:
Housing: Magnetic Stainless Steel
Optics: Quartz and Crown & Flint Glass
Adhesives: Vacuum Grade -- low volatility

Dimensions: See Figure.
Weight: 54 grams (1.9 oz)



Mirror & Beamsplitter Mount

Zygo Part Number: 6191-0445-01

Model: 7010B

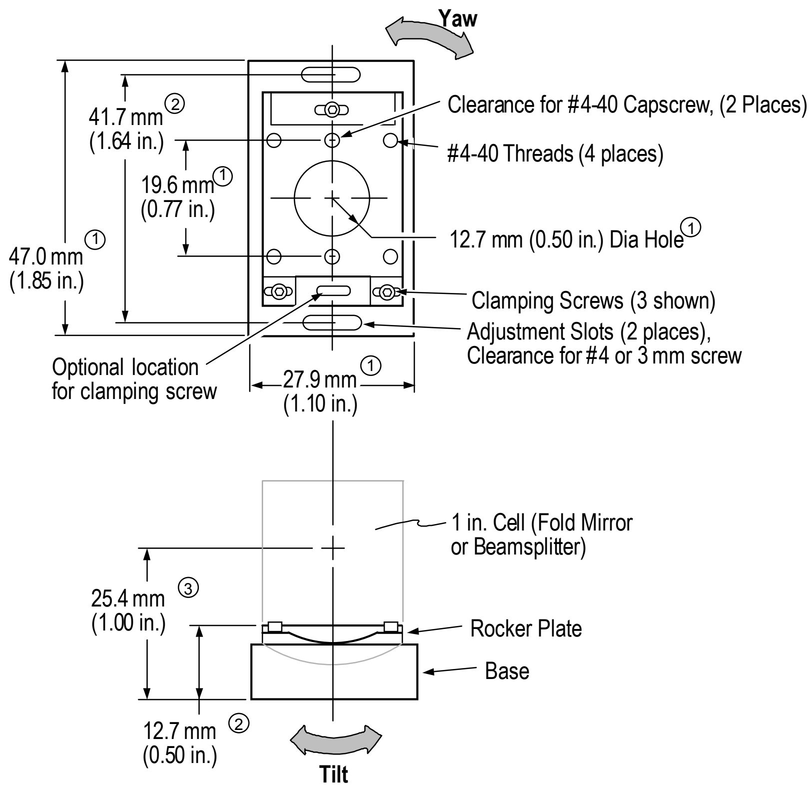
Description: Used to mount optical components with 1-inch square cells.

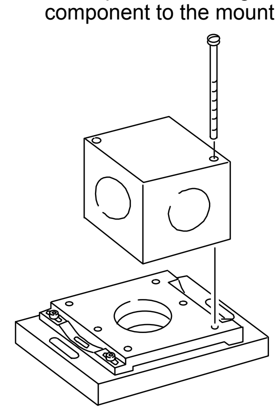
Dimensions: See Figure.

Weight: 86 grams (3.0 oz)

Materials: Magnetic Stainless Steel

Angular Adjustment:
Yaw: ± 8 degrees
Tilt: ± 4 degrees (when used with 3 clamping screws)
± 8 degrees (when used with 2 clamping screws in center slots of Rocker Plate)





Securing the Mount:

1. Attach the mount to the mounting surface with a #4 or 3 mm socket screw and two washers through each mounting slot. Note that 2 standard flat washers (included) must be used between the adjustment slot and the screw head.
2. Tighten the screws to 80 in-oz (0.6 N•m) maximum.

Mounting component to the mount:

1. Position the optical component to the mount so the reflected beam rotates about the input laser beam.
2. Attach the component to the mount with two #4-40 screws.
3. Tighten the screws to 40 in-oz (0.3 N•m) maximum.

Adjusting component location:

1. *To adjust for Yaw* - slightly loosen mounting screws and rotate entire mount. Tighten the mounting screws to 80 in-oz (0.6 N•m) maximum.
2. *To adjust for Tilt* –
   a. Slightly loosen the single clamping screw.
   b. Alternately tighten and loosed the paired clamping screws to rotate the component in the appropriate direction.
   c. Tighten the three clamping screws.

Interferometer Mount

Zygo Part Number: 6191-0446-01

Model: 7011B

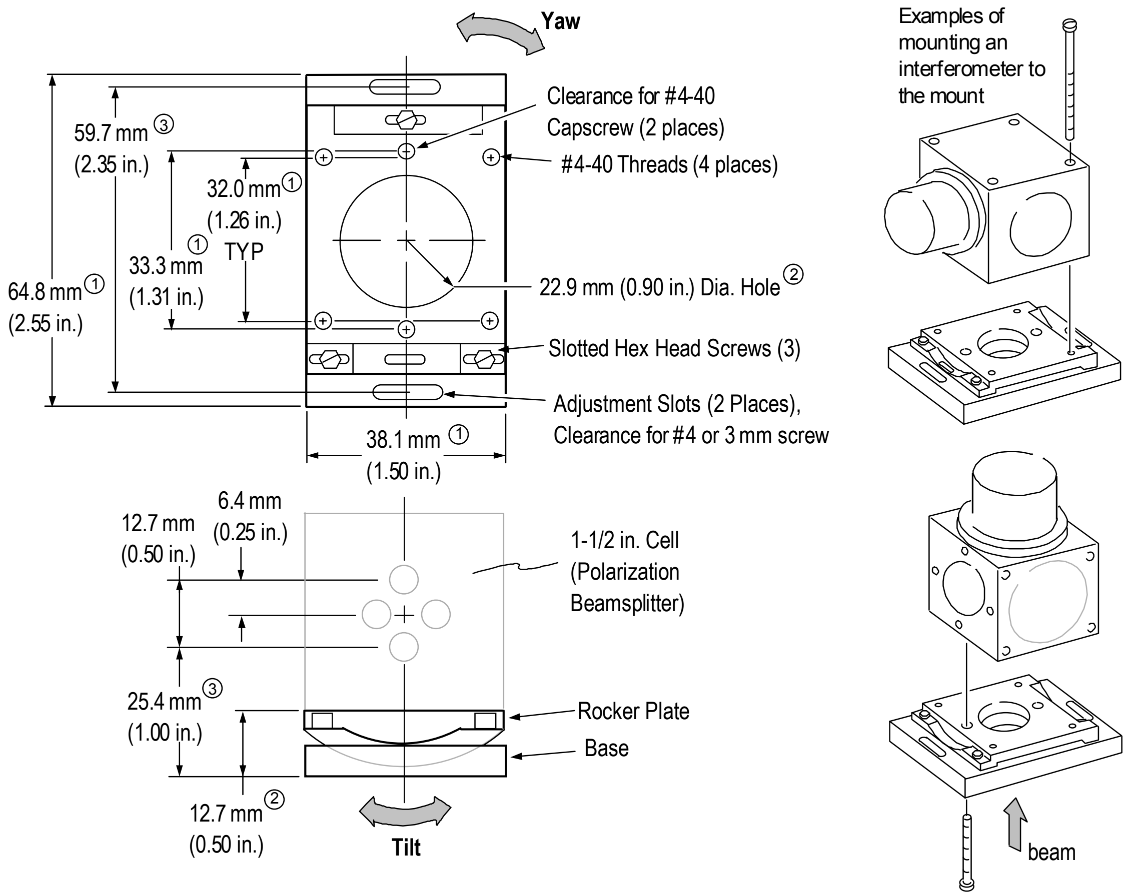
Description: Used to mount optical components with 1-1/2 inch square cells.

Dimensions: See Figure.

Weight: 137 grams (5.0 oz)

Materials: Magnetic Stainless Steel

Angular Adjustment:
Yaw: ± 8 degrees
Tilt: ± 5 degrees



Securing the Mount:

1. Attach the mount to the mounting surface with a #4 or 3 mm socket screw and two washers through each mounting slot. Note that 2 standard flat washers (included) must be used between the adjustment slot and the screw head.
2. Tighten the screws to 80 in-oz (0.6 N•m) maximum.

Mounting the interferometer to the mount:

1. Locate the retroreflector over the side of the mount with two adjustment screws.
2. Secure the polarization beamsplitter to the mount with two or four #4-40 screws (depends on mounting orientation and available holes.
3. Tighten the screws to 40 in-oz (0.3 N•m) maximum.

Adjusting interferometer location:

1. *To adjust for Yaw* - slightly loosen the mounting screws and rotate entire mount. Tighten the mounting screws to 80 in-oz (0.6 N•m) maximum.
2. *To adjust for Tilt* –
   a. Slightly loosen the single slotted hex head screw.
   b. Alternately tighten and loosed the paired slotted hex head screws to rotate the interferometer in the appropriate direction.
   c. Tighten the three slotted screws.

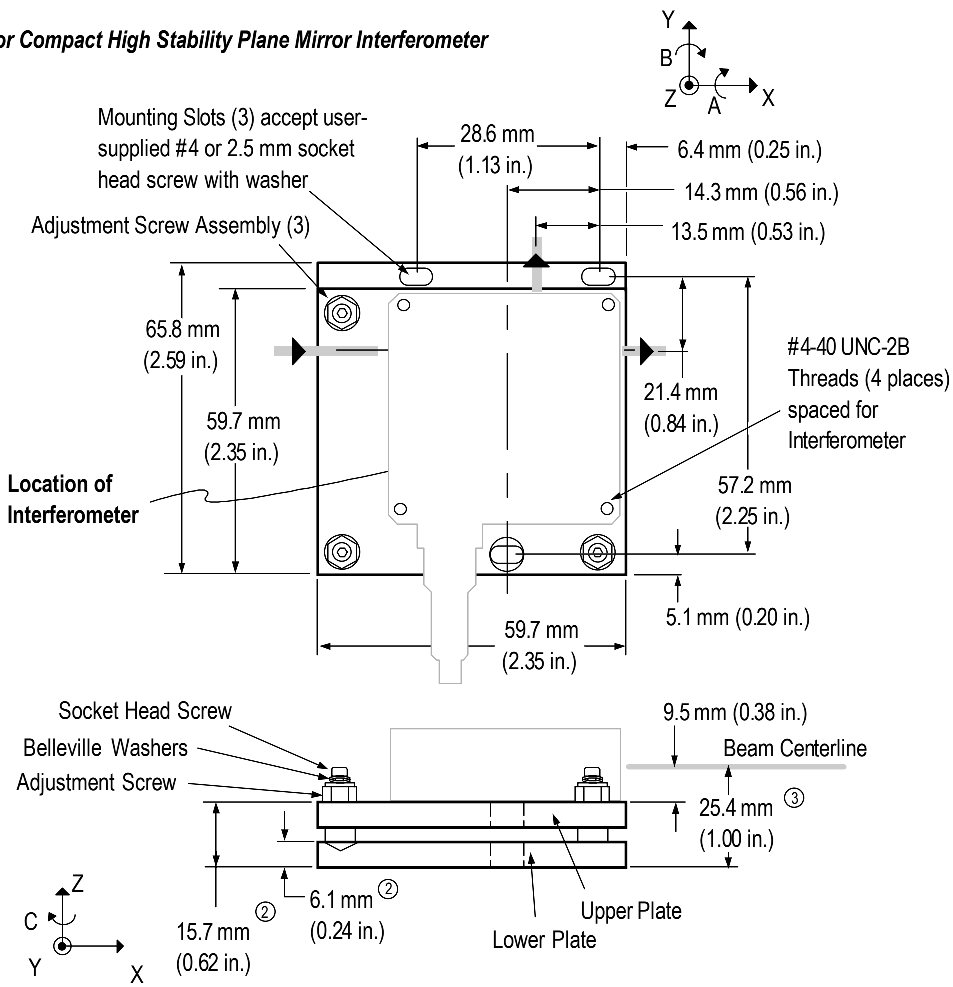
Compact Interferometer Mount, 1-Axis

Zygo Part Number: 8050-0101-01
Model: 2014-01
Dimensions: See Figure.
Weight: 370 grams (13.1 oz)
Materials:
Upper and Lower Plates:
Magnetic Stainless Steel
Adjustment Screws:
Non-magnetic Stainless Steel
Adjustment Screw Seat Finish: 63 Ra max.

Adjustment Range:

Axis	*Typical*	*Full*
X	±2 mm	5 mm
Y	±1 mm	2 mm
Z	±0.75 mm	3 mm
A	±1.5°	3°
B	±1.5°	3°
C	±1°	2°

For Compact High Stability Plane Mirror Interferometer



For mounting and alignment recommendations refer to page 2 of the Compact Interferometer Mount, 2 Axis specification.

Compact Interferometer Mount, 2-Axis

Zygo Part Number: 8050-0100-01

Model: 2014-02

Dimensions: See Figure.

Weight: 510 grams (18.0 oz)

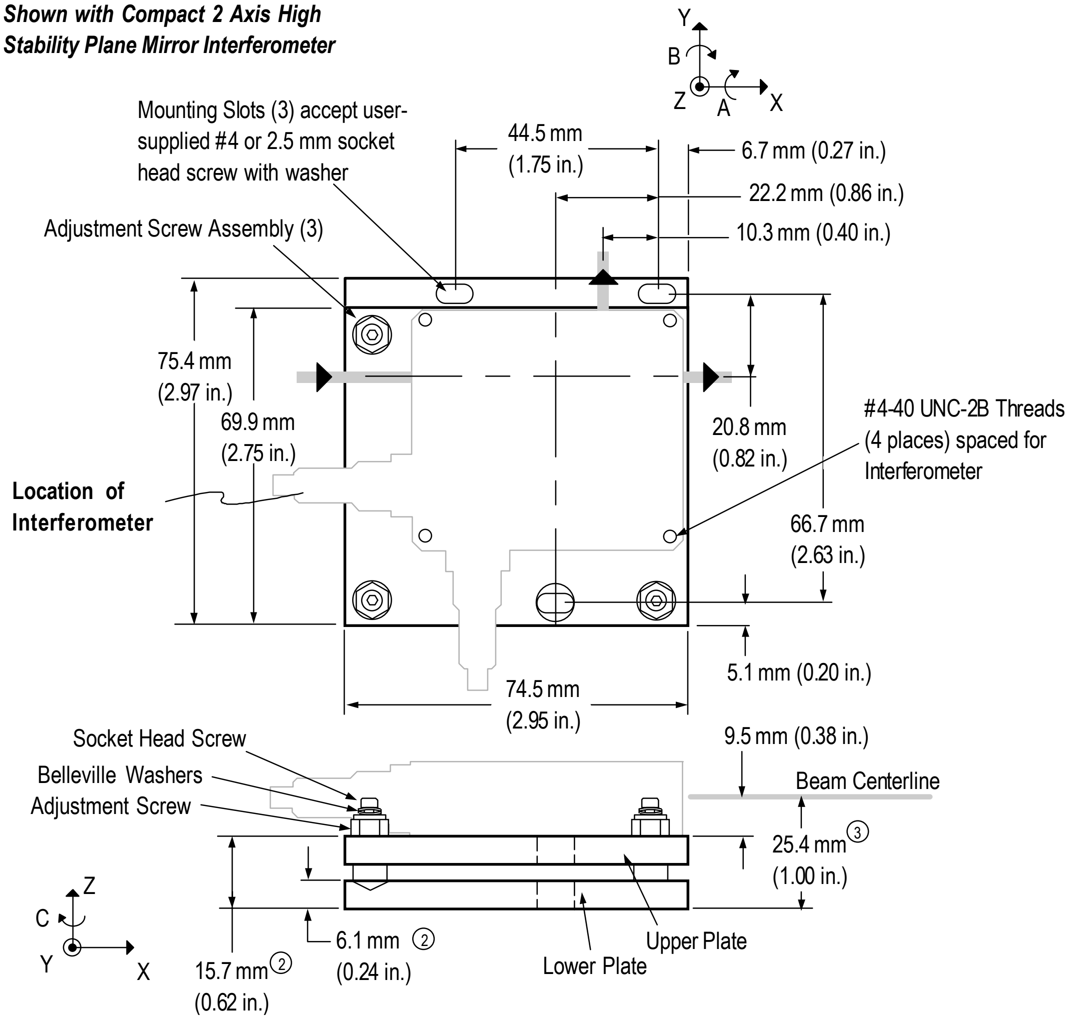
Materials:
- Upper and Lower Plates:
  - Magnetic Stainless Steel
- Adjustment Screws:
  - Non-magnetic Stainless Steel

Adjustment Screw Seat Finish: 63 Ra max.

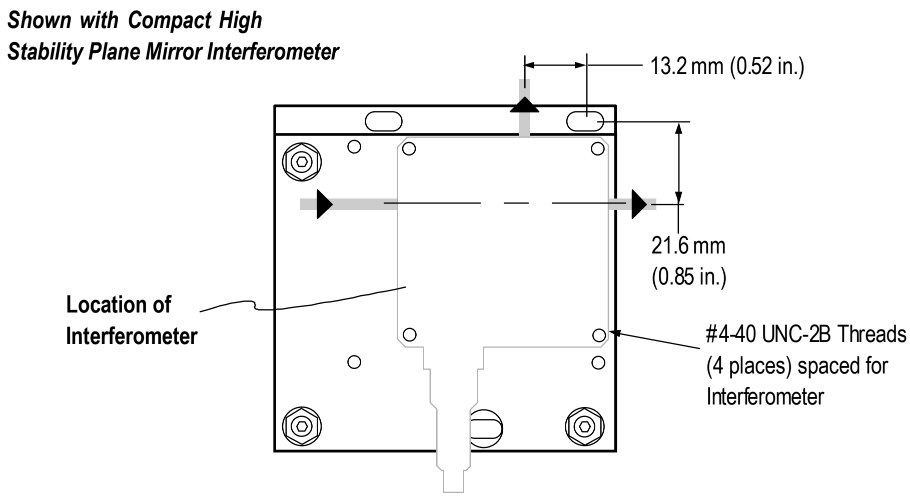
Adjustment Range:

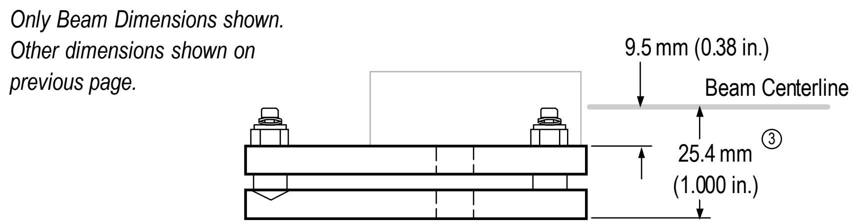
Axis	*Typical*	*Full*
X	±2 mm	5 mm
Y	±1 mm	2 mm
Z	±0.75 mm	3 mm
A	±1.5°	3°
B	±1.5°	3°
C	±1°	2°

Shown with Compact 2 Axis High Stability Plane Mirror Interferometer



Compact Interferometer Mount, 2-Axis (continued)





Securing the Mount:

1. Attach the mount to the mounting surface with a user-supplied #4 or 2.5 mm socket head screw and a washer, through each of the three mounting slots.
2. Tighten the screws to 80 in-oz (0.6 N•m) maximum.

Mounting the interferometer to the mount:

1. Position the interferometer on the mount as indicated by the shaded outline in the drawing.
2. Attach interferometer to the mount with four #4-40 screws.
3. Tighten the screws to 40 in-oz (0.3 N•m) maximum.

Adjusting interferometer location:

1. *To adjust Yaw* (shown as C about the z-axis) - slightly loosen the mounting screws and rotate the entire mount. Tighten the mounting screws to 80 in-oz (0.6 N•m) maximum.
2. *To adjust Tilt (in the X-Y plane) and the z-axis height -*
   a. Loosen the three socket head screws on the adjustment screw assemblies, with a 2 mm Allen wrench, until the washers are just free.

   Warning!
   Do not turn the adjustment screws while the socket head screws are tight or you may damage the threads and ruin the mount.

   b. Turn each adjustment screw, with an 8 mm wrench, to adjust the coarse interferometer position.
   c. Preload the adjustment assemblies by tightening the three socket head screws, with a 2 mm Allen wrench, a quarter turn after the head touches the washers.
   d. Turn each adjustment screw, with an 8 mm wrench, to fine adjust the z-axis height and tilt.
   e. Gradually tighten each socket head screw in an orderly sequence of two half turns and a quarter turn; for a total of 1-1/4 turns. (Torque specification: 40 in-oz (0.3 N•m) maximum.)

Precision Adjustable Mount

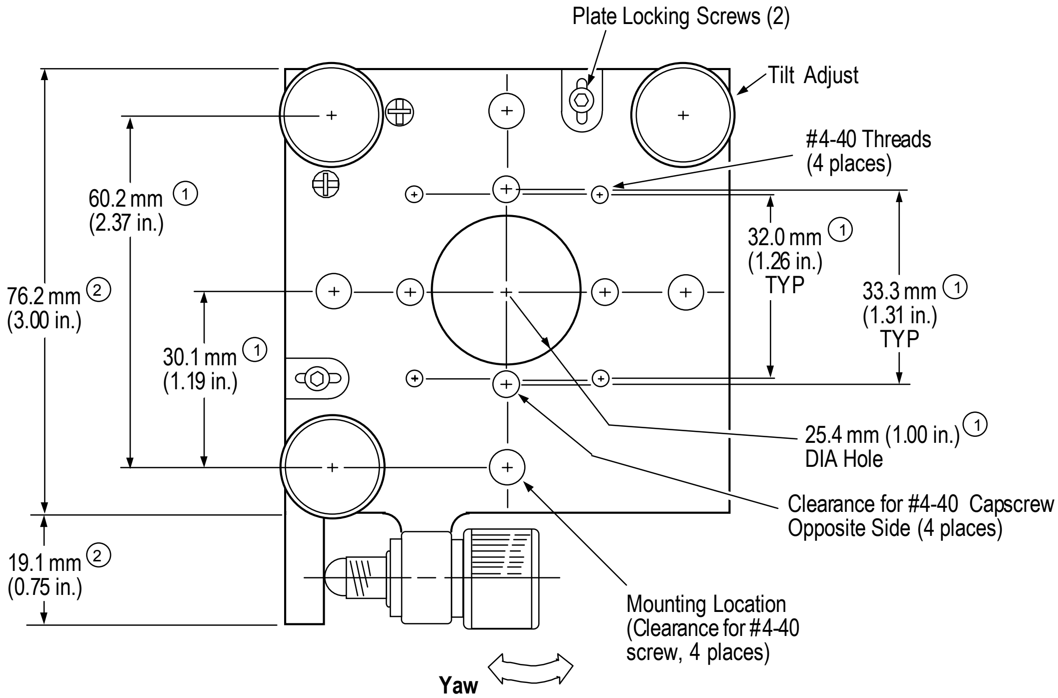
Configuration	Zygo Part Number	Model
Without adapter plate	6191-0310-01	7013-01
With adapter plate for 1-inch optics	6191-0310-02	7013-02
With adapter plate for Compact 1-Axis	6191-0310-03	7013-03
With adapter plate for Compact 2-Axis	6191-0310-04	7013-04

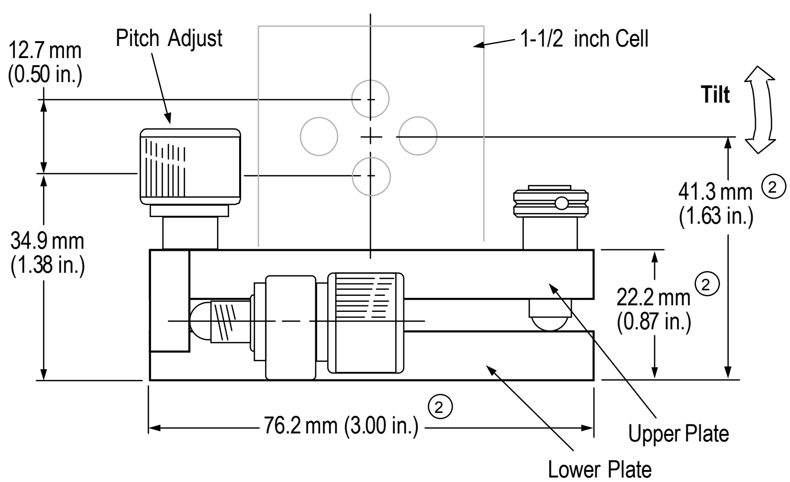
Adjustment Range:
Yaw: ± 2.5 degrees
Tilt: ± 2.5 degrees
Pitch: ± 2.5 degrees
Linear (Vertical):
± 0.5 mm (0.02 in.)

Dimensions: See Figure.

Weight: 794 grams (28.0 oz)

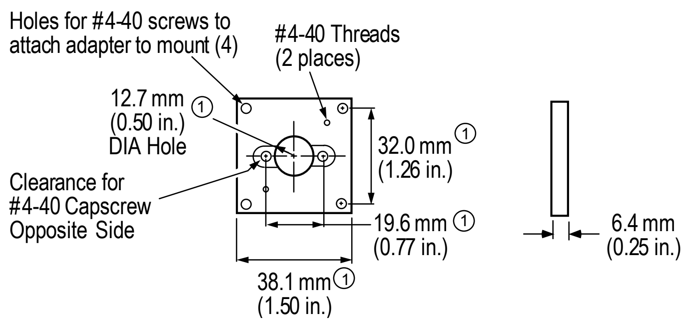
Materials: Magnetic Stainless Steel with Electroless Nickel Plating



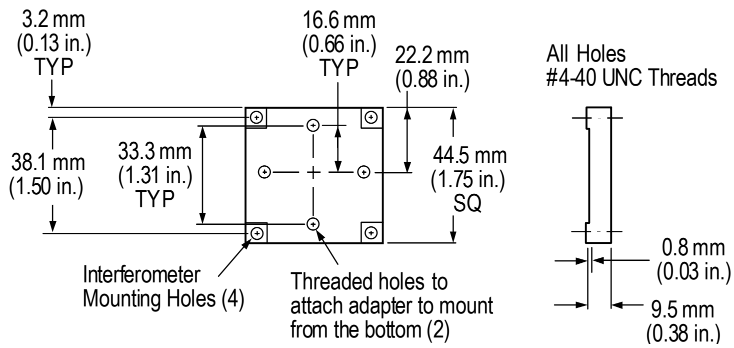


Adapter Plates for Precision Adjustable Mount

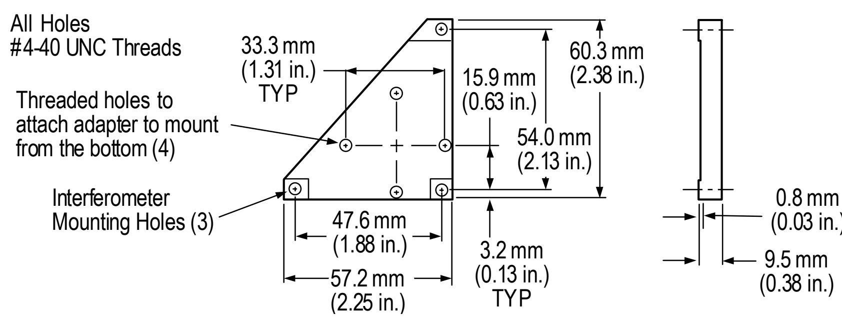
Zygo Part Number: 6191-1494-01
Model: 2013
Description: Adapts mount for optical components with 1-inch square cell.
Dimensions: See Figure.
Weight: 794 grams (28.0 oz)
Materials: Magnetic Stainless Steel with Electroless Nickel Plating



Zygo Part Number: 6191-1688-01
Model: 2012
Description: Adapts mount for Compact High Stability Plane Mirror Interferometers.
Dimensions: See Figure.
Weight: 794 grams (28.0 oz)
Materials: Magnetic Stainless Steel with Electroless Nickel Plating



Zygo Part Number: 6191-1658-01
Model: 2011
Description: Adapts mount for Compact 2 Axis High Stability Plane Mirror Interferometers.
Dimensions: See Figure.
Weight: 794 grams (28.0 oz)
Materials: Magnetic Stainless Steel with Electroless Nickel Plating



Optical Alignment

Chapter 3

In This Chapter

This chapter describes the principles that must be met during optical alignment, alignment tools, and step-by-step procedures for various optical components. It covers the following major topics:

- Basic Concepts
  - Optical Signal Efficiency
  - Measurement-Reference Beam Offset
  - Angular Misalignment
  - Polarization Alignment
- Alignment Tools
  - Zygo Alignment Tools
  - Other Equipment
- Step-by-Step Procedures
  - Basic Alignment Principles
  - Aligning Target Mirrors
  - Aligning the Laser Output Beam
  - Aligning Fold Mirrors and Beamsplitters
  - Aligning Straight-through Interferometers
  - Aligning Right-angle Interferometers
  - Aligning the Fiber Optic Pickup
- Optimizing Alignment
  - ZMI 4000 Measurement Board Test Point Characteristics
  - ZMI 2000 Measurement Board Test Point Characteristics
  - ZMI 1000A Measurement Board Test Point Characteristics

Basic Concepts

1. *Optical Signal Efficiency* - The AC optical power at the Fiber Optic Pickup must meet minimum system requirements over the entire measurement range for each axis. The minimum system requirements per axis are: 10 microwatts (ZMI 1000) or 5 microwatts (ZMI 2000).
2. *Measurement-Reference Beam Offset* - The measurement and reference laser beams must be concentric (or have minimal offset) at the Fiber Optic Pickup over the entire measurement range of displacement.
3. *Angular Misalignment* - To minimize cosine error, the measurement beam must be parallel to the axis of motion and perpendicular to the movable optical element.
4. *Polarization Alignment* - The optical components must be aligned properly with respect to the polarization orientation of the incident laser beam.

Optical Signal Efficiency

By using optical signal efficiency ratings, you can determine whether the AC optical power at the Fiber Optic Pickup for each axis of measurement will be sufficient for a reliable measurement. The optical signal efficiency of a device is defined as the ratio of the AC signal at the output beam of the device to the AC signal at the input beam of that device. The optical signal efficiency is based on AC signal amplitudes rather than optical power because the AC signal is the physical parameter that carries the measurement information.

$$\text{Optical Signal Efficiency} = \frac{\text{Output AC Signal}}{\text{Input AC Signal}}$$

Chapter 2 of this manual specifies the optical signal efficiency for all Zygo optical components. Values indicated on the specification sheets generally represent the minimum efficiency of the component.

The optical signal efficiency for the interferometers is the ratio of the AC amplitude of the signal at the output beam to the AC amplitude of the signal at the input beam, as measured by a Fiber Optic Pickup.

The optical signal efficiency for interferometers that use plane mirrors for the movable optical element is defined for a plane mirror with a reflectivity ≥ 99 percent. If the plane mirror has lower reflectivity, then the optical signal efficiency is reduced by $(R/99\%)^{B/2}$, where R is the mirror reflectivity in percent (%) and B is the number of reflections from the target mirror. The surface flatness of the plane mirror and misalignment of the laser can be other factors that degrade the signal efficiency of an interferometer.

The optical signal efficiency for nonpolarizing beamsplitters is the ratio of the transmitted and reflected output beam signals to the input beam signal. An ideal 33% Beamsplitter reflects one third of the beam power and transmits two thirds of the beam power; similarly, a 50% Beamsplitter transmits and reflects half of the beam power. However, since the transmission and reflection coefficients are slightly different for the two polarization components, Zygo specifies the optical efficiency at the minimum values for each polarization.

The published signal efficiencies for Zygo's optical components allow the system designer to quickly evaluate whether the AC optical power will be adequate for each axis of measurement. This is determined by multiplying the efficiencies of all of the components between the exit aperture of the laser and the fiber optic connector on the measurement board. For an optical power calculation example see Chapter 5.

Measurement-Reference Beam Offset

The measurement and reference beams should have zero offset at the Fiber Optic Pickup for the entire range of displacement. The AC measurement signal is produced only from the area of overlap of the measurement and reference beams. This overlap is referred to as "beam offset".

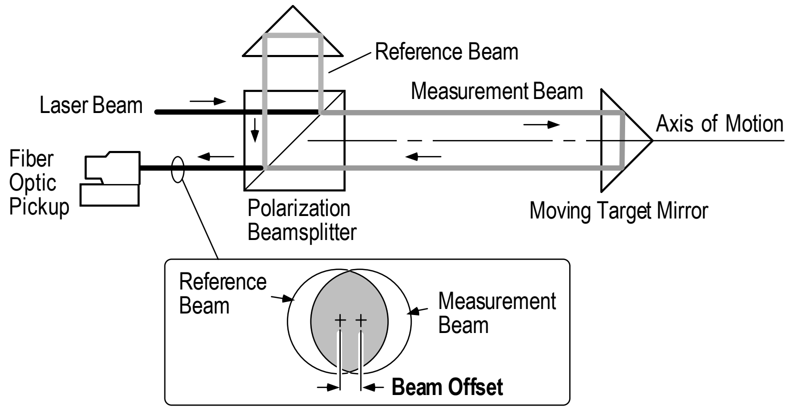


Figure 3-1 Measurement-Reference Beam Offset

Measurement-reference beam offset causes a reduction in the AC signal because optical interference takes place only at the region of overlap of the two beams. The nonoverlap areas generate a DC signal which contains no measurement information.

> **Note:** A good way to observe the overlap of the beams is to watch the spot on an alignment card while temporarily interrupting the measurement beam by waving your hand between the interferometer and the target mirror.

Measurement-reference beam offset can arise from two types of misalignment:

1. *Lateral* misalignment of an optical element, either the moving optical element or the interferometer module, and
2. *Angular* misalignment, either between a measurement beam and the axis of motion of the displacement being measured, or between the moving optical element and the laser beam incident upon this plane mirror.

Lateral misalignment will yield an offset which does not vary with displacement. A lateral offset of 0.4 millimeters of the moving target mirror causes an offset between the measurement and reference beams and reduces the AC signal by approximately 10%. Angular misalignment will yield an offset which varies with displacement.

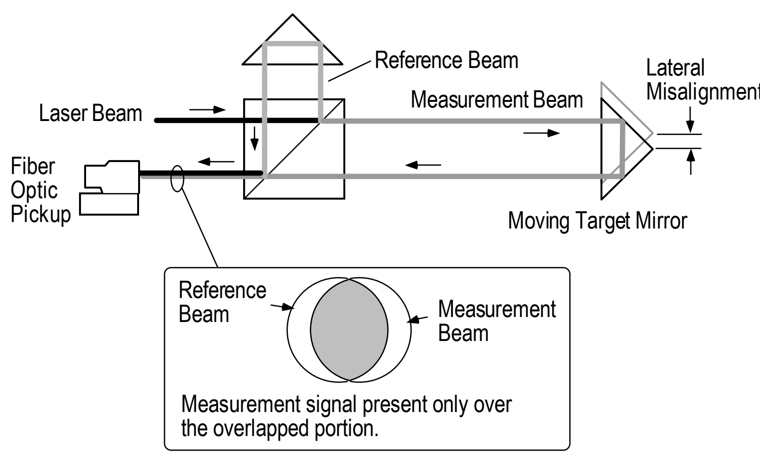


Figure 3-2 Beam Offset and Lateral Misalignment

For angular misalignment between the measurement beam and the axis of motion, the offset between the measurement and reference beams will vary by an amount directly proportional to the product of the angular misalignment in radians and the displacement range.

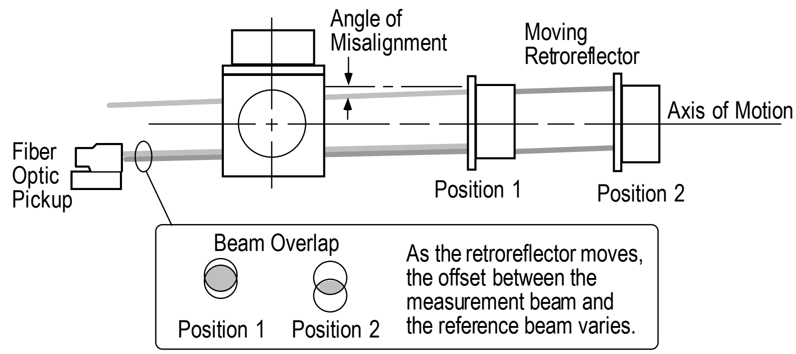


Figure 3-3 Beam Offset and Angular Misalignment

The constant of proportionality depends on the type of interferometer. Figure 3-4 shows the effect of angular misalignment and beam offset on a Plane Mirror Interferometer; included is a graph to illustrate the relationship between misalignment and the acceptable limit of measurable displacement. This limit line is based on a maximum recommended signal reduction of 10%. The system designer may allow greater signal reduction (and therefore larger angular alignment tolerance) if there is adequate AC signal strength.

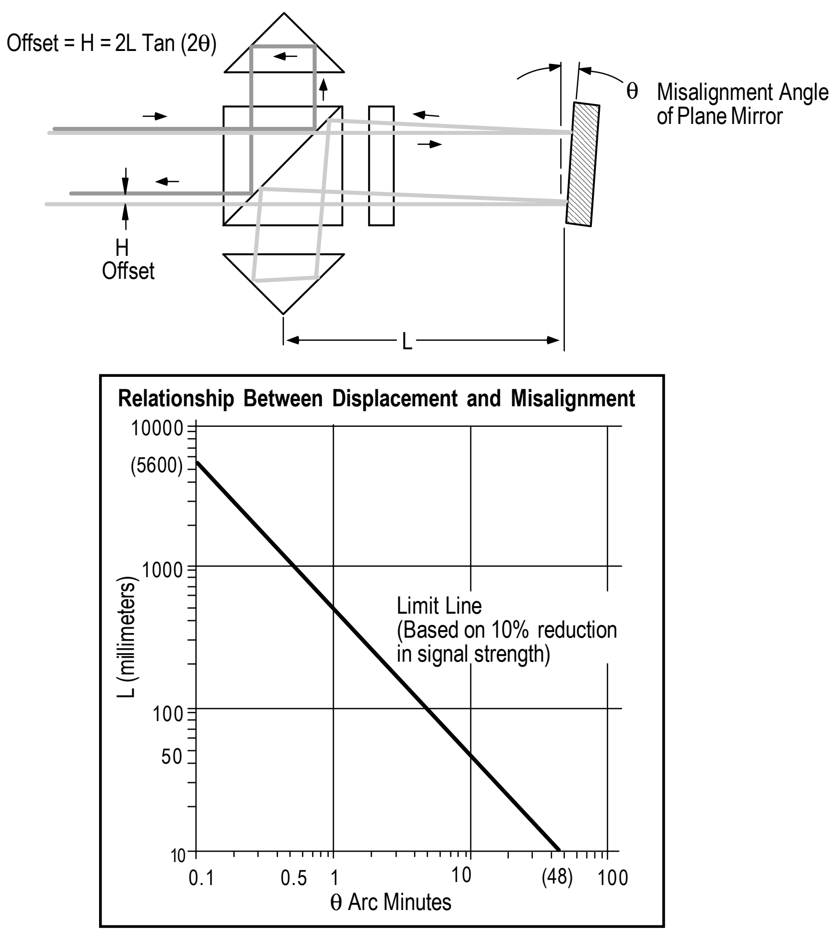


Figure 3-4 Plane Mirror Interferometer Beam Offset

Angular Misalignment

There are two very important effects of angular misalignment: cosine error and nonlinearity due to polarization mixing.

Cosine error is a measurement error caused by an angular misalignment between the measurement beam and the axis of motion of the displacement being measured. Besides degrading the AC signal, cosine error also degrades accuracy because the measured displacement is not the actual displacement traveled. Even if the AC signal strength at the photodetector is adequate over the entire range of displacement, it cannot be inferred that there is no angular misalignment.

Polarization mixing of the beam components within the interferometer causes a nonlinear relationship between the measured displacement and the actual displacement. To minimize errors caused by polarization mixing, a perpendicular relationship must be maintained between the two frequency components of the laser head and the orientation of the polarization-sensitive optical components.

Polarization Alignment

The Laser Head must be installed so that the two laser beam polarizations (F1 and F2) are parallel and perpendicular with respect to the optical components. F1 is the vertically polarized component (S-polarized) and F2 is the horizontally polarized component (P-polarized) with respect to the laser head mounting surface. The Laser Head may be mounted on any plane, as long as it is aligned with one of the polarizations perpendicular or parallel to the axes of measurement.

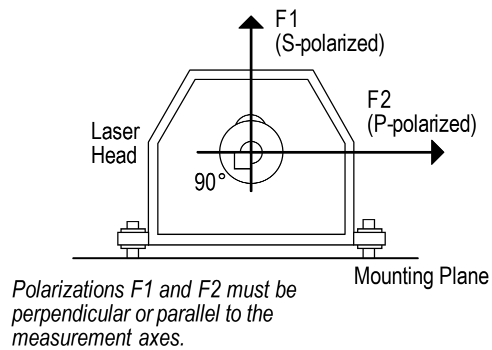


Figure 3-5 Laser Head Polarization Components

Each interferometer consists of at least one polarization beamsplitter. The polarization beamsplitter is the polarization-sensitive optic that directs the appropriate frequency component of the laser beam to the reference and measurement legs of the interferometer. If a percentage of the "unwanted" polarization state leaks into the wrong leg of the interferometer, the accuracy of the measurement will be affected. A misalignment of the laser or interferometer about the optical axis will significantly increase polarization leakage.

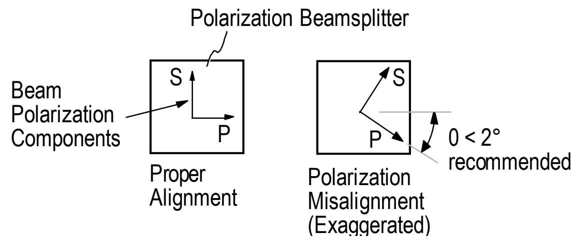


Figure 3-6 Polarization Beamsplitter Alignment

Figure 3-7 illustrates a properly aligned polarizing system. In this case, the transmitted and reflected beams each contain only one frequency. Figure 3-8 illustrates what happens when the laser is *misaligned* relative to the polarization Beamsplitter. In this case, the transmitted and reflected beams contain not only the single frequency each should have but also a small portion of the other frequency. This leads to a polarization mixing nonlinearity. To minimize the polarization mixing error, Zygo recommends limiting the rotational misalignment about the optical axis to less than 2 degrees.

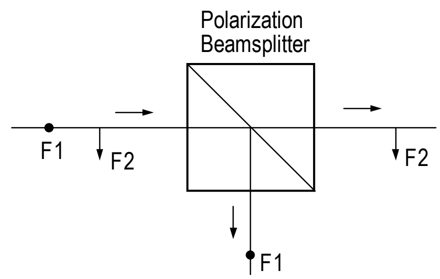


Figure 3-7 Proper Polarization Alignment

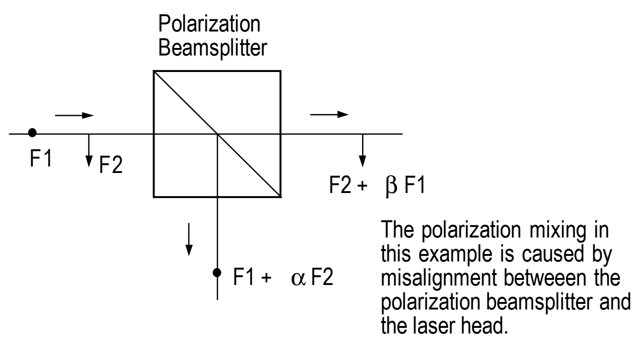


Figure 3-8 Polarization Mixing

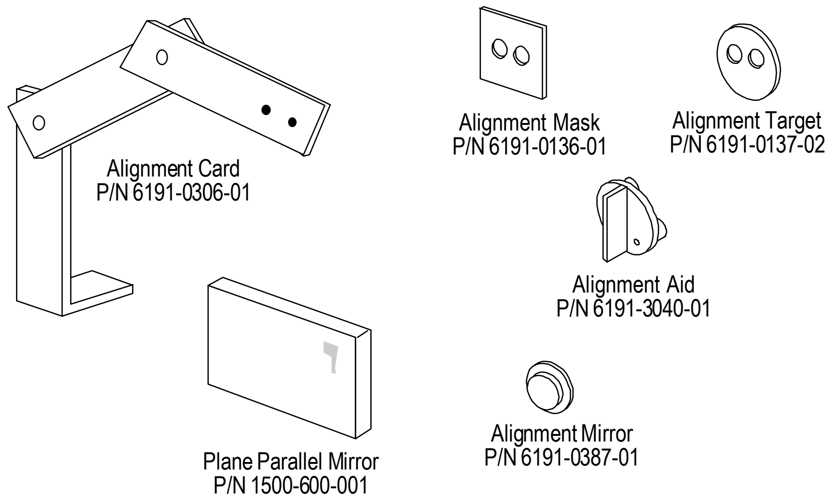
Due to imperfections in optical glass and their coatings, polarization mixing errors are present in all interferometers. Zygo uses the highest quality optics and coatings to minimize such polarization leakage. (See chapter 5 for the maximum polarization mixing error permitted in each interferometer.)

The previously described alignment concepts should help you to understand the ideals to attain during the actual alignment procedures. From this point on, the chapter deals with the actual alignment.

Alignment Tools

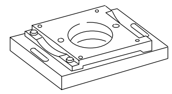
Zygo Alignment Tools

These alignment tools are included with many of Zygo's optical components.

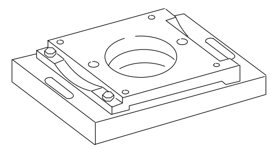


- *Alignment Card* - Zygo P/N 6191-0306-01, is shipped with most Laser Heads and used in all alignment procedures.
- *Alignment Mask* - Zygo P/N 6191-0136-01, is shipped with the Linear Interferometer and the Plane Mirror Interferometer; it is used to center the interferometer to the incoming beam.
- *Alignment Target* - Zygo P/N 6191-0137-02, is shipped with Plane Mirror Interferometers, Differential Plane Mirror Interferometer, and Compact Interferometers; it is used to align the interferometer to the target mirror.
- *Alignment Aid* - Zygo P/N 6191-3040-01, is shipped with the Differential Plane Mirror Interferometer; it is used to center the interferometer to the incoming beam.
- *Magnetic Alignment Mirror* - Zygo P/N 6191-0387-01, is included with the Compact Interferometers; it is used to center the beam in the interferometer and to set the tilt with respect to the input beam.
- *Plane Parallel Mirror* - Zygo P/N 1500-600-001, is optional. The mirror measures 25 x 35 x 6 millimeters (height x width x depth), and is coated on one side. It is used to reflect the beam back to the alignment card.
- *Alignment Kit* - Zygo P/N 6191-0417-01, contains the Alignment Card, Alignment Mask, Alignment Target, Alignment Mirror, and the Plane Parallel Mirror in a convenient storage box.

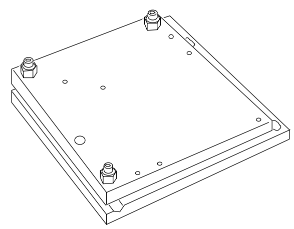
Zygo also offers mounts that facilitate optical alignment.



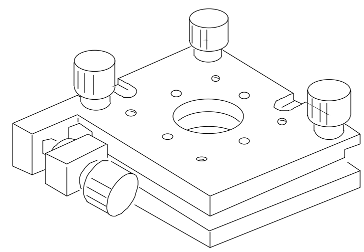
Mirror & Beamsplitter Mount
P/N 6191-0445-01



Interferometer Mount
P/N 6191-0446-01



Compact Interferometer Mounts
P/N 8050-0100-01 and P/N 8050-0101-01



Precision Adjustable Mount
P/N 6191-0310-XX

- *Mirror & Beamsplitter Mount* - Zygo P/N 6191-0445-01. This mount provides fine positioning adjustments in two axes for all optics housed in 1-inch square cells. These optics include nonpolarizing Beamsplitters, Fold Mirrors, and the Single Beam Interferometer.
- *Interferometer Mount* - Zygo P/N 6191-0446-01. This mount provides fine positioning adjustments in two axes for all optical components mounted in 1-1/2 inch square cells. These components include the Large Fold Mirror and the Polarization Beamsplitter (the center cell of all standard size interferometers).
- *Precision Adjustable Mount* - Zygo P/N 6191-0310-XX. This mount provides for fine positioning adjustments in four axes. With adapter plates it can be used with most of Zygo's optical components.
- *Compact Interferometer Mounts* - These mounts permit fine positioning adjustment of Compact Interferometers. Zygo P/N 8050-0101-01 is a small footprint mount for the Compact High Stability Plane Mirror Interferometer. Zygo P/N 8050-0100-01 is a larger mount that can be used for either the Compact High Stability Plane Mirror Interferometer or the Compact 2 Axis High Stability Plane Mirror Interferometer.

Other Equipment

Commercially available equipment may be used to facilitate optical alignment of a displacement measuring interferometry system. This equipment is not required, but may be helpful in some instances.

- *Mechanic's Level* - used for setting up and checking the level of machinery. The level should be sensitive to 10 arc minutes or less.
- *Penta Prism* - used to align the input beam at 90 degrees to the target mirror, prior to installing a right angle interferometer. A penta prism reflects a beam 90 degrees to the input beam, regardless of the angle of incidence. The prism should have a clear aperture of 10 to 15 millimeters, and should be accurate to ± 30 arc seconds or less.
- *Autocollimator* - useful when comparing the alignment of multiple surfaces to a reference surface. The autocollimator is used as a visual aid in aligning flat reflecting surfaces.
- *Theodolite* - A theodolite measures angle over 360 degrees in two planes. Using triangulation, a pair of theodolites can be used to align stick mirrors perpendicular to each other.

Step-by-Step Procedures

Basic Alignment Principles

Alignment requires meticulous effort and repetition of steps. Optical alignment is best performed in a series of separate, consecutive “modular” procedures. These modular procedures are described in detail over the succeeding pages. Perform the procedures required for your particular application. The recommended modular steps are:

1. Align the *target mirror(s)* parallel and/or perpendicular to the measurement axes of the application.
2. Align the laser output *beam* perpendicular to the target mirror(s). Ensure that the beam is aligned over the full range of travel.
3. Align all Fold Mirrors and Beamsplitters beginning with the components closest to the Laser Head.
4. Align the interferometer(s), one measurement axis at a time, per the detailed procedures in this and other relevant Zygo manuals.

    Note: Many of the interferometers come with their own, separate manuals.

5. Align the Fiber Optic Pickup and verify the signal strength at the test point on the measurement board for each axis.

To achieve the maximum accuracy possible with an interferometer, the entire system must be properly aligned. Careful alignment minimizes cosine error, which occurs when measurement beams are not perpendicular to the target mirrors or the to the axis of travel.

Acceptable misalignment depends upon the application. For example, a 1 degree misalignment results in a 152 ppm (parts per million) error, a 0.1 degree misalignment results in a 1.5 ppm error, and a 1 arc minute misalignment results in a 0.04 ppm error. In easier terms, a beam misalignment of one millimeter, at a distance of one meter from the interferometer, will contribute an error of approximately 0.5 ppm (0.5 μm).

Alignment Considerations:

- Warm up the Laser Head until it has stabilized before beginning alignment. Minimum recommended warm-up time is 10 minutes.
- Locate the component mounting positions so that only minor translations and rotations will be required to bring the optical components into proper alignment.
- To facilitate alignment, use adjustable mounts for all components, as illustrated in the specification sheets included in Chapter 2 of this manual.
- Firmly secure each component.
- Ensure that sufficient power is present at each Fiber Optic Pickup. Measure the test point voltage on each measurement board, as explained in the section “Optimizing Alignment” at the end of this chapter.

Aligning Target Mirrors

The first step in aligning any optical components is to accurately align the target mirror(s) (plane mirror or retroreflector) to the measurement axes of your particular application. Careful design of your application to provide precision mounting of the target mirror can help expedite this procedure. Mechanical or electronic indicators are usually necessary for this procedure.

A retroreflector is used on a linear interferometer in an application that translates in only one direction. Multipass interferometer configurations require plane mirrors as the target. The clear aperture of the mirror is based on the translation range of the components.

Target Mirror - Mechanical Alignment

1. Position the mirrors on the stage.

⚠ **Warning!** Be careful not to scratch the coated surface of the mirror when using the indicator in the following step.

2. Carefully position the dial indicator tip on the mirror surface outside the clear aperture, or on the back surface if it is parallel to the mirrored surface.
3. Translate the stage through its full range of travel. Adjust the rotation of each mirror to minimize the deviation measured by its indicator.
4. Secure the mirror and verify alignment.

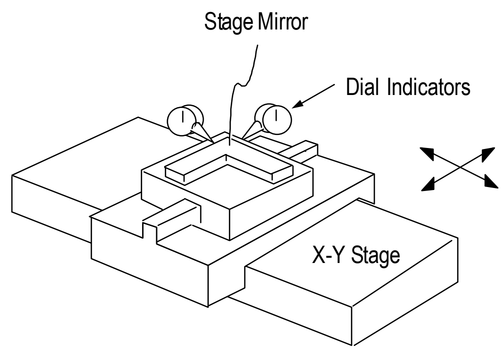


Figure 3-9 Mechanical Alignment

Target Mirror - Optical Alignment

1. Temporarily attach a paper target, with a hand drawn cross, on the mirror at the location of the laser beam.
2. Translate the stage over its full range of travel. If the beam walks off the target the mirror is not aligned to the axis of travel.
3. Adjust the mirror alignment until the beam remains on the target cross over the entire range of travel.

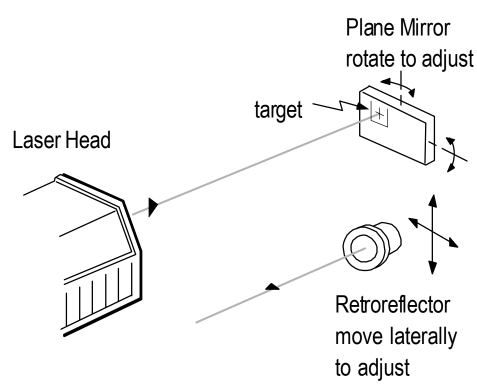


Figure 3-10 Optical Alignment

Aligning the Output Laser Beam

1. Mount the Laser Head. Turn on the Laser Head and allow it to stabilize.
2. Select the small aperture on the Laser Head. Place the Alignment Card in front of the Laser Head so the beam goes through the center of the pinhole in the card.
3. To align the output beam parallel to the reference surface:
   a. Move the Alignment Card along the reference surface. Adjust the tilt of the Laser Head so the beam goes through the center of the pinhole in the card. Ensure that the beam is centered in the Alignment Card pinhole as the card is moved along the full length of the reference surface.
   b. If necessary, adjust the height of the Laser Head so the beam is centered in the components' apertures.

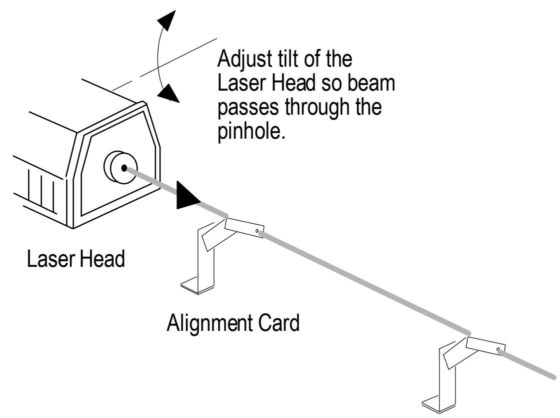


Figure 3-11 Aligning Beam to Surface

4. To align the output laser beam parallel to the axis of travel: (This step assumes that the target mirror is aligned to the axis of travel.)
   a. Adjust the horizontal rotation of the Laser Head so the beam goes through the center of the pinhole in the alignment card and reflects back from the target mirror to the center of the same hole. It should do this throughout the complete range of travel.

Note: If the output beam of the laser is designed to be perpendicular to the axis of travel, place a penta prism in the beam path to establish the 90° bend.

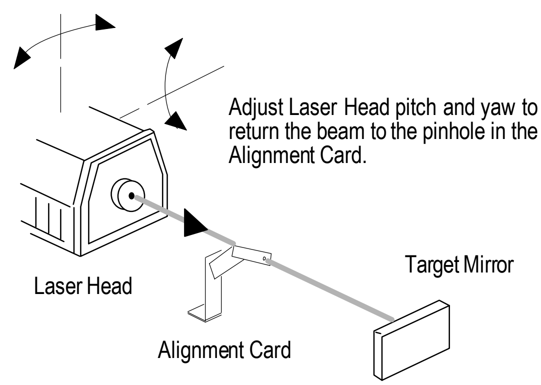


Figure 3-12 Aligning Beam to Axis

Aligning Fold Mirrors and Beamsplitters

Required Alignment Aids: Alignment Card and Plane Parallel Mirror

All Fold Mirror and Beamsplitters used in the measurement system must be aligned parallel or perpendicular to the laser beam. Precise alignment of beamsteering optics in an interferometer system requires highly stable, adjustable mounts, such as the Zygo Beamsplitter & Mirror Mount.

> **Note:** Begin the alignment with the optical component nearest to the Laser Head and work outward.

1. Turn on the Laser Head and allow it to stabilize. Select the small aperture on the Laser Head. Place the Alignment Card in front of the Laser Head so the center of the beam goes through the center of the pinhole in the card.
2. To align a *Fold Mirror:*
   a. Attach the Fold Mirror to the Mount. Position the mirror on the mount so that the reflected beam rotates about the input laser beam, and that the beam is centered in its input aperture.
   b. Place a Plane Parallel Mirror against the output face of the Fold Mirror. The mirror reflects the beam back through the Fold Mirror and toward the Laser Head. Adjust the tilt of the Fold Mirror so the beam reflects back through the center of the Alignment Card pinhole.
   c. Ensure that the reflected beam from the Fold Mirror is aligned parallel to the reference (mounting) surface. Place the alignment flag in the beam path before the mirror. Position the flag at the furthest location from the mirror in the reflected beam path. Adjust the tilt of the mirror until the reflected beam passes through the same hole in the flag.

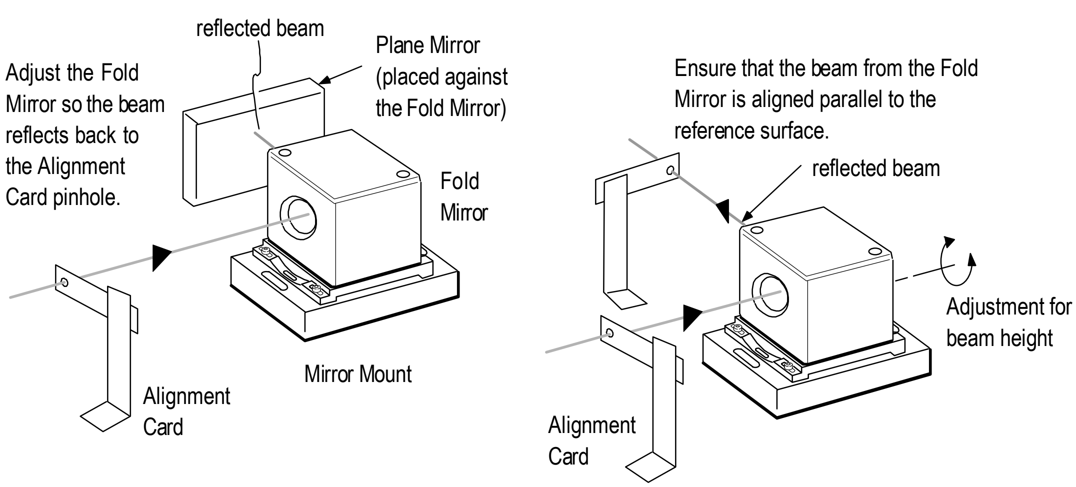


Figure 3-13 Aligning a Fold Mirror

3. To align a *Beamsplitter*:
   a. Attach the Beamsplitter to the Mount. Position the Beamsplitter on the mount so that the reflected beam rotates about the input laser beam, and that the beam is centered in its input aperture.
   b. Place a Plane Parallel Mirror against the output transmitted face of the Beamsplitter. The Alignment Mirror reflects the beam back through the Beamsplitter to the Laser Head. Adjust the tilt of the Beamsplitter so the transmitted beam reflects back to the center of the Alignment Card pinhole.
   c. Ensure that the reflected beam from the Beamsplitter is aligned parallel to the reference (mounting) surface. Place the alignment flag in the beam path before the Beamsplitter. Position the flag at the furthest location from the Beamsplitter in the reflected beam path. Adjust the tilt of the Beamsplitter until the reflected beam passes through the same hole in the flag.

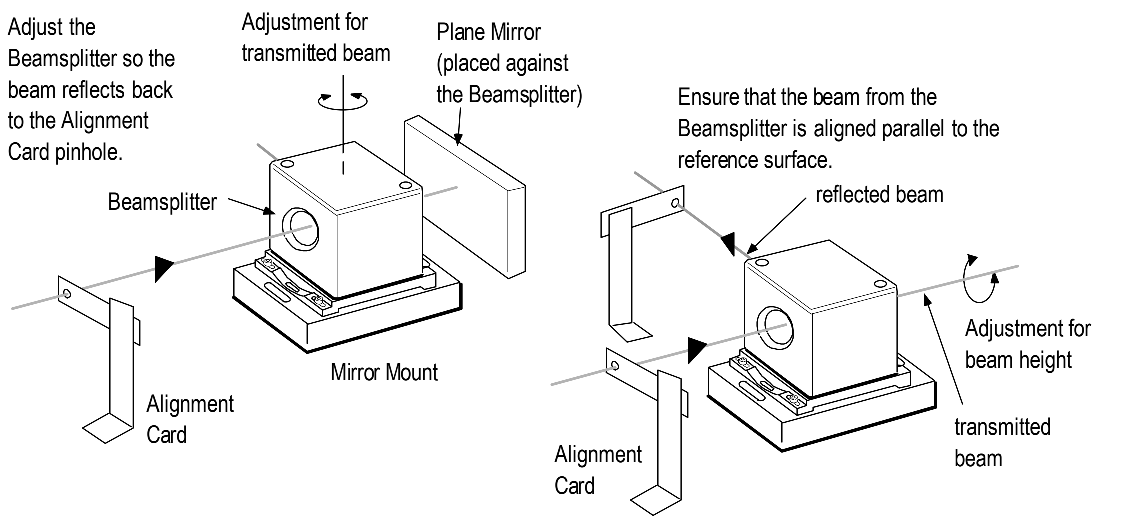


Figure 3-14 Aligning a Beamsplitter

Aligning Straight-through Interferometers

Required Alignment Aids: Alignment Card, Plane Parallel Mirror, and Alignment Mask

This is a general alignment procedure for any straight-through interferometer. Specific alignment procedures for the DPMI, Compact Interferometers, and Straightness Interferometer are included in their applicable manuals. Precise interferometer alignment requires use of a highly stable adjustable mount. Zygo offers three types of adjustable mounts for use with various interferometer designs.

1. Turn on the Laser Head and allow it to stabilize. Select the small aperture on the Laser Head. Place the Alignment Card in front of the Laser Head so the beam goes through the center of the pinhole in the card.
2. Attach the interferometer on its mount. Place the Alignment Mask on the input face of the interferometer. Adjust the position of the interferometer so that the input beam enters the interferometer through one of the holes in the Alignment Mask. Then remove the Mask.
3. Align the interferometer to the input beam:
   a. Place a Plane Parallel Mirror against the front surface of the interferometer. Adjust the tilt of the interferometer so the beam reflected from the mirror returns to the center of the Alignment Card pinhole. Then remove the mirror.
   b. Check that the beam is still centered in the interferometer's input aperture. If necessary, adjust the interferometer's position.

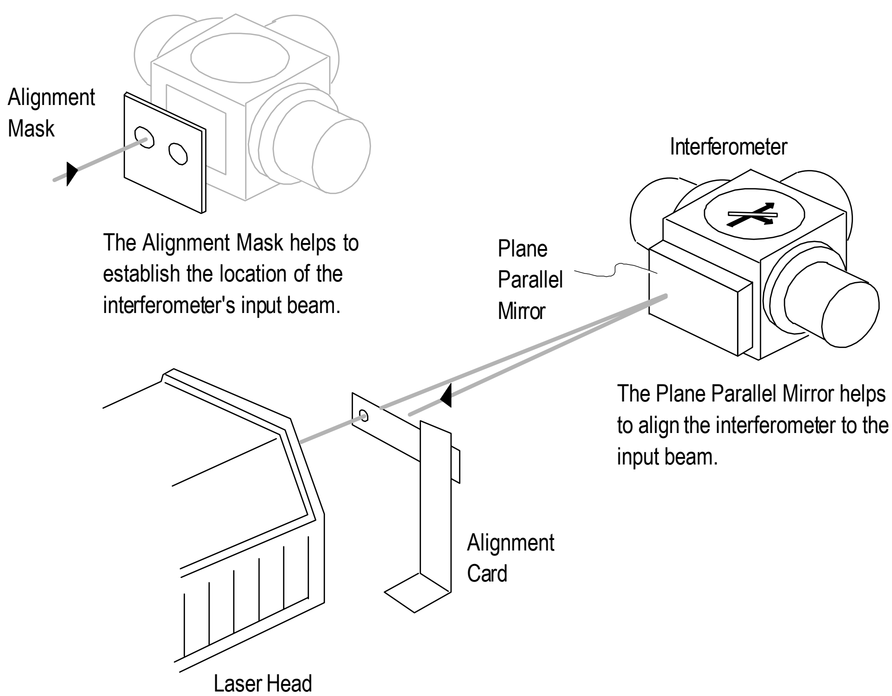


Figure 3-15 Straight-through Interferometer Alignment

4. Align the interferometer's measurement beam to the stage mirror:
   a. Place an Alignment Target (with integral quarter waveplate) in the output beam of the interferometer. The beam should reflect back from the stage mirror to the interferometer and to the Alignment Card placed in front of the Laser Head.
   b. Adjust the position of the input laser beam so that the reflected beam is centered in the Alignment Card pinhole. This may mean adjusting the position of beam directing optics and/or the Laser Head.
   c. Make sure that the input beam is centered in the interferometer's aperture; if necessary, adjust the interferometer's position.
   d. Remove the Alignment Target and view the beams on the target mirror. Two beams should be present.
5. Check the interferometer alignment:
   a. At the output beam location check for the overlap of the reference and measurement beams by blocking and unblocking the measurement beam between the interferometer and the stage mirror.
   b. Fine adjust the alignment to optimize the beam overlap.
   c. Mount and align the Fiber Optic Pickup as explained later in this chapter.

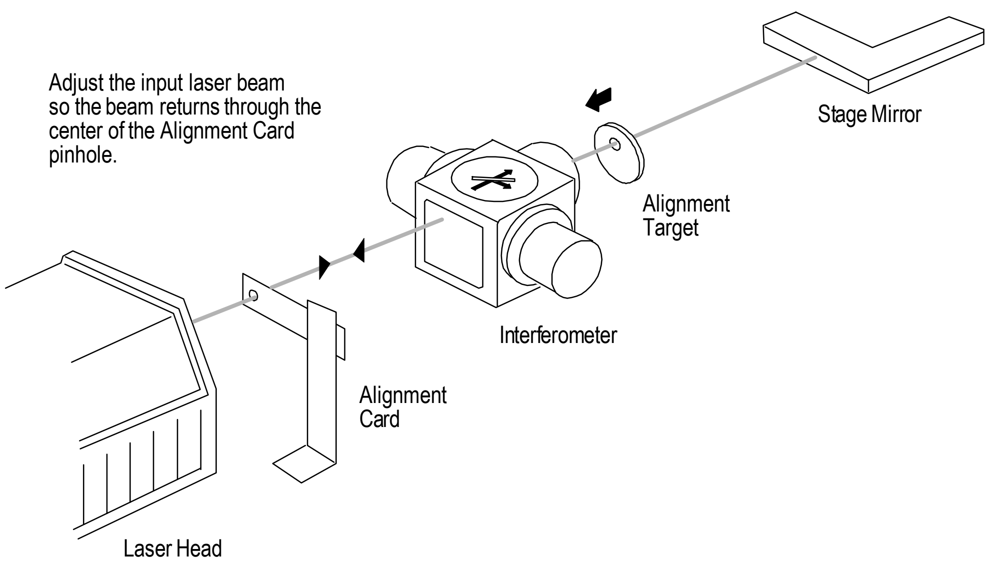


Figure 3-16 Straight-through Interferometer Measurement Beam Alignment

Aligning Right-Angle Interferometers

Required Alignment Aids: Alignment Card, Plane Parallel Mirror, Alignment Mask; Penta Prism (optional)

This is a general alignment procedure for any right-angle interferometer. Specific alignment procedures for the DPMI, Compact Interferometer, and Straightness Interferometer are included in their applicable manuals. Precise interferometer alignment requires use of a highly stable adjustable mount. Zygo offers three types of adjustable mounts for use with various interferometer designs.

1. Turn on the Laser Head and allow it to stabilize. Select the small aperture on the Laser Head. Place the Alignment Card in front of the Laser Head so the beam goes through the center of the pinhole in the card.
2. *With Penta Prism* To adjust the input beam perpendicular to the axis of travel:

   Note: If a penta prism with an accuracy of <10 arc seconds is not available, skip to the next step. (A penta prism establishes a perpendicular relationship between the input beam and the stage mirror.)

   a. Place a penta prism in the position where the interferometer will be mounted. Adjust the position of the penta prism so that the first surface reflection is centered in the Alignment Card pinhole.

   b. Adjust the input beam so the stage mirror reflection is centered in the Alignment Card pinhole.

   c. Carefully adjust the position of the penta prism until both the above conditions are met.

   d. Attach the interferometer on its mount. Place the Alignment Mask on the input face of the interferometer. Adjust the position of the interferometer so that the input beam enters the interferometer through one of the holes in the Alignment Mask. Then remove the Mask.

   e. Go to Step 4.
3. *Without Penta Prism* To adjust the interferometer perpendicular to the axis of travel:

   a. Attach the interferometer on its mount. Place the Alignment Mask on the input face of the interferometer. Adjust the position of the interferometer so that the input beam enters the interferometer through one of the holes in the Alignment Mask. Then remove the Mask.

   b. Place a Plane Parallel Mirror against the front surface of the interferometer. Adjust the interferometer's position so the beam reflected from the mirror is centered in the Alignment Card pinhole.

   c. Carefully adjust the interferometer's position until the above conditions are met.

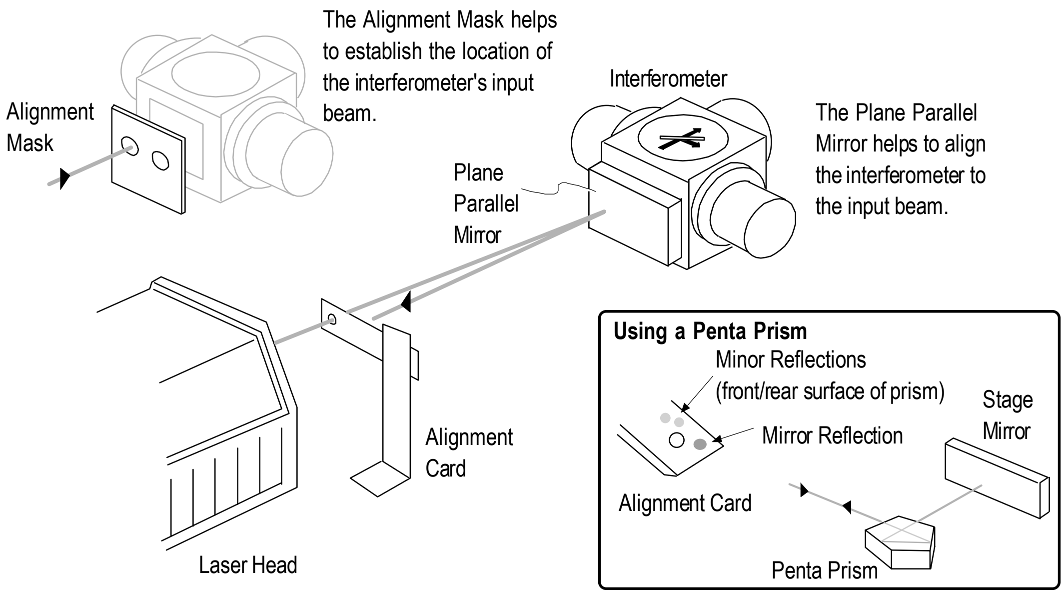


Figure 3-17 Right-angle Interferometer Alignment

4. Align the interferometer's measurement beam so that it is perpendicular to the stage mirror:
   a. Place an Alignment Target (with integral quarter waveplate) in the output beam of the interferometer. The beam should reflect back from the stage mirror to the interferometer and to the Alignment Card in front of the Laser Head.
   b. Adjust the position of the input laser beam so that the reflected beam is centered in the Alignment Card pinhole. This may mean adjusting the position of beam directing optics and/or the Laser Head.

   Note: Translate the stage and ensure that the interferometer is aligned through the full range of travel.

   c. Use the Alignment Mask to check that the beam is still centered in the interferometer's beam aperture. If necessary, adjust the interferometer's position. Then remove the mask.
5. Check the interferometer alignment:
   a. At the output beam location check for the overlap of the reference and measurement beams by blocking and unblocking the measurement beam between the interferometer and the stage mirror.
   b. Fine adjust the alignment to optimize the beam overlap.
   c. Mount and align the Fiber Optic Pickup as explained later in this chapter.

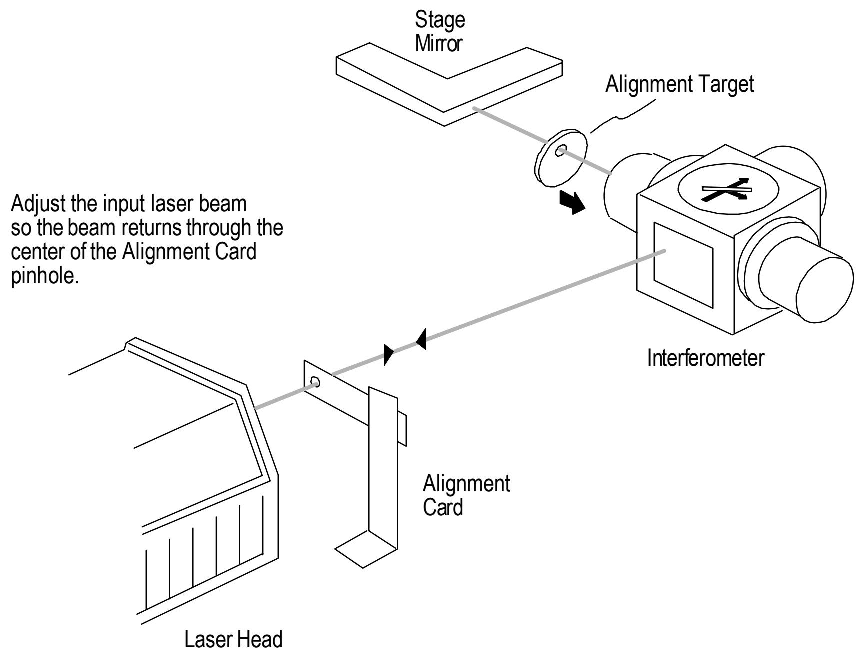
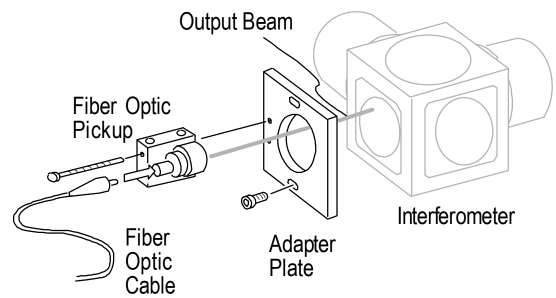


Figure 3-18 Right-angle Interferometer Measurement Beam Alignment

Aligning the Fiber Optic Pickup

Note: You must align the interferometer before aligning the Fiber Optic Pickup.

1. Attach the adapter plate to the interferometer. Leave the screws slightly loose so the plate can still be moved.
2. Mount the Fiber Optic Pickup to the adapter plate. Leave the screws slightly loose so the pickup can still be moved.
3. Translate the adapter plate until the output beam is centered in the Fiber Optic Pickup lens.
4. Remove the covers from both ends of the fiber optic cable. Attach one end of the cable to the pickup.



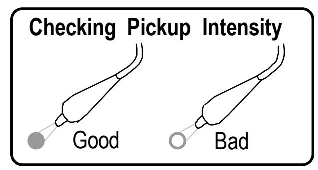


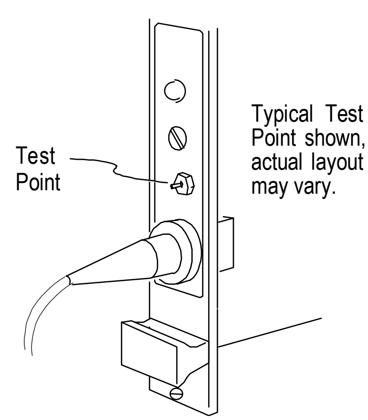
Figure 3-19 Fiber Optic Pickup Alignment

5. Direct the beam from the end of the cable onto a piece of paper and check the light intensity pattern. The pattern should be a solid white circle and not ring shaped. If the pattern is not a solid, uniform circle, readjust the position of the adapter plate.
6. Block the measurement beam path, and observe the intensity change and beam overlap. As you block the beam, the intensity should decrease by about one-half and the measurement and reference beams should have more than 80 percent overlap.
7. Secure the adapter plate to the interferometer cell and the Pickup to the adapter plate
8. Continue with “Optimizing Alignment”.

Optimizing Alignment

After the interferometer system is installed and aligned, you should optimize each axis for maximum signal. A test point located on the front of the ZMI Measurement Board provides a direct reading of the signal strength at the board’s detector.

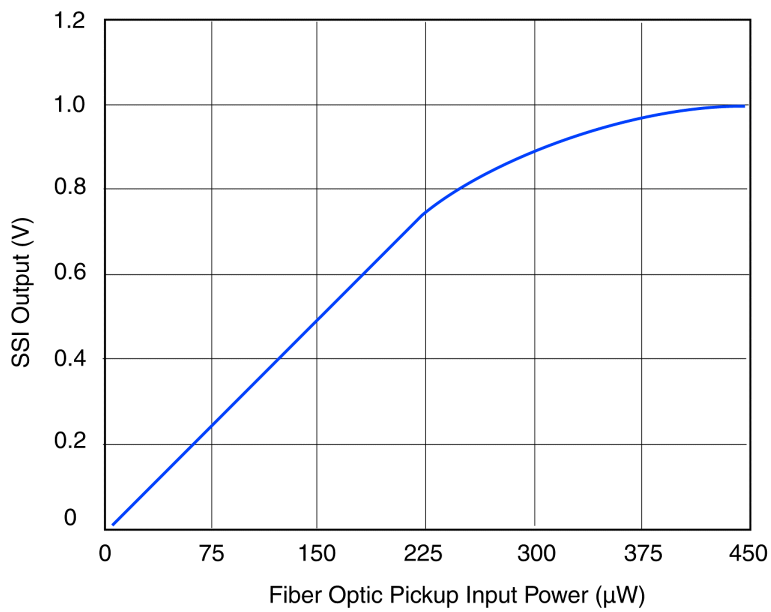
1. Ensure that the fiber optic cable is connected from the interferometer or Fiber Optic Pickup to the Measurement Board.
2. Connect the positive lead from a voltmeter to the Test Point on the Measurement Board, and connect the negative lead to ground on the VME chassis.
3. Carefully adjust the alignment of the interferometer to obtain the maximum voltage reading. Disconnect the voltmeter when complete.
4. Continue with “Measurement Board Test Point Characteristics”.



ZMI 4000 Measurement Board Test Point Characteristics

The following graph shows the fiber optic pickup input intensity and the associated test point voltage. The graph is depicts a typical transfer function characteristic; tolerance on the transfer function is 30% due to Measurement Board component tolerances. In general, the Fiber Optic Pickup position should be adjusted to maximize the front panel test point voltage.

ZMI 4004 Measurement Board Output Voltage verses Input Power



Determining if There is Sufficient Optical Signal

To ensure that there is enough optical signal to satisfy the ZMI 4004 Measurement Board, for the life of the Laser Head, use the following formula:

Good Signal ≥ 20 mV * Power Factor

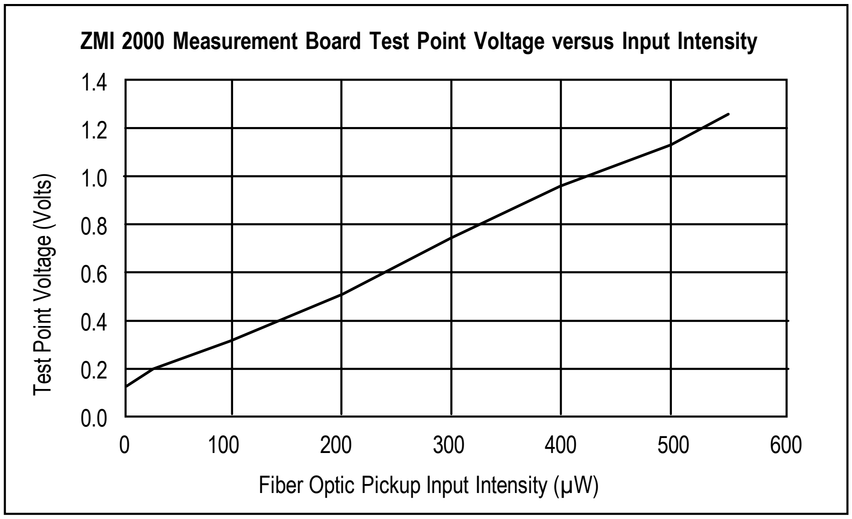
Where:

$$\text{Power Factor} = \frac{\text{Current laser head optical power}}{\text{Specified minimum laser head optical power (see table below)}}$$

Laser Head Model	Zygo P/N	Minimum Power
7702	8070-0102-01/02/03/04	400 µW
7702	8070-0102-05/06	525 µW
7712	8070-0159-0X	1350 µW

ZMI 2000 Measurement Board Test Point Characteristics

The Input Intensity refers to the intensity at the Fiber Optic Pickup. The graph shows a typical transfer function characteristic; tolerance on the transfer function is 40% due to Measurement Board component tolerances. In general, the Fiber Optic Pickup position should be adjusted to maximize the front panel test point voltage.



Determining if There is Sufficient Optical Signal

To ensure that there is enough optical signal to satisfy the ZMI 2000 Measurement Board, for the life of the Laser Head, use the following formula:

Good Signal ≥ (No signal voltage + 25 mV) (Power Factor)

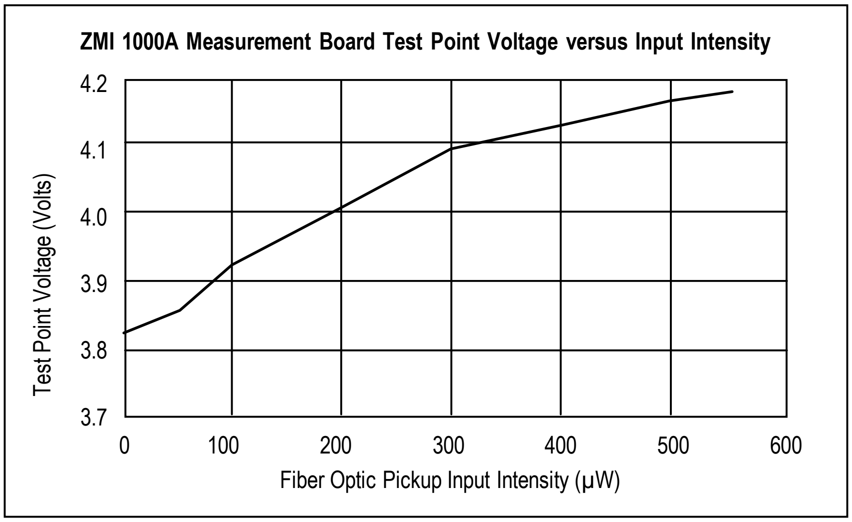
No signal voltage = Front panel test point voltage with fiber optic cable disconnected.

$$\text{Power Factor} = \frac{\text{Current laser head optical power}}{\text{Specified minimum laser head optical power (see table below)}}$$

Laser Head Model	Zygo P/N	Minimum Power
7702	8070-0102-01/02/03/04	400 μW
7702	8070-0102-05/06	525 μW
7712	8070-0159-0X	1350 μW

ZMI 1000A Measurement Board Test Point Characteristics

The Input Intensity refers to the intensity at the Fiber Optic Pickup. The graph shows a typical transfer function characteristic; tolerance on the transfer function is 25% due to Measurement Board component tolerances. To determine the exact baseline voltage, measure the test point with the incoming fiber optic cable disconnected.



ZMI 1000A Measurement Board Threshold Adjustment

The Signal OK LED should only illuminate when a sufficient signal is present at the detector. The threshold adjustment screw on the front panel of ZMI 1000A Measurement boards varies the sensitivity of the detector. This adjustment is normally set at Zygo; it should be verified on each measurement board as explained below.

1. Ensure that the Signal OK LED is illuminated.
2. Block the beam from reaching the Fiber Optic Pickup. If the Signal OK LED goes off, the threshold setting is correct. If the LED does not go off, proceed to step 3.
3. If the LED does not go off, block the measurement beam; then turn the Threshold adjustment screw clockwise until the LED goes off. Unblock the beam and confirm that the LED goes back on. (Note: The Threshold adjustment screw is turned counterclockwise for the ZMI 1000 Measurement Board.)

Programming

Chapter 4

Programming Overview

Data output from ZMI Measurement Boards is in electrical counts. To view actual dimensional measurement units, these counts must be converted, using the appropriate equation, in a software program running on the host computer. The equations used vary depending on the interferometer type and resolution, and the wavelength of the measurement beam.

Measurement Beam Wavelength

The basic measurement unit for a ZMI system is the wavelength of the measurement beam. The laser head outputs a beam with two orthogonal linear polarizations, f1 and f2. These frequency components are separated in frequency by 20 MHz. Which frequency component is in the measurement leg of the interferometer is dependent on the system configuration. Figure 4-1 shows examples of the measurement beam as f1 and f2.

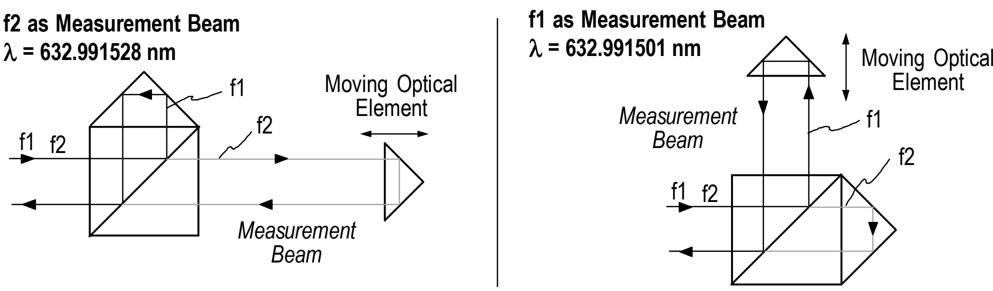


Figure 4-1 Measurement Beam Wavelength

F1 is vertically polarized with respect to the mounting plane of the laser head, has a wavelength of 632.991501 nanometers, and is 20 MHz higher in frequency than f2. F2 is horizontally polarized and has a wavelength of 632.991528 nanometers.

One way to assign the proper wavelength to the measurement beam is to trace the beam polarization in each interferometer. Another way is to observe the sign of the displacement figure read at the corresponding Measurement Board. The wavelength of the measurement beam can be determined by comparing the direction of the object's motion with the sign of the measurement, as shown in Table 4-1. For example, if the Measurement Board indicates negative numbers for the measurement when the measured object is moving away from the interferometer, then the frequency of the measurement beam is f1.

Sign of the Measurement	Direction of Motion Relative to the Interferometer: Away	Toward
Positive	F2	F1
Negative	F1	F2

Table 4-1 Determining Measurement Beam Wavelength

Equations (see Table 4-2)

Key to symbols used in the equations:

d, x, α, θ_x = displacement value

N = raw data from the Measurement Board in counts.

λ = compensated wavelength of the measurement beam in air.

λ_v = vacuum wavelength of the measurement beam.
$\lambda 1$ = 632.991501 nm $\lambda 2$ = 632.991528 nm

n = refractive index of air. [For normal conditions (20°C, 760 mm Hg, 50% humidity) the refractive index is 1.000271296. For other conditions, use look-up tables or change in refractive index of air equation.] n = 1 in a vacuum.

n_g = refractive index of the shear plate or prism, it equals 1.5151

n_o = initial refractive index of air.

P = atmospheric pressure in Torr.

T = temperature in degrees Celsius.

F = partial pressure of water vapor in the air in Torr.

h = thickness recorded on the Polarization Shear Plate (DPMI).
= retrospacing of the Compact 2 Axis High Stability Plane Mirror Interferometer.

α = angle of incidence of the beam from the laser on the Polarization Shear Plate, this angle is 48.75°.

t = length recorded on the Rhomboid prism.

θ = deviation angle recorded on the straightness prism.

L = measurement cell cavity length of the Wavelength Compensator.

Calculation	*ZMI 2000*	*ZMI 4000*
Optical path change	$OPC = \frac{Nn\lambda}{512} = \frac{N\lambda_V}{512}$	$OPC = \frac{Nn\lambda}{1024} = \frac{N\lambda_V}{1024}$
Determining wavelength in air	$\lambda = \frac{\lambda_V}{n}$	$\lambda = \frac{\lambda_V}{n}$
Linear displacement (d and λ in same units) single pass interferometer double pass interferometer four pass interferometer	 $d = \frac{N\lambda}{1024}$ $d = \frac{N\lambda}{2048}$ $d = \frac{N\lambda}{4096}$	 $d = \frac{N\lambda}{2048}$ $d = \frac{N\lambda}{4096}$ $d = \frac{N\lambda}{8192}$
Angular displacement (θ_X and α in radians) DPMI, approximate, 1 arc second accuracy Compact 2 Axis High Stability Plane Mirror Interferometer	 $\theta_x = \frac{\sqrt{1 - \left(\frac{\sin\alpha}{n_g}\right)^2}}{\sin 2\alpha} \frac{n_g \lambda}{1024h} N$ $\theta = \arctan\left(\frac{N\lambda}{2048h}\right)$	 $\theta_x = \frac{\sqrt{1 - \left(\frac{\sin\alpha}{n_g}\right)^2}}{\sin 2\alpha} \frac{n_g \lambda}{2048h} N$ $\theta = \arctan\left(\frac{N\lambda}{4096h}\right)$
Straightness of travel (x and λ in same units)	$x = \frac{N\lambda}{4096 \sin\theta}$	$x = \frac{N\lambda}{8192 \sin\theta}$
Initial Refractive Index of Air	$n_o = 1 + (3.83639 x 10^{-7} P) x \left[\frac{1 + P(0.817 - 0.0133T) x 10^{-6}}{1 + 0.003661T}\right] - 5.607943 x 10^{-6} F$	
Refractive Index of Air (relative) (λ_V and L in same units) (sign depends upon the measurement beam)	$n = n_o \pm \frac{N\lambda_V}{2048L}$	$n = n_o \pm \frac{N\lambda_V}{4096L}$

Table 4-2 Interferometer Equations

Accuracy and Installation Considerations

Chapter 5

In This Chapter

Overview

Specifying the correct configuration for a displacement measuring interferometer (DMI) requires thorough review and analysis of the system's error sources and optical power requirements. The accuracy of a laser based measuring system is dependent on many factors ranging from alignment errors to changes in the environment. Details on the error contributors and a sample error analysis are included in the first section of this chapter.

The last portion of this chapter discusses the optical power requirements of a displacement measuring interferometer system. The measurement boards require a minimum amount of optical power in each axis to achieve a detectable signal. Using optical components with optimum efficiency and target mirrors with sufficient reflectivity play an important role in meeting the optical power requirements of a DMI system.

Error Analysis

The sample error analysis, shown in Figure 5-1, displays the most common error sources in a displacement measuring interferometer. The value in each box represents an error source in nanometers due to the condition shown. Note in the error analysis that the environment and the target mirror uniformity are the biggest contributors to measurement error.

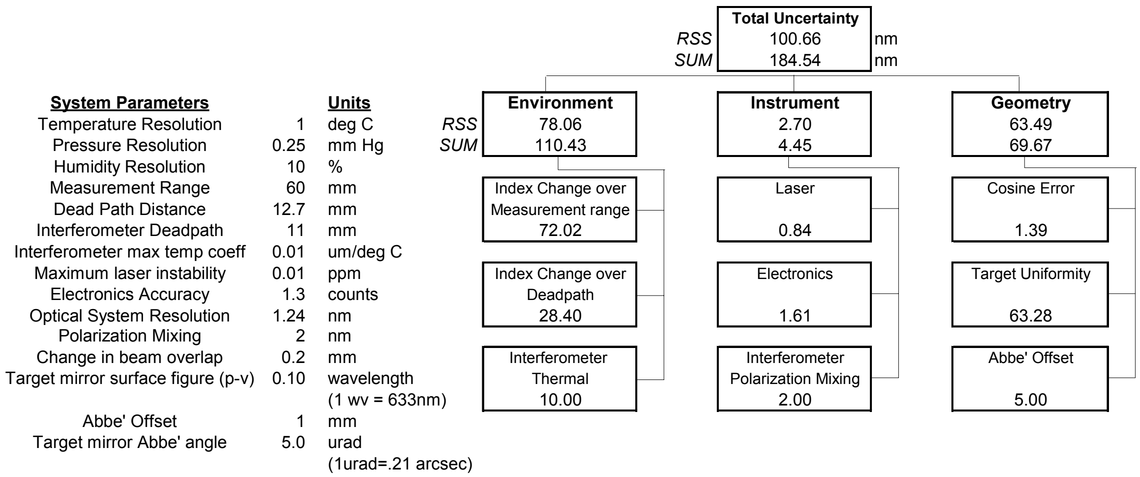


Figure 5-1 Sample Error Analysis

Environmental Errors

Index Change Over Measurement Range

Accurate knowledge of the vacuum wavelength of the laser source is a key to achieving sub-nanometer resolution with a laser based displacement interferometry system. Variations in the index of refraction of the air alter the wavelength and change the apparent length of the optical path. The index of refraction changes with deviations in the temperature, pressure, and humidity.

An error of approximately one part per million (ppm) occurs for each of the following environmental changes:

- 1° C change in the air temperature,
- 2.8 mm Hg change in the air pressure,
- 90% change in the relative humidity.

Controlling the climate and reducing the time of the measurement will minimize the environmental sources of error. Pressure, temperature and humidity sensors or a wavelength compensator can be used to correct for the environmental changes that occur over the duration of measurement.

The change in the index of refraction caused by variations in the environment can be calculated using Edlèn's equation. Variations of Edlèn's formula exist and can be used for more precise work such as incorporating the partial pressure of CO_2 into the calculation. The equations that follow include Edlèn's formula with a power series expansion for the water vapor pressure term and an alternative formulation using an exponential fit.

$$n = 1 + (3.8369 \cdot 10^{-7} \cdot P)\left[\frac{1 + P \cdot (0.817 - 0.0133 \cdot T) \cdot 10^{-6}}{1 + 0.003661 \cdot T}\right] - 5.607943 \cdot 10^{-8} \cdot f$$

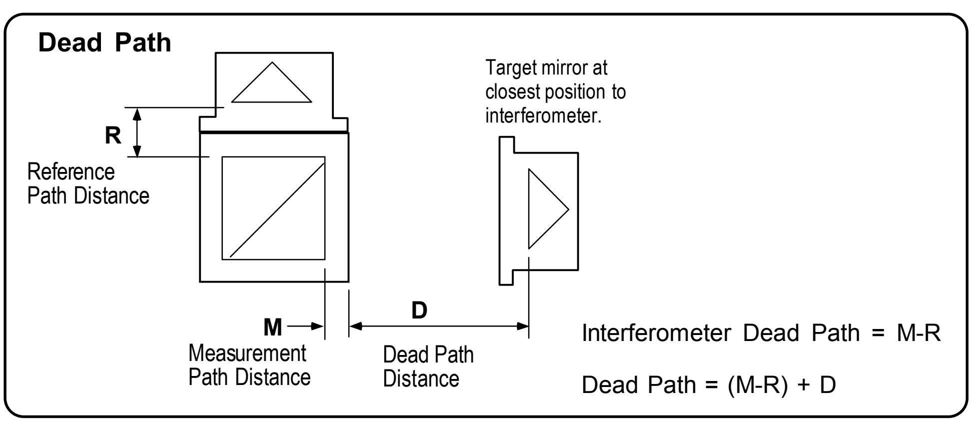
$$f = \frac{RH}{100} \cdot \left[4.07859739 + 0.44301857 \cdot T + 0.00232093 \cdot T^2 + 0.00045785 \cdot T^3\right]$$

$$n = 3.836391 \cdot P\left[\frac{1 + P \cdot (0.817 - 0.0133 \cdot T) \cdot 10^{-6}}{1 + 0.003661 \cdot T}\right] - 3.033 \cdot 10^{-3} \cdot RH \cdot e^{0.057627 \cdot T}$$

Index Change Over Dead Path

Dead path is the difference in distance in air between the reference and measurement paths of an interferometer configuration. Dead Path error is caused by a change in the environment during the measurement. To minimize the dead path distance, locate the interferometer as close to the target mirror as possible. Minimizing environmental changes during the time of the measurement also reduces the dead path error.

The interferometers have a fixed dead path represented by the difference between M and R. Where M represents the dead path in the measurement leg of the interferometer and R is the reference path distance in air. Adding the interferometer dead path to the dead path distance results in the total dead path for a measurement axis. The dead path distance is the minimum dimension between the interferometer and the closest position of the target mirror. The distance to the target mirror is measured from the cell that houses the last element in the interferometer to the reflective surface of the target.



The distances in Zygo's interferometers for calculating dead path are:

Interferometer	*M (mm)*	*R (mm)*
Linear	6.35	7.24
Plane Mirror	14.22	7.24
4-Pass Plane Mirror	14.22	13.11
High Stability Plane Mirror	14.22	13.08
Differential Plane Mirror	16.76	0
Compact HSPMI	13.70 ±1.87	0
Compact HSPMI (right-angle)	12.07 ±1.87	0
Compact 2 Axis HSPMI linear leg	10.96 ±1.82	0
Compact 2 Axis HSPMI angle leg	10.96 ±1.82	10.96 ±1.82
Compact 2 Axis HSPMI (right-angle) linear leg	11.34 ±1.82	0
Compact 2 Axis HSPMI (right-angle) angle leg	11.34 ±1.82	11.34 ±1.82

Temperature Coefficient

A uniform change in temperature will cause expansion or contraction of the interferometer components and introduce an error in the displacement measured. This error can be minimized by stabilizing the environment or choosing an interferometer with a low temperature coefficient. For example, an environment controlled to 0.1°C, results in less than a 0.001 micrometer error with the compact interferometers.

The temperature coefficients for Zygo's interferometers are:

Interferometer	*Temperature Coefficient (micrometer/degree C)*
Linear	< 0.022
Plane Mirror	< 0.306
4-Pass Plane Mirror	< 0.01
High Stability Plane Mirror	< 0.018
Differential Plane Mirror	< 0.01
Compact HSPMI	< 0.01
Compact 2 Axis HSPMI	< 0.01

Instrument Errors

Laser Wavelength Stability

The basis of a displacement measuring interferometry system is the wavelength of the laser source. Stability circuitry within the laser head is designed to control the output frequency of the laser tube at a fixed value. Refer to the laser head specification sheet in the appropriate Zygo manual to determine the laser's contribution to the system error analysis.

Electronics Uncertainty

The ZMI 1000 and ZMI 1000A Measurement Boards have a maximum electronic error of 1.3 counts. The ZMI 2000 Measurement Boards have a maximum electronic uncertainty of 1.2 counts.

The contribution of the electronic uncertainty to the error analysis is a product of the electronic accuracy and the optical resolution of the interferometer. For example; the 4-Pass Plane Mirror Interferometer has an optical resolution of 0.62 nm, therefore; the electronic uncertainty using a ZMI 1000 Measurement Board is 1.3 x 0.62 nm = 0.81 nm.

Interferometer Polarization Mixing

Imperfections in optical components and their coatings cause leakage of the unwanted polarization state. Polarization mixing is a noncumulative cyclic error with a period of 360 degrees; it occurs every 158 nanometers of displacement for a double pass interferometer. Polarization errors can not be eliminated but they can be minimized by optimizing the angular relation between the mounting plane of the laser head and the interferometer. As a result of the tight specifications Zygo places on the quality of its optics and coatings, the polarization mixing errors induced by the interferometer are minimal.

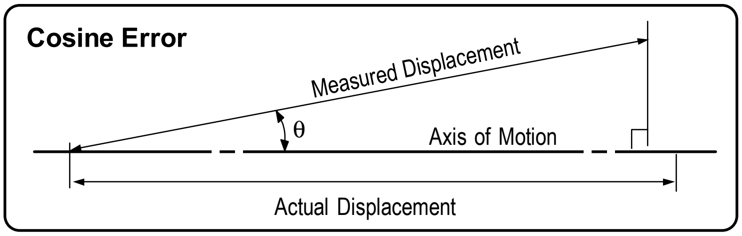
The maximum polarization mixing error in Zygo's interferometers are:

Interferometer	*Maximum*
Linear	± 0.8 nm
Plane Mirror	± 1.0 nm
4-Pass Plane Mirror	± 1.0 nm
High Stability Plane Mirror	± 1.0 nm
Differential Plane Mirror	± 2.0 nm
Compact HSPMI	± 2.0 nm
Compact 2 Axis HSPMI	± 2.0 nm

Geometry Errors

Cosine Error

This error results from an angular misalignment between the measurement laser beam and the axis of motion. Besides degrading the AC signal, a cosine error will cause the interferometer to measure a displacement shorter than the actual distance traveled.



The measured displacement (M) is related to the actual displacement (L) by: $M = L\cos\theta$

The difference between the measured and actual displacement represents the cosine error. Cosine error may be calculated using the relationship; where θ is the angular misalignment:

$$\Delta = 1 - \cos\theta$$

The change in overlap between the measurement and reference beams over the range of travel can be used to estimate the angular misalignment. For a two-pass interferometer twice the measurement range must be used to calculate θ.

For example, using a plane mirror interferometer (double pass) with a measurement range of 60 mm and a beam overlap deviation of 0.2 mm the angular misalignment can be calculated as follows:

$$\tan 2\theta = \frac{0.2}{120}$$

Target Uniformity

This error source is dependent on the uniformity of the clear aperture of the target mirror. Surface figure variations will appear to be changes in displacement as the measurement beam is reflected off different portions of a distorted mirror. A mirror with a λ/10 surface figure specification can contribute 63 nanometers of error. Mirror irregularities can be compensated by mapping the change in figure over the range of measurement.

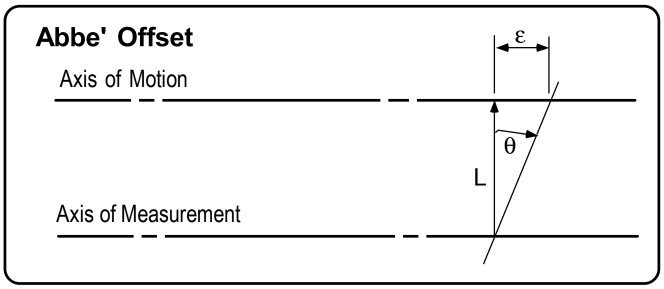
Mirror distortion is routinely caused by the improper mounting of a mirror. Target mirror surface figure should be characterized following the integration of the mirror in its mount. Zygo can supply the custom optic or mounted mirror assembly that will meet your DMI system requirements.

Abbe' Offset

Abbe' error results from an offset between the measurement laser beam and the axis of motion of the part under test.

The Abbe' error (ε) is equal to the product of the tangent of the target angle times the distance between the measurement axis and the axis of travel. Positioning the measurement beam as close as possible to the item of interest will reduce the Abbe' offset.

$$\varepsilon = L \cdot \tan\theta$$



Other Error Sources

Coefficient of Thermal Expansion

Changes in temperature can cause a material to expand or contract. The target mirror material and the components used to interface to the interferometer system should be specified based on the environmental conditions of the measurement facility. The change in length of a material with a known coefficient of thermal expansion (α) can be calculated using the following formula:

$$L_1 = L_2 [1 - \alpha \, \Delta T]$$

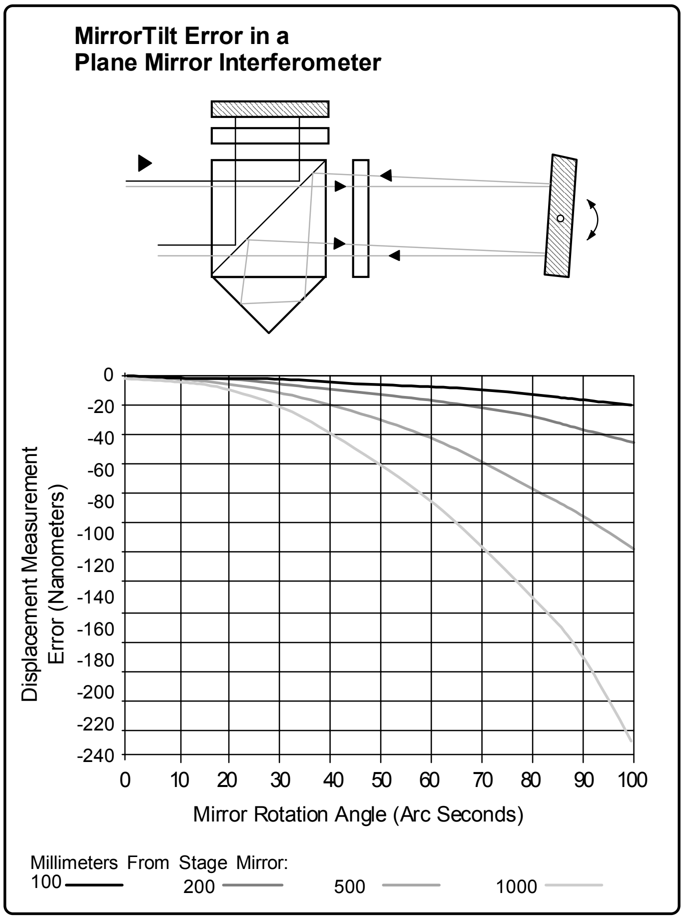
Where ΔT is the change in temperature, L_1 is the length of the material at room temperature and L_2 is the length of the material at the new temperature.

Mirror Tilt Error

Plane mirror linear displacement interferometers have an error due to rotation of the stage mirror. This mirror tilt error is directly proportional to the amount of stage mirror rotation and the distance to the stage mirror.

The angle leg of the Compact 2 Axis High Stability Plane Mirror Interferometer does not have this error because the measurement beam switches with the reference beam and the errors cancel each other out.

This effect of mirror tilt error is shown in the picture below. A typical degree of error is represented in the graph.



Optical Power

The ZMI measurement boards require a fixed amount of optical power to achieve a detectable signal. The on-board detector is fed by a fiber optic cable that interfaces with a fiber optic pick-up at the output of an interferometer.

The minimum optical power for operation of a ZMI 1000 Measurement Board is 10 microwatts (measured at the input to the fiber optic pick-up). However, in designing a ZMI 1000 based system, Zygo recommends specifying 20 microwatts of signal per axis to account for system misalignments and the potential contamination of optical surfaces.

The minimum optical power for operation of a ZMI 2000 Measurement Board is 5 microwatts of power to obtain a detectable signal. However, in designing a ZMI 2000 based system, Zygo recommends 10 microwatts of optical power per axis.

To determine the signal loss in any measurement system, each optical component has been assigned a minimum optical efficiency. The optical efficiency of a given measurement axis is the product of the efficiencies of the optics in the beam path. The optical power at the fiber optic pickup is calculated by multiplying the laser output times the combined optical efficiency.

The basic formula for calculating the optical power is:

$$P = L \times (E_1 \times E_2 \times E_3 \ldots) \times (R/99\%)^{B/2}$$

Where P is the optical power in microwatts at the fiber optic pickup of one axis, L is the optical power output of the laser head in microwatts, and E is the minimum signal efficiency of each optical component. Since the efficiency of the Zygo interferometers is measured using a 99% reflector, a target mirror with an efficiency of less than 99% must be accommodated by using $(R/99\%)^{B/2}$. Where R is the mirror reflectivity and B is the number of reflections from the target mirror.

Some multiple axis configurations require more optical power than a single laser source can provide. Due to phase differences in the reference frequency from one laser to the next many DMI systems are limited to designing around a single source. However, Zygo offers laser head versions which have reference frequency synchronization. This allows a DMI system with demanding optical power requirements to be fed by multiple lasers operating at the exact same reference frequency.

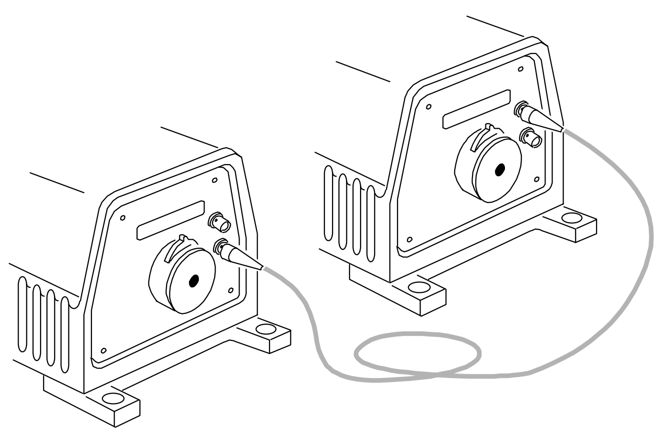


Figure 5-2 Multiple Synchronized Laser Heads

Optical Power Calculation Examples

Single Axis System Example

$P = L \times (E_1)$

$P = 425\ \mu w \times .70$

$P = 297.5\ \mu w$

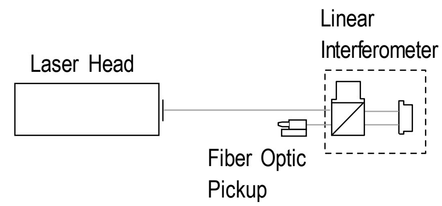


Figure 5-3 Single Axis System

Two Axis System Example

Axis 1

$P = L \times (E_1 \times E_2)$

$P = 425\ \mu w \times (.43 \times .70)$

$P = 127.9\ \mu w$

Axis 2

$P = L \times (E_1 \times E_2)$

$P = 425\ \mu w \times (.43 \times .50)$

$P = 91.4\ \mu w$

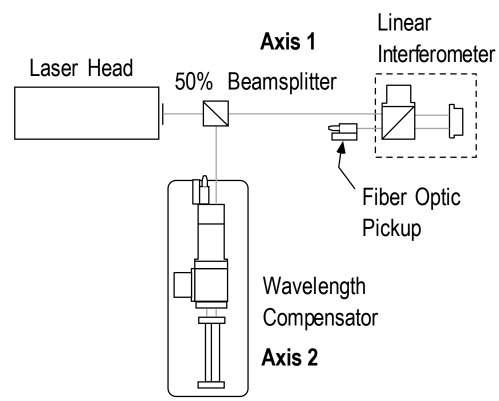


Figure 5-4 Two Axis System

Three Axis System Example

Axis 1

$P = L \times [E_1 \times E_2 \times E_3 \times (R/99\%)^{B/2}]$

$P = 425\ \mu w \times [.27 \times .97 \times .60 \times (.90/.99)^{2/2}]$

$P = 60.7\ \mu w$

Axis 2

$P = L \times [E_1 \times E_2 \times E_3 \times (R/99\%)^{B/2}]$

$P = 425\ \mu w \times [.62 \times .43 \times .60 \times (.90/.99)^{2/2}]$

$P = 61.8\ \mu w$

Axis 3

$P = L \times (E_1 \times E_2 \times E_3 \times E_4 \times E_5)$

$P = 425\ \mu w \times (.62 \times .43 \times .97 \times .97 \times .70)$

$P = 74.6\ \mu w$

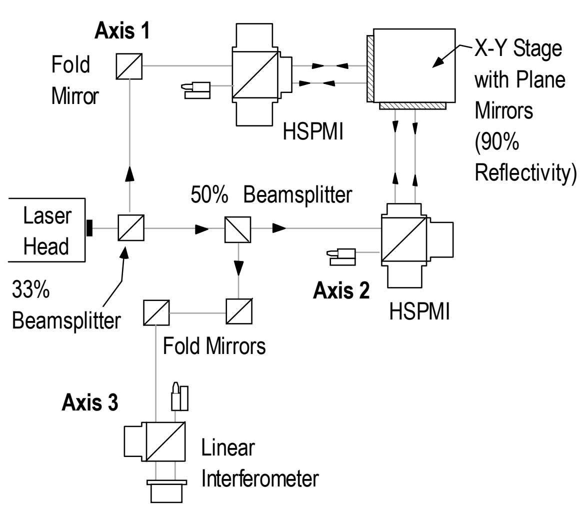


Figure 5-5 Three Axis System

Beam Shear Efficiency Calculation

An additional factor that can affect the optical power of a system is angular motion of the target mirror. When the target mirror's pitch or yaw angle changes during translation, the alignment of the measurement beam with respect to the reference beam changes. This causes a change in the beam overlap at the fiber optic pickup called beam shear. Beam shear causes a reduction in the AC signal as the region of overlap between the two beams is reduced.

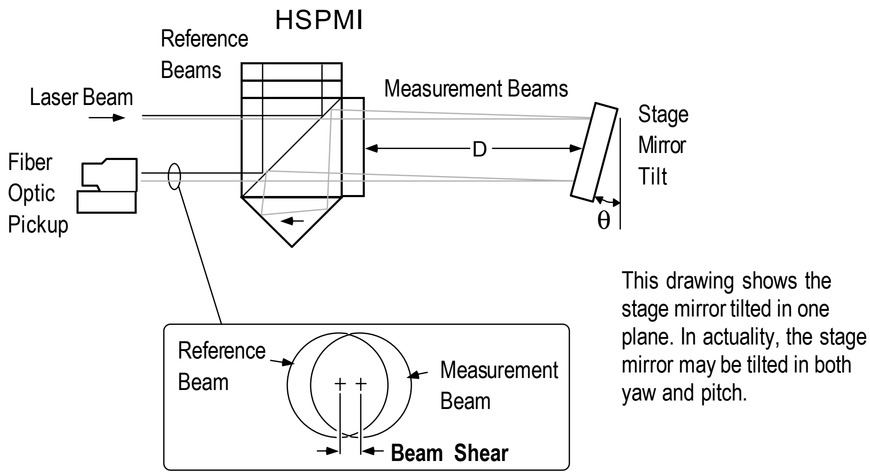


Figure 5-6 Measurement-Reference Beam Shear

The efficiency due to beam shear, E_0, must be included when calculating the optical power of a system when the target mirror tips and tilts over the translation range. Once this efficiency is known, multiply the optical power equation by E_0 to find the total power of the system.

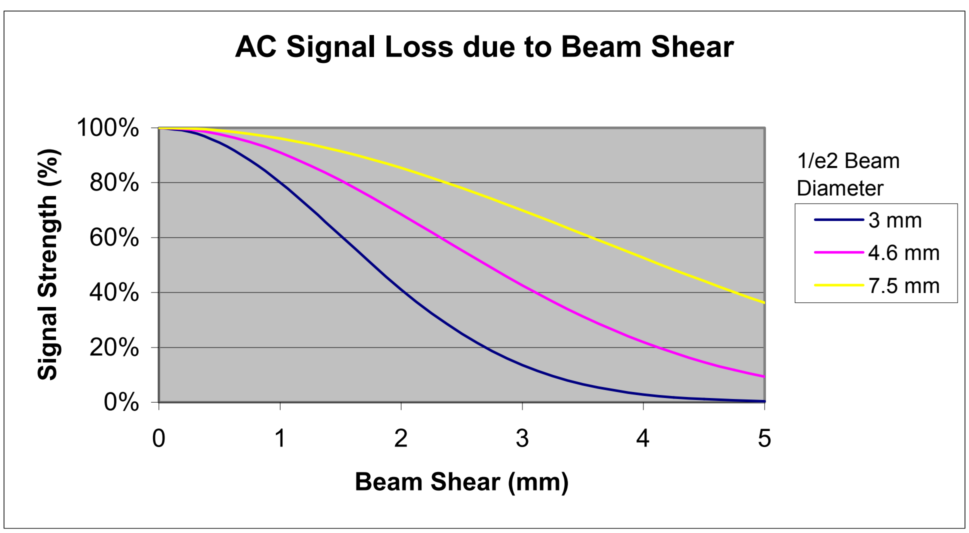
To calculate E_0, the maximum beam shear (b) must first be determined by using the following equation:

$$b = 2B \times [(D \times \tan\theta)^2 + (D \times \tan\phi)^2]^{.5}$$

Where B is the number of reflections from the target mirror, D is the dead path distance between the interferometer and the target mirror, θ is the maximum yaw of the target mirror, and ϕ is the maximum pitch of the target mirror.

Determine the efficiency (E_0), as based on the laser beam diameter and the beam offset as calculated using the previous equation. These values are also plotted in the graph.

b – Beam Offset in mm	**Efficiency (E_0) of 3 mm ($1/e^2$) Beam Diameter**	**Efficiency (E_0) of 4.6 mm ($1/e^2$) Beam Diameter**	**Efficiency (E_0) of 7.5 mm ($1/e^2$) Beam Diameter**
0.00	100.0%	100.0%	100.0%
0.25	98.6%	99.4%	99.8%
0.50	94.6%	97.7%	99.0%
0.75	88.3%	94.8%	97.8%
1.00	80.1%	91.0%	96.1%
1.25	70.7%	86.3%	94.0%
1.50	60.7%	80.8%	91.5%
1.75	50.6%	74.8%	88.6%
2.00	41.1%	68.5%	85.4%
2.25	32.5%	61.9%	81.8%
2.50	24.9%	55.3%	78.1%
2.75	18.6%	48.9%	74.1%
3.00	13.5%	42.6%	69.9%
3.25	9.6%	36.8%	65.6%
3.50	6.6%	31.3%	61.3%
3.75	4.4%	26.4%	56.9%
4.00	2.9%	21.9%	52.6%
4.25	1.8%	18.0%	48.3%
4.50	1.1%	14.6%	44.2%
4.75	0.7%	11.7%	40.1%
5.00	0.4%	9.3%	36.3%



Below is a sample calculation of the optical power measured at a fiber optic pickup when E_0 is included. Figure 5-7 shows the same system configuration as Figure 5-5. For this example we are assuming a maximum yaw (θ) of 1 arc minute, a maximum pitch (ϕ) of 0.5 arc minutes, a dead path distance (D) of 1000mm, and that this system is using a 4.6 mm ($1/e^2$) beam diameter. Beam shear (b) must be calculated first.

$$b = 2 \times 2 \times [(1000 \times \tan(1/60))^2 + (1000 \times \tan(.5/60))^2]^{.5}$$

$$b = 1.30 \text{ mm}$$

Now interpolate from previous table and chart to find the value of E_0.

$$E_0 = 85.2\%$$

Example Optical Power Calculation Which Includes Beam Shear

Axis 1

$P = L \times E_0 \times [E_1 \times E_2 \times E_3 \times (R/99\%)^{B/2}]$

$P = 425\ \mu w \times .852 \times [.27 \times .97 \times .60 \times (.90/.99)^{2/2}]$

$P = 51.7\ \mu w$

Axis 2

$P = L \times E_0 \times [E_1 \times E_2 \times E_3 \times (R/99\%)^{B/2}]$

$P = 425\ \mu w \times .852 \times [.62 \times .43 \times .60 \times (.90/.99)^{2/2}]$

$P = 52.7\ \mu w$

Axis 3

$P = L \times (E_1 \times E_2 \times E_3 \times E_4 \times E_5)$

$P = 425\ \mu w \times (.62 \times .43 \times .97 \times .97 \times .70)$

$P = 74.6\ \mu w$

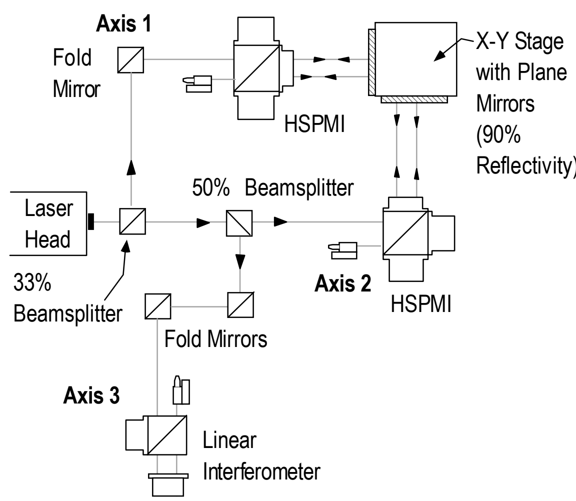


Figure 5-7 Three Axis System

Notice the difference between the values of P for Axis 1 and 2 in Figure 5-5 and the values of P for Axis 1 and 2 in Figure 5-7. Also, notice that the power in Axis 3 does not change, because a retroreflector is not affected by angular misalignments.

Optical Power Calculation for the Compact 2 Axis High Stability Plane Mirror Interferometer

The Compact 2 Axis High Stability Plane Mirror Interferometer has additional factors to consider when calculating optical power; these include unequal path length and the angular measurement range. These factors are considered in detail in the Compact Interferometer Accessory Manual, OMP-0239.

Cleaning Optics

Chapter 6

In This Chapter

General Cleaning Guidelines

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.

Handling and Cleaning Guidelines

- 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.
- Do not attempt to clean the optical surface of any component unless experience in optical cleaning techniques.

Cleaning of any precision optic risks degrading the surface. All the cleanable optic surfaces are coated. Coated optics are easily damaged by improper or unnecessary cleaning. The need for cleaning can be minimized by proper handling techniques and by keeping the environment clean.

If cleaning is required, use the materials listed in the next section and comply with the recommended cleaning procedures.

Cleaning Materials

- Polyethylene lab gloves. Wear to prevent contamination of surfaces and protect the skin against harsh chemicals.
- Dust free tissue. Use lens tissue made for cleaning optical surfaces.
- Dust free blower. Filtered dry nitrogen blown through an antistatic nozzle is recommended. Bulb type blowers and brushes must be very clean to prevent redistribution of dirt.
- Mild, neutral soap, 1% in distilled water. Several drops of green soap (available at any pharmacy) per 100 cc of distilled water is appropriate. (Or use Orvus WA Paste.)
- Spectroscopic grade isopropyl alcohol and/or acetone.
- Cotton swabs. Use only wooden or paper stem swabs; plastic stems can dissolve in acetone.

Cleaning Optical Components (see Table 6-1)

Warning!
Be careful when using isopropyl alcohol and acetone; both are flammable and toxic.

Do not reuse any cleaning tissue or pads, reusing tissues can cause contamination and damage to the optic.

Before cleaning the optic component, remove all rings and jewelry from your hands and wrists; wash your hands thoroughly to remove excess skin oils; and put on lab gloves.

Contaminant	*Procedure*
Dust or light dirt	1. Blow off loose particles. 2. If any dust remains, twist two sheets of lens tissue around a swab and dampen it with alcohol or acetone. 3. Wipe rectangular optics in a zigzag fashion, starting at one end. Wipe circular optics in a spiral fashion, starting at the lens center. 
Fingerprints, oil and water spots *Note: Clean surface immediately; skin acids attack lens coatings.*	1. Blow off loose particles. 2. Twist two sheets of lens tissue around a swab and dampen it with 1% soap solution. Wipe rectangular optics in a zigzag fashion, starting at one end. Wipe the lens in a spiral fashion, starting at the lens center.  3. Repeat step 2 with swabs dampened with distilled water. 4. Repeat step 2 with swabs dampened with alcohol or acetone.

Table 6-1 Cleaning Optical Components

Cleaning Fiber Optic Cables

Dirty or damaged fiber optic cable ends greatly reduce fiber optic efficiency.

Warning!
Protective caps should be installed when the cable is not in use.

1. Remove protective caps from both ends of fiber optic cable. If the cable is connected to an interferometer or board, disconnect the cable.
2. Wet a lint free wipe with Methanol or Isopropyl.
3. Gently wipe both cable ends.
4. Examine the end to ensure no contaminants or reside are present. Repeat steps 2 and 3 if necessary.

U

V

W

X

Y

Z

ZMI
Optical Table Accessories
OMP-0355C

Zygo Corporation
Laurel Brook Road
P.O. Box 448
Middlefield, Connecticut 06455-0448

Telephone: (860) 347-8506
Fax: (860) 346-4188
E-mail: inquire@zygo.com
Website: www.zygo.com

MANUAL REVISION INFORMATION

The document (OMP) number and latest publication date for this manual appear on the title page. Any revision letter following the document number indicates that the manual has been revised. Revision letters also appear at the bottom of each revised page.

Revision	*Publication Date*
Original	August 1995
B	July 1996
C	December 2001

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. to 8 p.m. (EST)
(860) 347-8506 Zygo Corporation

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

WRITE Zygo Corporation
Laurel Brook Road
P.O. Box 448
Middlefield, Connecticut USA 06455-0448

NOTICE: The descriptions, drawings, and specifications contained herein are subject to change. Zygo is not responsible for errors or omissions herein or for incidental damages in connection with the furnishing or use of this information. This document shall not be reproduced, photocopied, or duplicated, in whole or in part, without prior written approval of Zygo Corporation.

ZMI Optical Table Accessories

The ZMI Optical Table Accessories provide for easy mounting and alignment of ZMI system components on optical tables with 1/4 x 20 threaded holes on 1-inch centers. Typically, the accessories provide an optical axis height of 2.75 inches (69.9 millimeters).

The following accessories are available:

Accessory	*Part Number*	*See Page*
Laser Head Mounting Kit (for kinematic feet models)	6191-0519-01	*3*
Laser Head Mounting Kit (for cast feet models)	6191-0520-01	*4*
Riser Block Assembly (for 1-inch or 1½-inch cells)	6191-0521-01	*5*
Riser Block Assembly (for Compact Adjustable Mount)	6191-0521-02	*5*
Riser Block Assembly (for 1-inch cells)	6191-0521-03	*6*
Riser Block Assembly (for Precision Adjustable Mount)	6191-0521-04	*6*
Riser Block Assembly (for 1½-inch cells)	6191-0521-05	*7*
Circular Optics Mount	6191-0522-01	*7*

The Laser Head Mounting Kits retrofit the ZMI laser heads so they can be attached to an optical table. Mounting kit 6191-0519-01 is for laser heads with the kinematic mounting feet (Zygo p/n's 6191-0460-01/-02 and 8070-0102-01/-02/-05); it consists of a thermoplastic foot design that reduces stresses placed on the laser head, and applicable hardware. Mounting kit 6191-0520-01 attaches to the front feet of laser heads with the cast feet (Zygo p/n's 6191-0460-03/-04 and 8070-0102-03/-04); it consists of foot adapters, insulating washers and spherical washer sets. Both mounting kits position the laser beam 2.75 inches above the table.

Riser Block Assemblies are used with Zygo mounts to attach the various optical components to an optical table at the proper beam heights. There are riser blocks to accommodate all Zygo optical components and interferometers based on 1-inch or 1½-inch cubes or cells.

Riser Block Assembly 6191-0521-01 accepts the Zygo Mirror Mount or Interferometer Mount. The Mirror Mount and a 1-inch cell, centers the beam height in the optic aperture. The Interferometer Mount and a 1½-inch interferometer cell locates the input beam height ¼-inch below the cube's center. This configuration, referred to as "hi-low", returns the output beam ¼-inch above the cube's center.

Riser Block Assembly 6191-0521-02 accepts the Zygo Compact Interferometer Mounts and provides the 2.75-inch beam height for the compact interferometers. Riser Block Assembly 6191-0521-03 accepts the Zygo Mirror Mount and provides the 2.75-inch beam height for 1-inch optics. Riser Block Assembly 6191-0521-04 accepts the Zygo Precision Adjustable Mount and provides the 2.75-inch beam height for a variety of optics.

Riser Block Assembly 6191-0521-05 accepts the Zygo Interferometer Mount and provides the proper beam height for 1½-inch optics. This configuration can locate the input beam ¼-inch to the left or right of the interferometer's vertical center, and the output beam ¼-inch to the opposite side.

The Circular Optics Mount, 6191-0522-01, is made to attach to a 1-inch high translation stage. The mount accepts 1-inch diameter Zygo retroreflectors and target mirrors.

Laser Head Mounting Kit
for p/n's 6191-0460-01/-02 and 8070-0102-01/-02/-05

Part Number: 6191-0519-01

Description: Thermoplastic feet attach to the bottom of the Laser Head to provide for mounting the Laser Head on optical tables with 1-inch centered holes; provides 2.75 in. optical axis height. The kinematic design reduces stresses placed on the Laser Head.

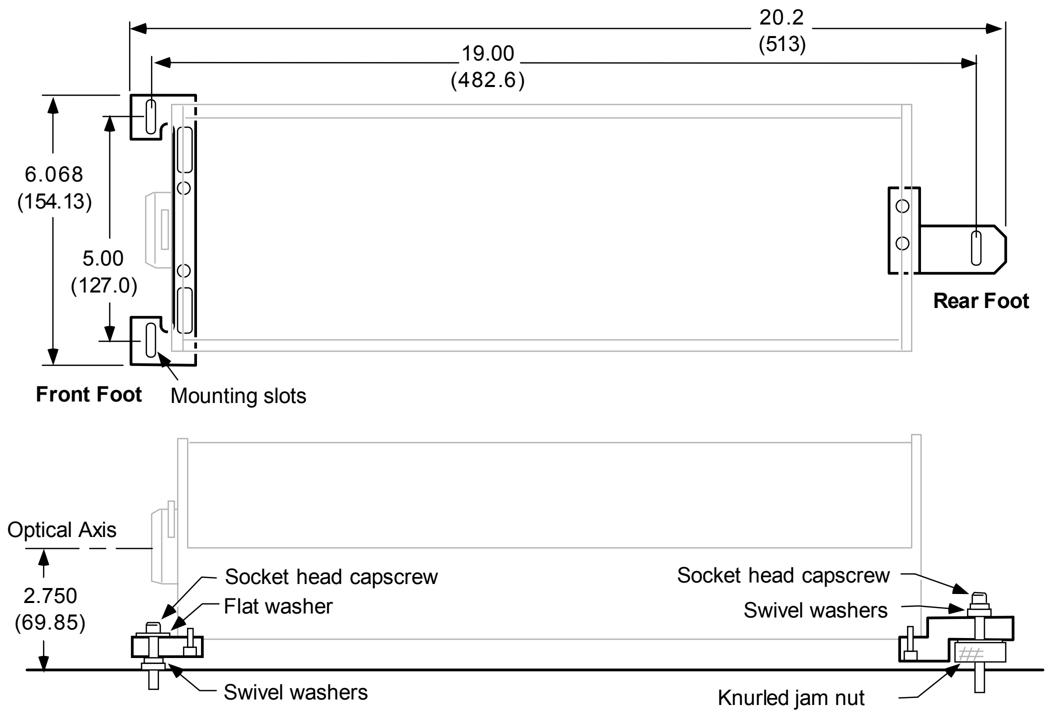
List of Components:

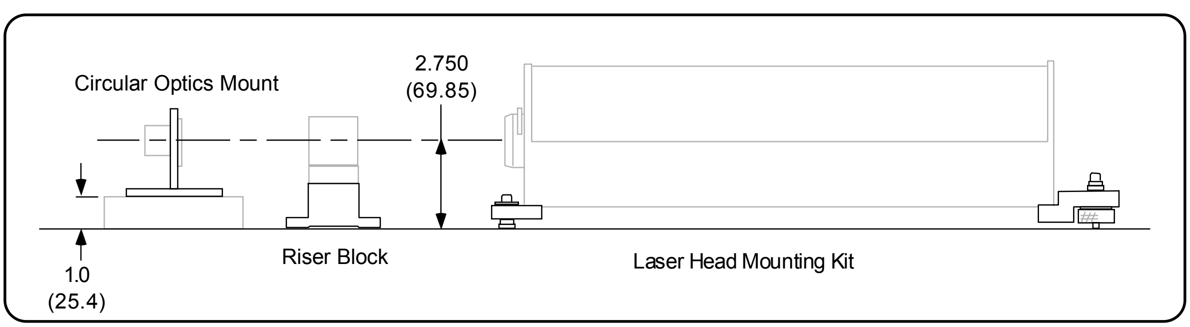
Front Foot

(1) Front Foot
(2) socket head capscrews 1/4-20 x 1.25 in.
(2 sets) swivel washers
(2) flat washers

Rear Foot

(1) Rear Foot
(1) socket head capscrew 1/4-20 x 1.75 in.
(1 set) swivel washers
(1) knurled jam nut





Dimensions shown in inches and (millimeters)

Laser Head Mounting Kit
for p/n's 6191-0460-03/-04 and 8070-0102-03/-04

Part Number: 6191-0520-01

Description: Aluminum adapters attach to the front feet of the Laser Head to provide for mounting the Laser Head on optical tables with 1-inch centered holes; provides 2.75 in. optical axis height.

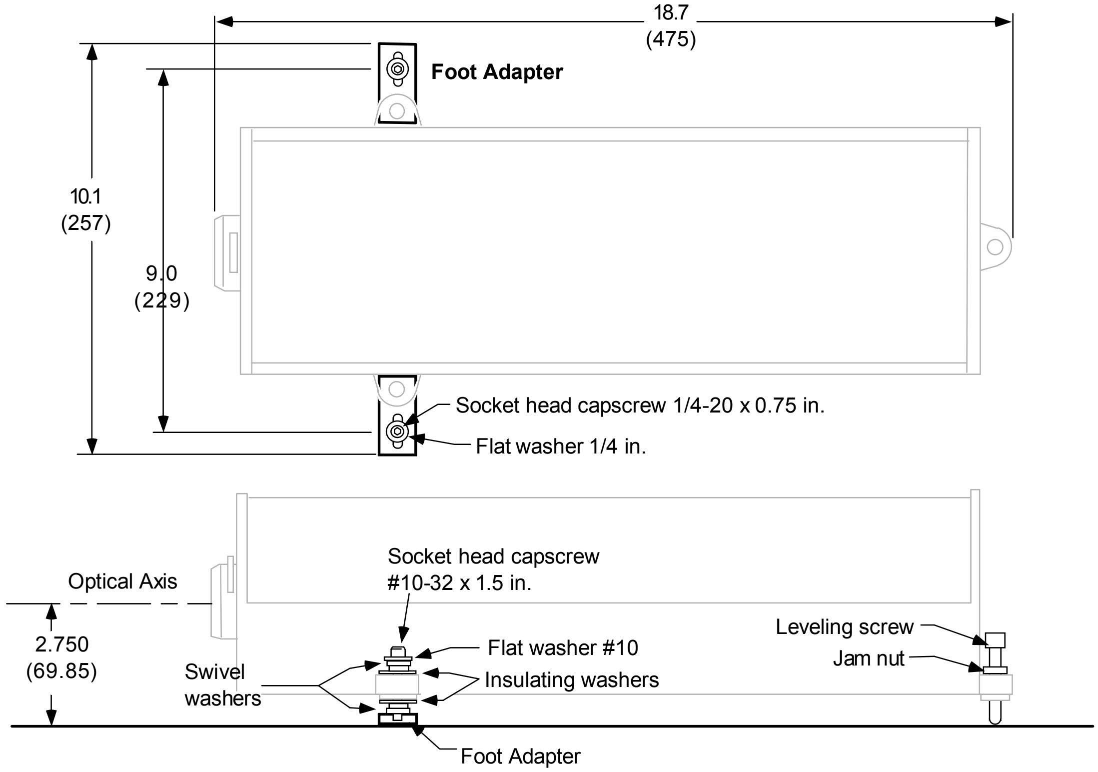
List of Components:

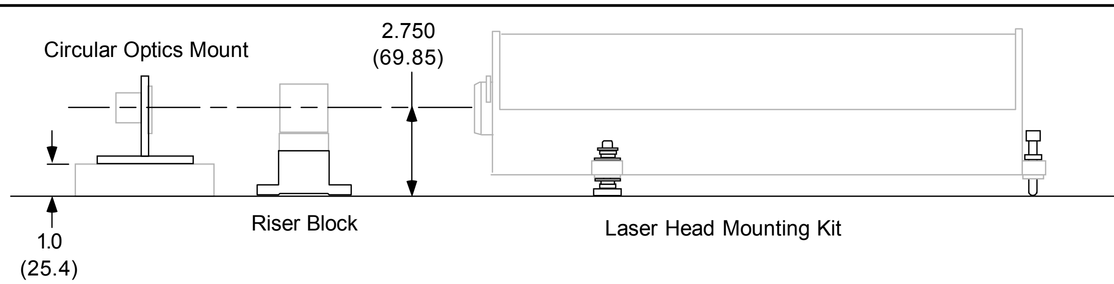
Front Feet

(2) Foot Adapters
(2) socket head capscrews #10-32 x 1.5 in.
(2) #10 flat washers
(4 sets) swivel washers
(4) insulating washers
(2) socket head capscrews 1/4-20 x 0.75 in.
(2) 1/4 in. flat washers

Rear Foot

(1) leveling screw
(1) jam nut





Dimensions shown in inches and (millimeters)

Riser Block Assembly
for 1-inch or 1-1/2 inch cells

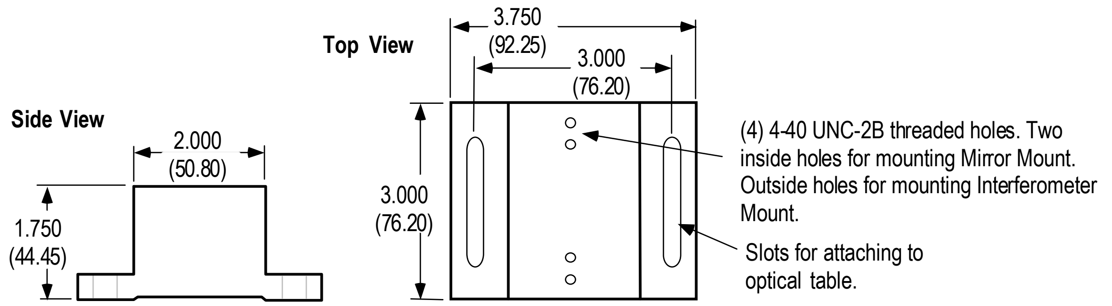
Part Number: 6191-0521-01

Dimensions: See below.

Materials: Black Anodized Aluminum

Description: Riser block for mounting 1-inch or 1½-inch optical cells at 2.75-inch optical axis height. Used with the Zygo model 7010 Mirror Mount or model 7011 Interferometer Mount. Will establish "hi-low" configuration for the 1½-inch interferometer cells.

List of Components: (1) Pedestal, (2) socket head capscrews 1/4-20 x 1 in., (2) flat washers



Dimensions shown in inches and (millimeters)

Riser Block Assembly
for Compact Interferometer Mounts

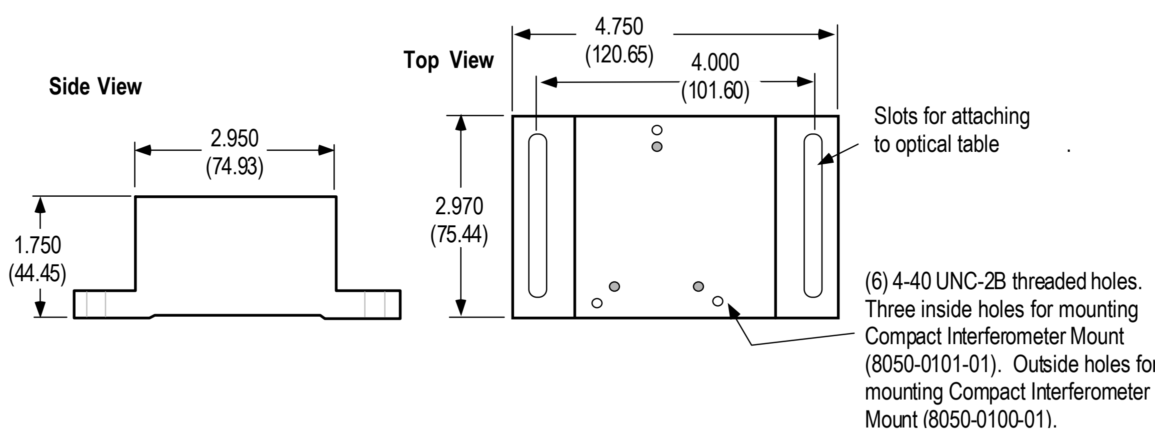
Part Number: 6191-0521-02

Dimensions: See below.

Materials: Black Anodized Aluminum

Description: Riser block for mounting Zygo Compact Interferometers at 2.75-inch optical axis height. Used with the Zygo Compact Adjustable Mounts (8050-0100-01 and 8050-0101-01) and the model 2001 or 2002 compact interferometers.

List of Components: (1) Pedestal, (3) socket head capscrews 1/4-20 x 1 in., (3) flat washers



Dimensions shown in inches and (millimeters)

Riser Block Assembly
for 1-inch cells

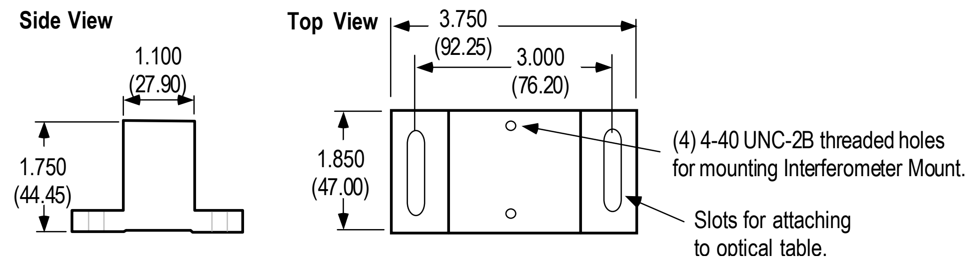
Part Number: 6191-0521-03

Dimensions: See below.

Materials: Black Anodized Aluminum

Description: Riser block for mounting Zygo optics in 1-inch square cells at 2.75 inch optical axis height. Used with the Zygo model 7010 Mirror Mount and the single beam interferometer or beam directing optics. Beam directing optics include the 1-inch fold mirrors and the 33% and 50% non-polarizing beamsplitters.

List of Components: (1) Pedestal, (2) socket head capscrews 1/4-20 x 1 in., (2) flat washers



Dimensions shown in inches and (millimeters)

Riser Block Assembly
for Precision Adjustable Mount

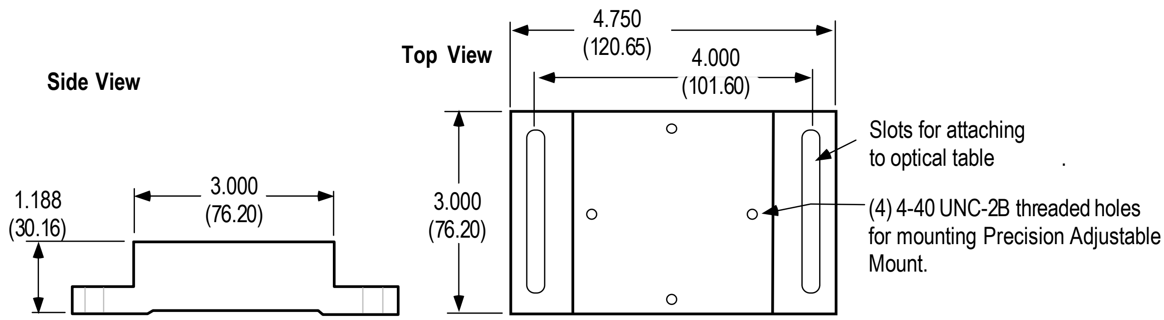
Part Number: 6191-0521-04

Dimensions: See below.

Materials: Black Anodized Aluminum

Description: Riser block for mounting optics used with Zygo Precision Adjustable Mount (6191-0310-xx) at 2.75 inch optical axis height.

List of Components: (1) Pedestal, (4) socket head capscrews 1/4-20 x 1 in., (4) flat washers



Dimensions shown in inches and (millimeters)

Riser Block Assembly
for 1-1/2 inch cells

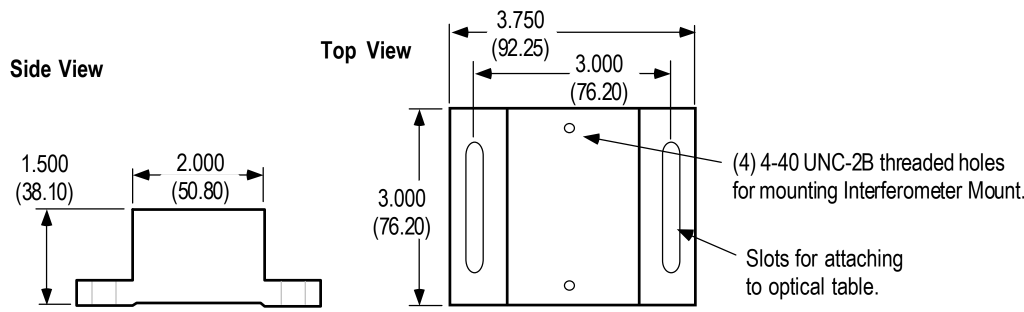
Part Number: 6191-0521-05

Dimensions: See below.

Materials: Black Anodized Aluminum

Description: Riser block for mounting Zygo optics in 1½-inch square cells at 2.75 inch optical axis height. Used with the Zygo model 7011 Interferometer Mount. Will establish a “side-side” configuration for the interferometer.

List of Components: (1) Pedestal, (2) socket head capscrews 1/4-20 x 1 in., (2) flat washers



Dimensions shown in inches and (millimeters)

Circular Optics Mount

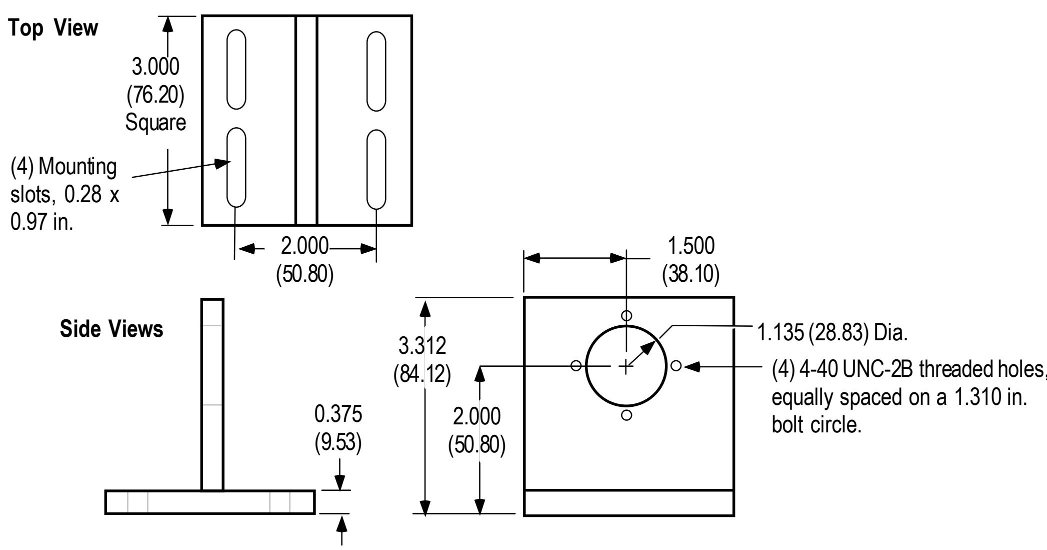
Part Number: 6191-0522-01

Dimensions: See below.

Materials: Black Anodized Aluminum

Description: Base for mounting Zygo optics housed in 1.12 inch diameter cells. When placed on a 1-inch high stage, the center of the optic is located at 2.75 inches. Accepts all Zygo optics in 1.12 inch circular cells: 7003 retroreflector, 7017 and 7018 reference mirrors and 7019 target mirror.

List of Components: (1) Mount, (4) socket head capscrews 1/4-20 x 0.5 in., (4) flat washers



Dimensions shown in inches and (millimeters)