

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



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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.

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What This Manual Covers

This manual describes the ZMI Model 7702 Laser Head¹, 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.

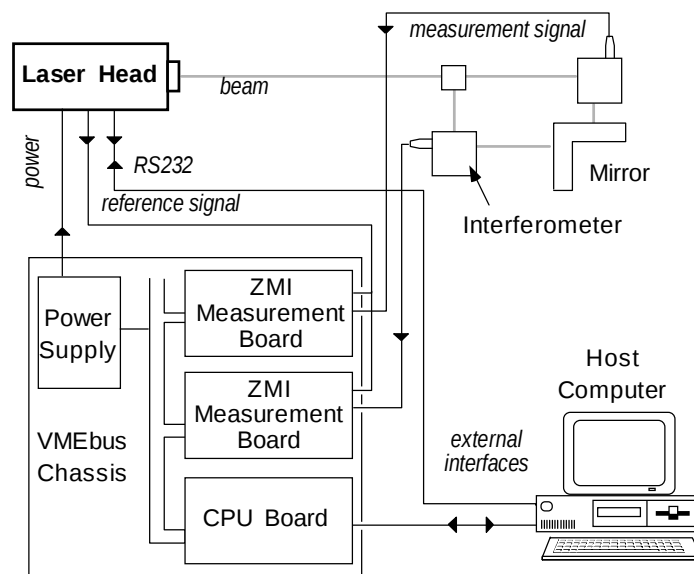


Figure 1-1 Typical Interferometer System

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.

<i>Beam Component</i>	<i>Polarization</i>	<i>Vacuum Wavelength (nominal)</i>	<i>Frequency</i>
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.

<i>Configuration</i>	<i>Beam Size (mm)</i>	<i>Mounting Pattern</i>	<i>Sync Capability</i>
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.

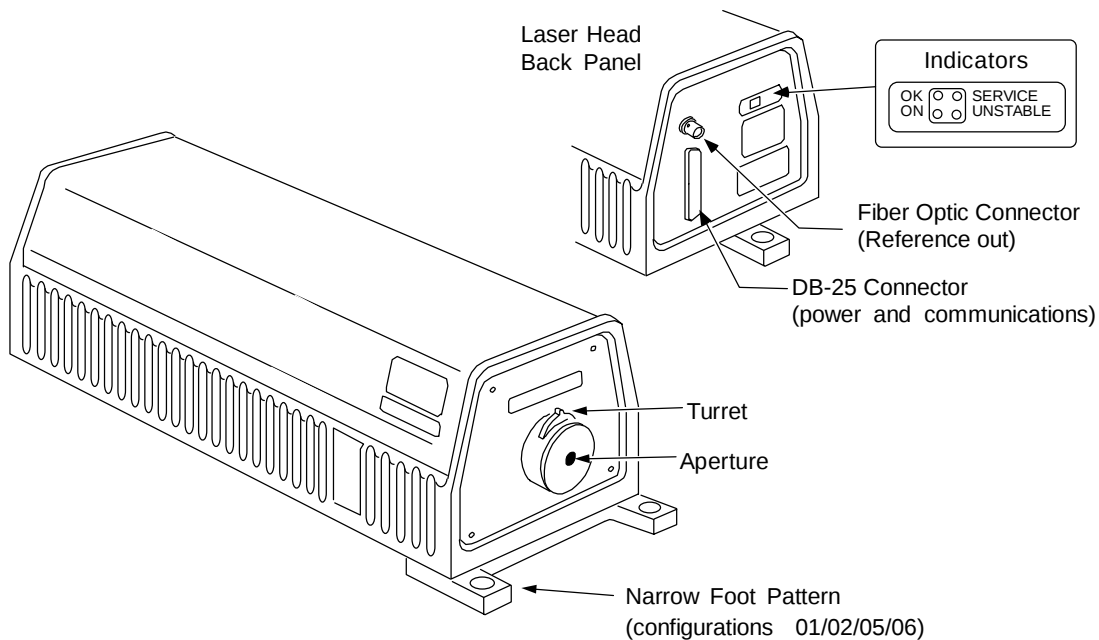


Figure 1-2 Typical ZMI Laser Head

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

<i>Indicator</i>	<i>Color</i>	<i>Function</i>
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

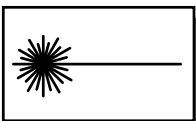
There are two optional laser head mounting kits available for the laser head to mount it on optical tables with $\frac{1}{4}$ x 20 threaded holes on 1-inch centers. These kits provide an optical axis height of 2.75 inches (69.9 millimeters).

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

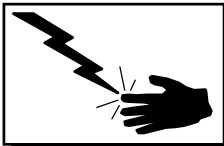
Laser Emission Control Devices

<i>Device</i>	<i>Function</i>
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

<i>Label</i>	<i>Purpose</i>
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.

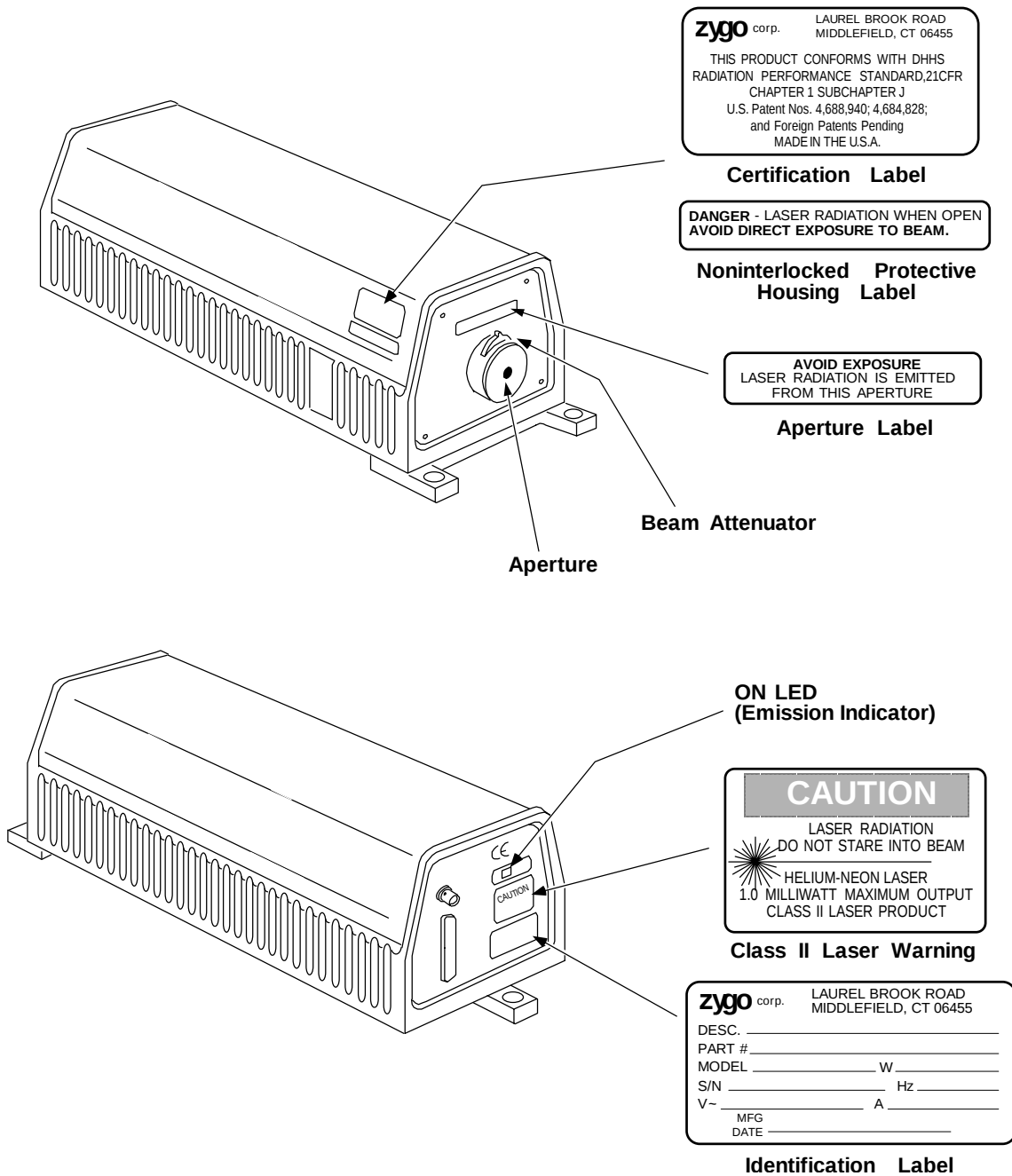


Figure 1-3 Laser Head Safety Controls and Labels

Safety Labels

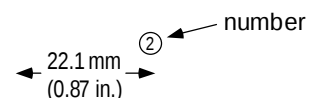
The following table describes the general meaning of safety labels found on the equipment. Specific warnings are covered in the applicable section within this manual. Failure to follow the safety labels and the recommendations in this manual could result in damage to personnel and the instrument, and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

<i>Label</i>	<i>Meaning</i>
	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:

<i>Number</i>	<i>Millimeters</i>	<i>Inches</i>
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 $\pm 0.5V$ @ 2.1 A
 - 15 VDC $\pm 0.5V$ @ 1.2 A
 Power Dissipation (max.):
 39 watts during operation
 50 watts peak during warm-up
 Wavelength Stability Time: <10 minutes

Laser Beam Characteristics:

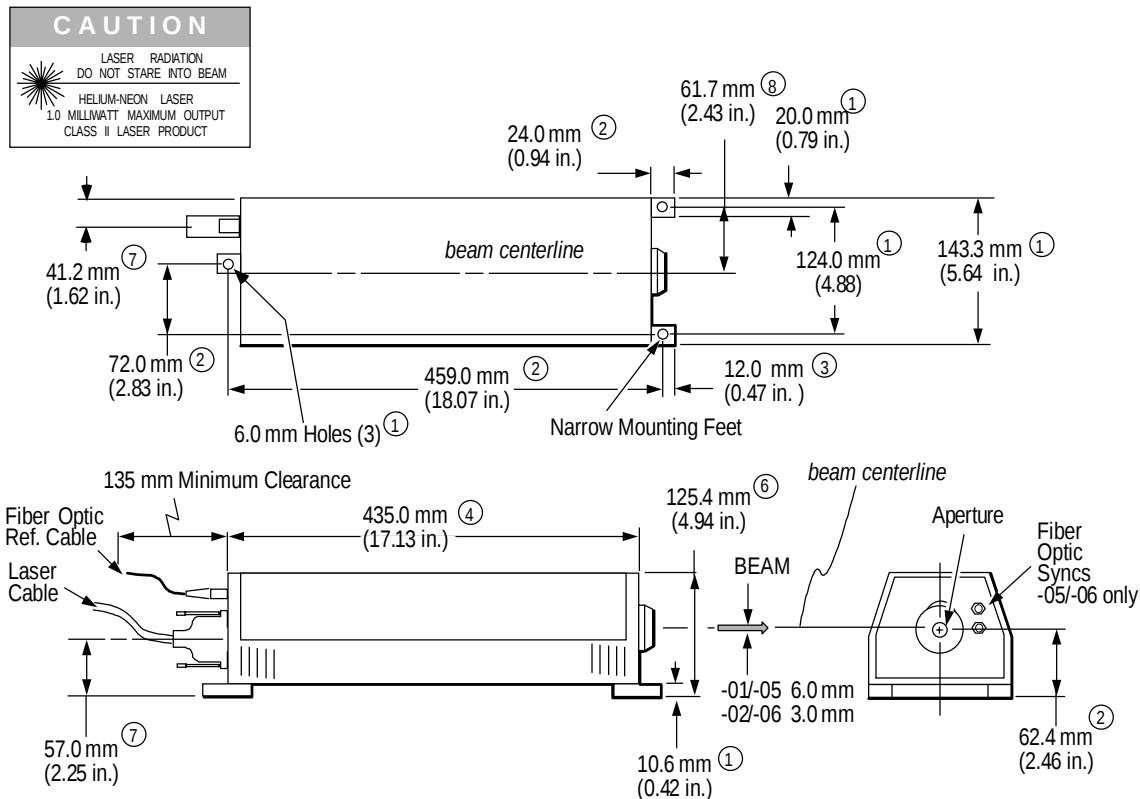
Type: Helium-Neon, Continuous Wave,
 Two-Frequency
 Maximum Beam Power Output: < 1 milliwatt
 Minimum Beam Power Output:
 >400 microwatts -01/-02/-03/-04
 >525 microwatts -05/-06
 Frequency Difference: 20 MHz ± 1600 Hz
 Maximum Power Difference Between Two
 Frequency Components: 5% of total power
 Time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

Laser Beam Characteristics (continued):

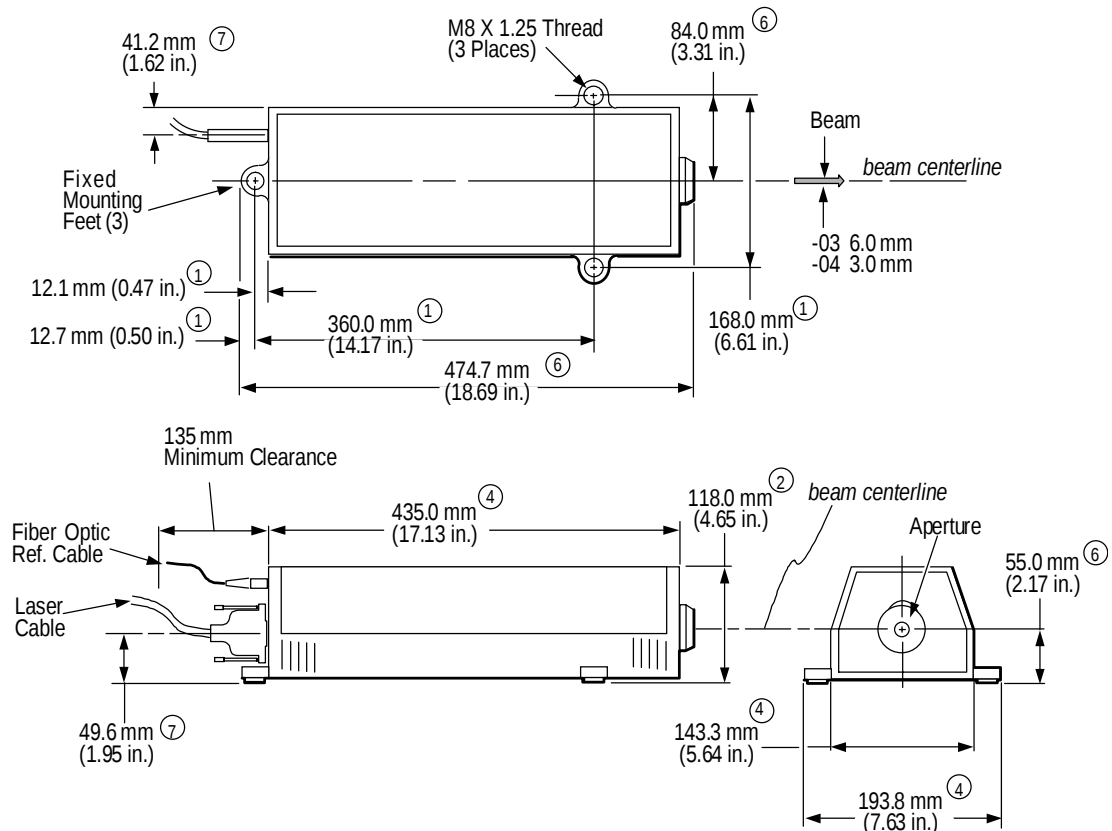
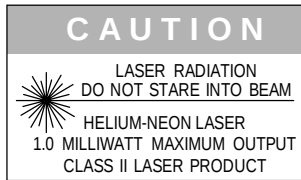
Beam Diameter:
 6 millimeters (0.24 in.) -01/-03/-05
 3 millimeters (0.12 in.) -02/-04/-06
 Usable Beam Length:
 25 meters (82 ft) -01/-03/-05
 2 meters (6.6 ft) -02/-04/-06
 Beam Pointing Stability: < 0.1 arc sec/ $^{\circ}$ C ambient
 temperature change after wavelength is stable
 Polarization Orthogonality: $90^{\circ} \pm 0.5^{\circ}$
 (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 configurations 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.

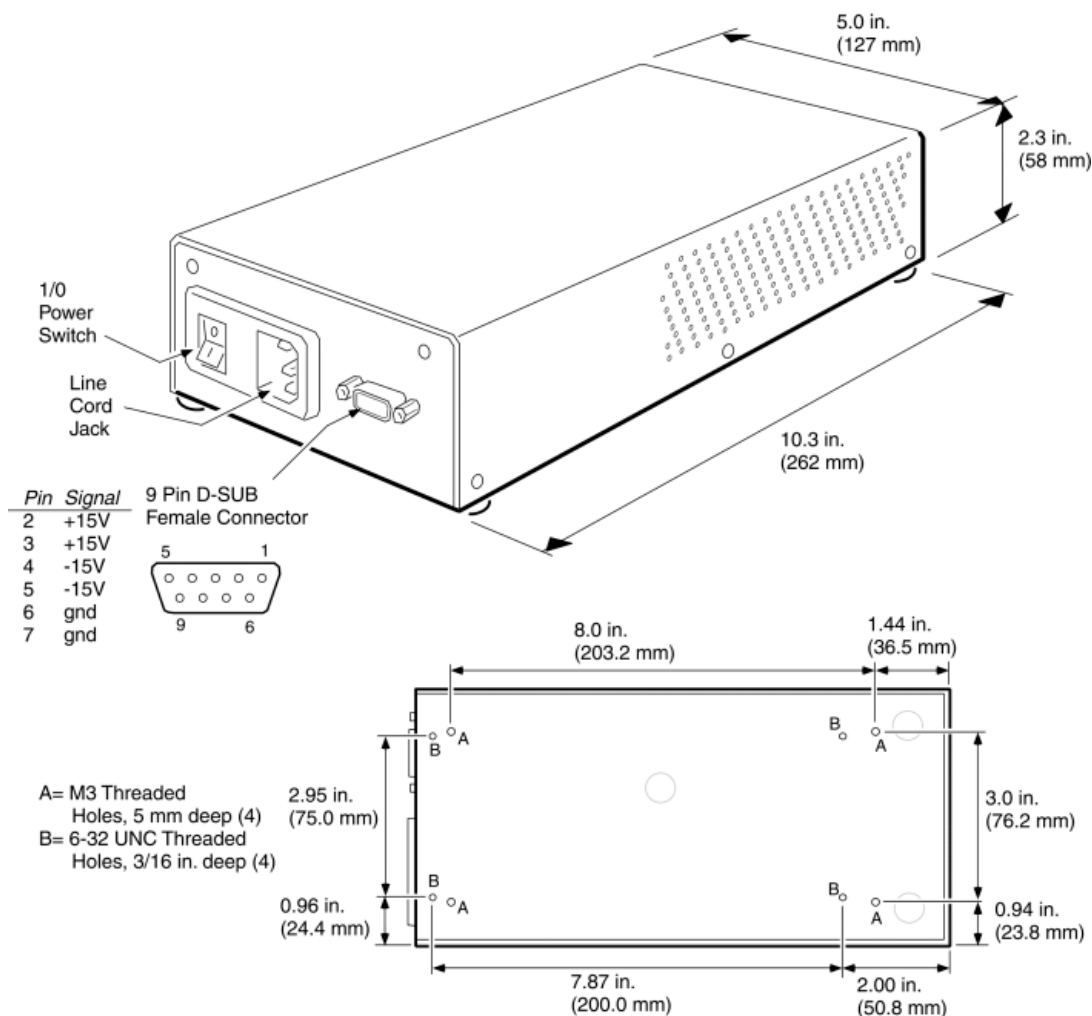
Note: Provide clearance for air flow. Do not mount near measurement axes due to heat dissipation.

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)



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.

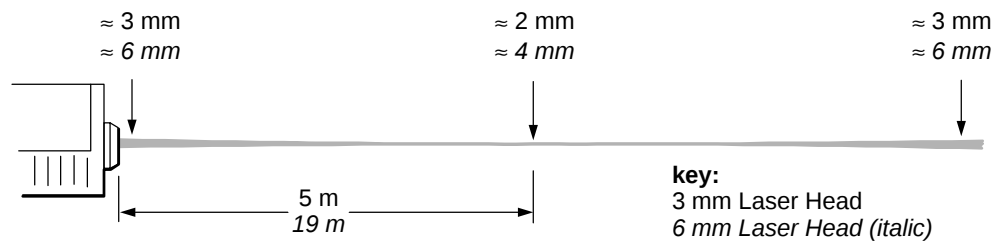


Figure 2-1 Output Beam Diameter

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).

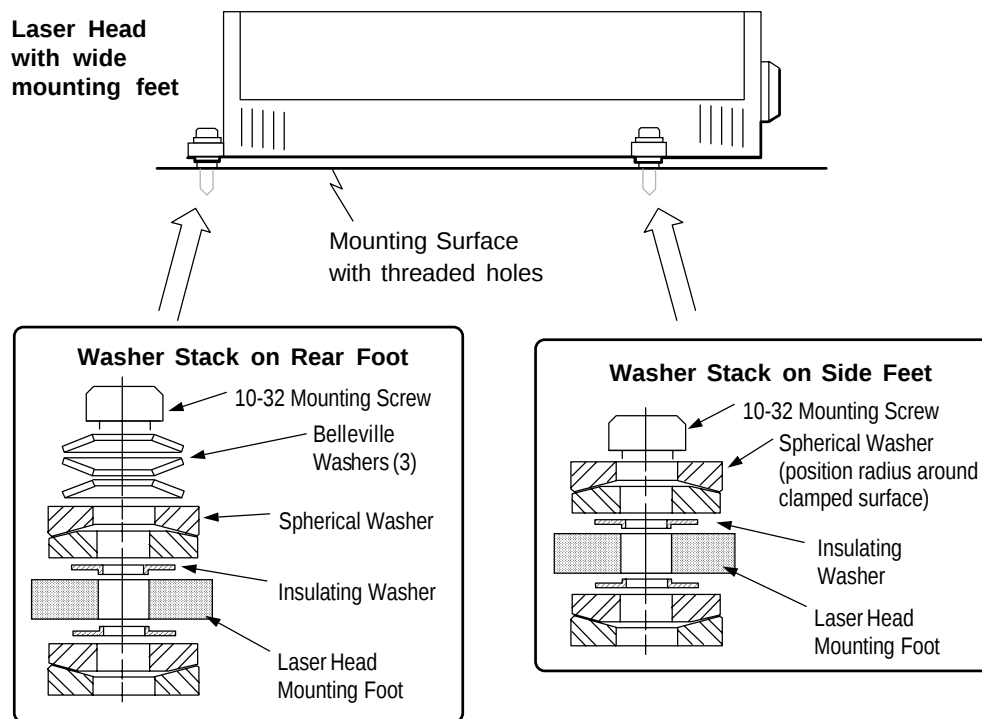


Figure 2-2 Mounting Kit Detail



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).

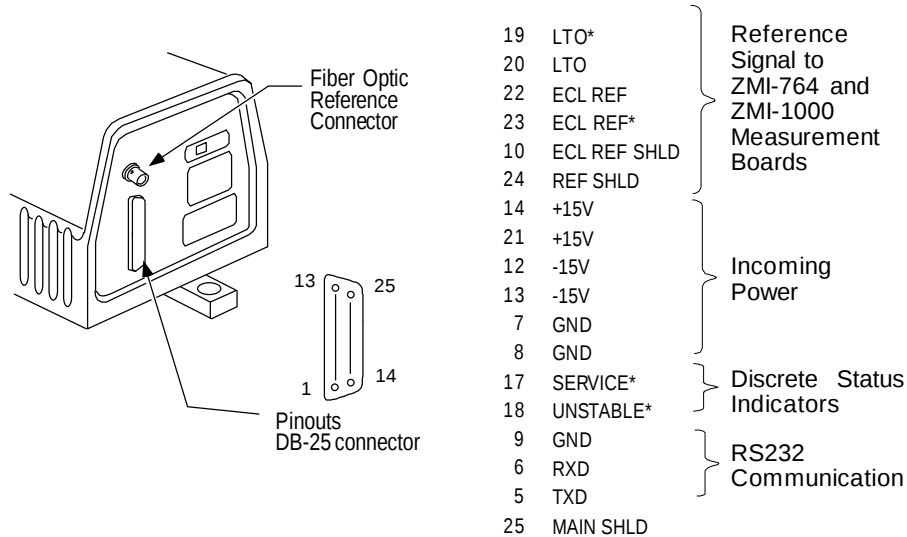


Figure 2-3 Laser Head Connector Pinout

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.

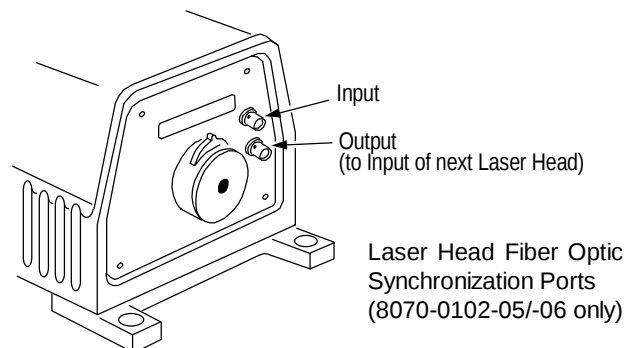


Figure 2-4 Laser Head Sync Ports

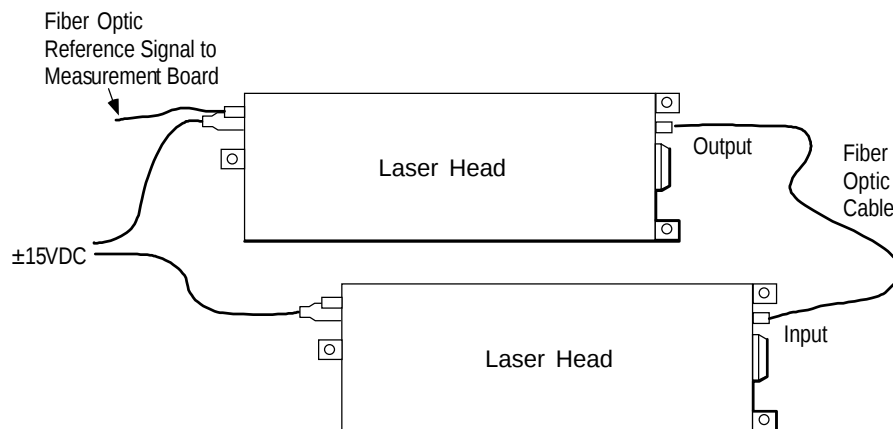


Figure 2-5 Synchronizing Multiple Laser Heads

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.

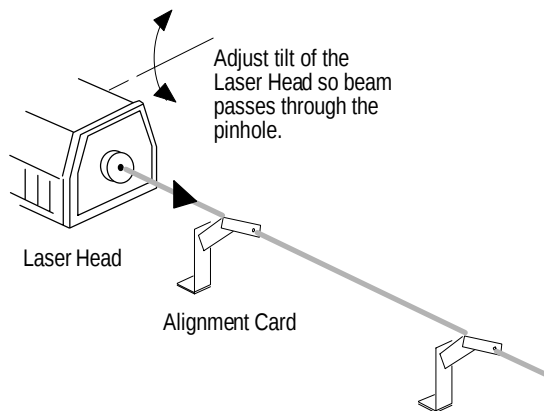


Figure 2-6 Aligning Beam to Surface

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.

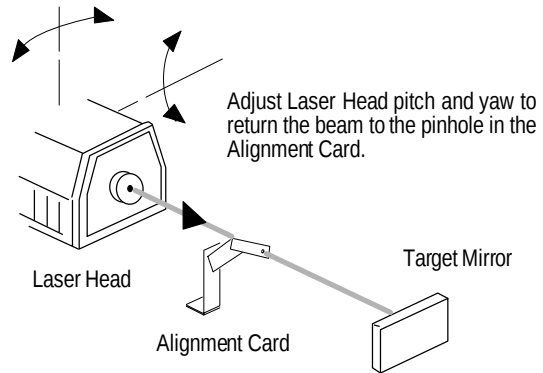


Figure 2-7 Aligning Beam to Axis

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).

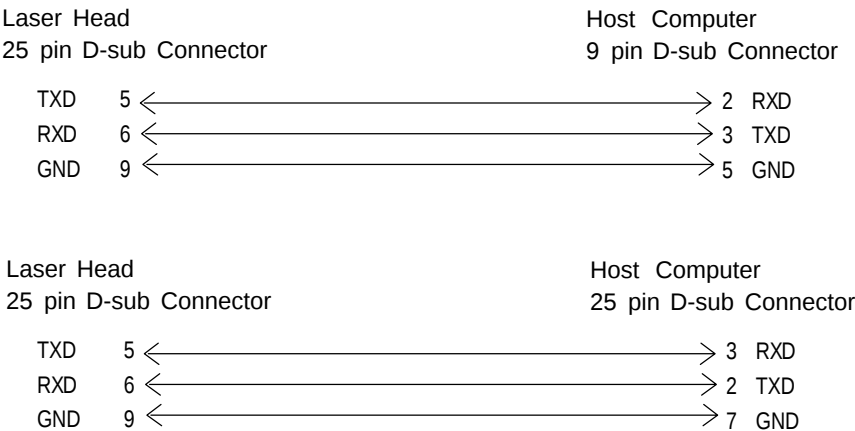


Figure 3-1 Typical RS232 Laser Head Connections

<i>Parameter</i>	<i>Value</i>
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”.

<i>Command</i>	<i>Description</i>
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.

<i>State Number</i>	<i>Description</i>
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.

<i>Error Number</i>	<i>Description</i>
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

<i>Error Number</i>	<i>Description</i>
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.

<i>Value</i>	<i>Description</i>
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 LASER HEAD