Agilent
Laser and Optics

User's Manual, Volume II

Agilent Technologies

Notices

Manual Part Number

05517-90086

Edition

Fifth edition, September 2007

Printed in USA

Agilent Technologies, Inc.
5301 Stevens Creek Boulevard
Santa Clara, California 95052-8059

Warranty

The material contained in this document is provided "as is," and is subject to being changed, without notice, in future editions. Further, to the maximum extent permitted by applicable law, Agilent disclaims all warranties, either express or implied, with regard to this manual and any information contained herein, including but not limited to the implied warranties of merchantability and fitness for a particular purpose. Agilent shall not be liable for errors or for incidental or consequential damages in connection with the furnishing, use, or performance of this document or of any information contained herein. Should Agilent and the user have a separate written agreement with warranty terms covering the material in this document that conflict with these terms, the warranty terms in the separate agreement shall control.

Technology Licenses

The hardware and/or software described in this document are furnished under a license and may be used or copied only in accordance with the terms of such license.

Restricted Rights Legend

If software is for use in the performance of a U.S. Government prime contract or subcontract, Software is delivered and licensed as "Commercial computer software" as defined in DFAR 252.227-7014 (June 1995), or as a "commercial item" as defined in FAR 2.101(a) or as "Restricted computer software" as defined in FAR 52.227-19 (June 1987) or any equivalent agency regulation or contract clause. Use, duplication or disclosure of Software is subject to Agilent Technologies' standard commercial license terms, and non-DOD Departments and Agencies of the U.S. Government will receive no greater than Restricted Rights as defined in FAR 52.227-19(c)(1-2) (June 1987). U.S. Government users will receive no greater than Limited Rights as defined in FAR 52.227-14 (June 1987) or DFAR 252.227-7015 (b)(2) (November 1995), as applicable in any technical data.

Safety Notices

CAUTION

A CAUTION notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a CAUTION notice until the indicated conditions are fully understood and met.

WARNING

A WARNING notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

User's Manual

Agilent 5517A/B/C/D/DL/FL Laser Head
Agilent 5519A/B Laser Head
Agilent 5529A Dynamic Calibrator
Agilent 10567A Dual Beam Beam-Splitter
Agilent 10700A 33% Beam Splitter
Agilent 10700B 4% Beam Splitter
Agilent 10700C 15% Beam Splitter
Agilent 10701A 50% Beam Splitter
Agilent 10702A Linear Interferometer (and 10702A-001 with Windows)
Agilent 10703A Retroreflector
Agilent 10704A Retroreflector
Agilent 10705A Single Beam Interferometer
Agilent 10705A-080 Fiber Optic Receiver Adapter
Agilent 10706A Plane Mirror Interferometer
Agilent 10706A-080 Fiber Optic Receiver Adapter
Agilent 10706B High Stability Plane Mirror Interferometer
Agilent 10707A Beam Bender
Agilent 10710B Adjustable Mount
Agilent 10711A Adjustable Mount
Agilent 10713B/C/D Cube Corner
Agilent 10715A Differential Interferometer (and 10715A-001 Turned Configuration)
Agilent 10716A High Resolution Interferometer (and 10716A-001 Turned Configuration)
Agilent 10717A Wavelength Tracker
Agilent 10719A One-axis Differential Interferometer
Agilent 10719A-C02 One-axis Differential Interferometer (low thermal drift)
Agilent 10721A Two-axis Differential Interferometer
Agilent 10721A-C01 Two-axis Differential Interferometer (low thermal drift)
Agilent 10722A Plane Mirror Converter
Agilent 10723A High Stability Adapter
Agilent 10724A Plane Mirror Reflector
Agilent 10725A 50% Beam Splitter
Agilent 10725B 4% Beam Splitter
Agilent 10725C 15% Beam Splitter
Agilent 10726A Beam Bender
Agilent 10728A Plane Mirror
Agilent 10735A Three-axis Interferometer
Agilent 10736A Three-Axis Interferometer
Agilent 10736A-001 Three-Axis Interferometer / Beam Bender
Agilent 10737L, R Compact Three-axis Interferometers
Agilent 10753B Laser Tripod
Agilent 10759A Footspacing Kit
Agilent 10766A Linear Interferometer
Agilent 10767A Linear Interferometer
Agilent 10767B Lightweight Retroreflector
Agilent 10768A Diagonal Measurement Kit
Agilent 10769A Beam Steering Mirror
Agilent 10766A Linear Interferometer
Agilent 10767A Linear Interferometer
Agilent 10767B Lightweight Retroreflector
Agilent 10770A Angular Interferometer
Agilent 10771A Angular Retroreflector
Agilent 10772A Turning Mirror
Agilent 10773A Flatness Mirror
Agilent 10774A Short Range Straightness Optics
Agilent 10776A Straightness Accessory Kit
Agilent 10777A Optical Square
Agilent 10780C Receiver
Agilent 10780F Remote Receiver
Agilent 10790A/B/C Receiver Cable
Agilent 10880A/B/C Receiver Cable
Agilent 10881A/B/C Laser Head Cable
Agilent 10882A/B/C Laser Head Cable
Agilent 10884B Power Supply
Agilent E1705A Fiber Optic Cable
Agilent E1706A Remote Sensor
Agilent E1708A Remote Dynamic Receiver
Agilent E1709A Remote High-Performance Receiver
Agilent E1705A Fiber-Optic Cable
Agilent E1706A Remote Sensor
Agilent E1708A Remote Dynamic Receiver
Agilent E1709A Remote High-Performance Receiver

Continued on next page . .

Laser and Optics

User's Manual

(Continued)

Agilent E1826E/F/G One-Axis Plane Mirror Interferometer
Agilent E1827A Two-Axis Vertical Beam Interferometer
Agilent E1837A Three-Axis Vertical Beam Interferometer
Agilent E1833C 15% Bare Beam Splitter
Agilent E1833E 33% Bare Beam Splitter
Agilent E1833G 50% Bare Beam Splitter
Agilent E1833J 67% Bare Beam Splitter
Agilent E1833M 100% Bare Beam Splitter (Beam Bender)
Agilent N1203C Precision Beam Translator
Agilent N1204C Precision Horizontal Beam Bender
Agilent N1207C Precision Vertical Beam Bender
Agilent N1208C 33% Bare Beam Splitter
Agilent N1208D 40% Bare Beam Splitter
Agilent N1208E 50% Bare Beam Splitter
Agilent N1208F 66% Bare Beam Splitter
Agilent N1208G 60% Bare Beam Splitter
Agilent N1250A/B High Performance Receiver Cable
Agilent N1251A/B High Performance Laser Head Cable
Agilent Z4399A Three-Axis Interferometer
Agilent Z4420B Five-Axis Interferometer

Certification and Warranty

Certification

Agilent Technologies certifies that this product met its published specification at the time of shipment from the factory. Agilent further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology (formerly National Bureau of Standards), to the extent allowed by the Institute's calibration facility, and to the calibration facilities of other International Standards Organization members.

Warranty

Agilent warrants Agilent hardware, accessories and supplies against defects in materials and workmanship for a period specified by each product from date of shipment. If Agilent receives notice of such defects during the warranty period, Agilent will, at its option, either repair or replace products which prove to be defective. Replacement products may be either new or like-new.

Agilent warrants that Agilent software will not fail to execute its programming instructions, for the period specified above, due to defects in material and workmanship when properly installed and used. If Agilent receives notice of such defects during the warranty period, Agilent will replace software media which does not execute its programming instructions due to such defects.

For detailed warranty information, see back matter.

Safety Considerations

General

This product and related documentation must be reviewed for familiarization with this safety markings and instructions before operation.

This product is a safety Class I instrument (provided with a protective earth terminal).

Before Applying Power

Verify that the product is set to match the available line voltage and the correct fuse is installed.

Before Cleaning

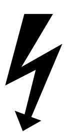
Disconnect the product from operating power before cleaning.

Safety Earth Ground

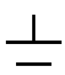
An uninterruptible safety earth ground must be provided from the mains power source to the product input wiring terminals or supplied power cable.

Warning Symbols That May Be Used In This Book

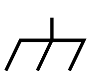
Instruction manual symbol; the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual.



Indicates hazardous voltages.



Indicates earth (ground) terminal.



or

Indicates terminal is connected to chassis when such connection is not apparent.

Safety Considerations (contd)

Indicates Alternating current.

Indicates Direct current.

WARNING

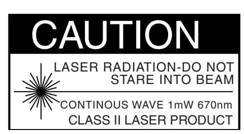
BODILY INJURY OR DEATH MAY RESULT FROM FAILURE TO HEED A WARNING. DO NOT PROCEED BEYOND A WARNING UNTIL THE INDICATED CONDITIONS ARE FULLY UNDERSTOOD AND MET.

CAUTION

Damage to equipment, or incorrect measurement data, may result from failure to heed a caution. Do not proceed beyond a CAUTION until the indicated conditions are fully understood and met.

These CAUTION labels are required by the United States Center for Devices and Radiological Health. Failure to follow their instructions may result in personal injury.

This symbol indicates laser radiation.



CAUTION: Laser radiation when open.
DO NOT STARE INTO THE BEAM

For additional safety and acoustic noise information, see back matter.

Agilent Technologies, Inc.
Santa Clara Site
5301 Stevens Creek Boulevard
Santa Clara, California 95052-8059

8.CD.L.03.11.97.R1.J.CW1FL

Contents

16 Laser Heads

24 Agilent 10717A Wavelength Tracker

25 Agilent 10719A and 10719A-C02 One-Axis Differential Interferometers

Figures

Tables

16
Laser Heads

General

One laser head is required in most measurement systems, regardless of the number of measurement axes in the system.

The wavelength of light from the laser head is used as the length standard for Agilent laser measurement systems. The laser head generates a coherent (all light waves in phase), collimated (all waves traveling parallel to one another), light beam consisting of two orthogonally polarized frequency components. To differentiate between the frequencies, the lower frequency is identified as f_1 and the higher as f_2.

The difference between these two frequencies is the “Reference Frequency”, listed in Table 70.

Agilent offers several laser head models to fill a variety of requirements. A summary listing of Agilent laser heads is provided in Table 70.

In addition to system information for the laser heads, complete descriptions, equipment supplied information, and specifications for each laser head are given in this chapter.

Each of these laser heads requires a cable to connect it to the measurement system electronics. Cables are listed in Chapter 36, “Accessories,” of this manual.

Table 70 Laser Heads Summary

Agilent Model	Reference Frequency	Beam Diameter	Polarization	Indicators	Shutter	Vented Cover
5517A	1.5 MHz to 2.0 MHz	6 mm	f_1 Horiz f_2 Vert	LASER ON READY	Open, reduced, closed	No
5517B	1.9 MHz to 2.4 MHz	6mm	f_1 Horiz f_2 Vert	+15V POWER ON -15V POWER ON LASER ON READY	Open, reduced closed	No
5517BL	1.9 MHz to 2.4 MHz	6mm	f_1 Horiz f_2 Vert	+15V POWER ON -15V POWER ON LASER ON READY	Open, reduced closed	Yes
5517C	2.4 MHz to 3.0 MHz	6 mm (std) 3 mm (5517C-003) 9 mm (5517C-009)	f_1 Horiz f_2 Vert	+15V POWER ON -15V POWER ON LASER ON READY	Open, reduced closed	No

Table 70 Laser Heads Summary (continued)

Agilent Model	Reference Frequency	Beam Diameter	Polarization	Indicators	Shutter	Vented Cover
5517D	3.4 MHz to 4.0 MHz	6 mm	f_1 Horiz f_2 Vert	+15V POWER ON -15V POWER ON LASER ON READY	Open, reduced closed	No
5517DL	≥4.4 MHz	6 mm (std) 9 mm (5517DL-009)	f_1 Horiz f_2 Vert	+15V POWER ON -15V POWER ON LASER ON READY	Open, reduced closed	Yes
5517FL	≥7.0 MHz	6 mm (std) 9 mm (5517FL-009)	f_1 Horiz f_2 Vert	+15V POWER ON -15V POWER ON LASER ON READY	Open, reduced closed	Yes
5519A	2.4 to 3.0 MHz	6 mm	f_1 Horiz f_2 Vert	LASER ON SIGNAL READY	Turret ring configures for straightness or other measurement	No
5519B	3.4 to 4.0 MHz	Same as 5519A	Same as 5519A	Same as 5519A	Same as 5519A	No
F_1 is the lower frequency, and f_2 is the higher frequency. The Agilent 5517A is the basic laser head.						

The Agilent 5517B/BL/C/D/DL/FL Laser heads are smaller packages than the Agilent 5517A Laser Head.

The Agilent 5517B/BL/C/D/DL/FL have higher reference frequencies than the Agilent 5517A. The higher frequencies allow higher axis velocity capability, depending on the electronics used.

The Agilent 5519A and Agilent 5519B are designed to be used as a part of the Agilent 5529A Dynamic Calibrator system. The Agilent 5519B has a higher frequency than the Agilent 5519A. The higher frequency allows higher axis velocity capability.

Frequencies and Polarizations

Agilent laser heads produce a coherent, collimated, two-frequency laser beam consisting of two orthogonally polarized frequency components.

Frequencies f_1 (the lower frequency) and f_2 are always orthogonally polarized with respect to one another. However, either may be vertically (or horizontally) polarized. Agilent laser heads have f_1 horizontally polarized. Polarization affects the direction sense. For example, if:

- f_1 (the lower frequency) is in the measurement path,
- f_2 is in the reference path, and
- the optics are moving away from each other, the fringe counts will be increasing. Interchanging f_1 and f_2 in this example will cause the fringe counts to decrease.

Before the laser beam leaves the laser head, part of it is sampled to determine the difference frequency between its two optical components. This difference frequency is called the Reference Frequency or Split Frequency.

The beam leaving the laser head is directed through a configuration of beam-directing optics and measurement optics and then to a receiver.

The receiver provides a Measurement Frequency, which, when compared to the Reference Frequency from the laser head, yields displacement information.

If a measurement axis is used for wavelength tracking instead of a displacement measurement, its Measurement Frequency yields wavelength-of-light information instead of displacement information.

Number of Measurement Axes

The output from a single laser head can be used for measurements involving many axes of motion, plus the wavelength tracking compensation axis. The number of axes that can be measured depends on the optical power available from the laser head and the optics and system measurement electronics being used.

Measurement Range

Nominal optical measurement range for the system is 40 meters (130 feet) for the sum of all axes when using a laser head with a (standard) 6 mm beam.

Heat Generation

There is some heat dissipation from the laser heads. Where possible, install the laser head far enough away from the measurement area to avoid any thermal effects. On a small or very accurate machine, choose the mounting method and location with care.

Accuracy Considerations

The wavelength of light from the laser head serves as the length standard for Agilent laser measurement systems. Since the laser transition of the neon atom provides a fundamental physical reference, the Agilent interferometric system is considered a “primary standard” for metrology.

The standard long-term wavelength accuracy (in a vacuum) of Agilent laser heads is 0.1 part-per-million (1×10^{-7}) or 0. 1 micron per meter (0. 1 microinch per inch). It is customary to specify laser accuracy in vacuum because the variable characteristics of air (such as temperature, humidity, pressure, and gas mixture) have a significant effect on the wavelength of light.

As with any measuring device, improper installation or operation can degrade measurement accuracy. Before installing the equipment, you should study the basic measurement capabilities of the system, along with considerations of relevant sources of errors. Many potential problems that could be encountered during installation and initial operation can be avoided by careful planning and a thorough understanding of laser interferometry.

Motion of the receiver or laser head along the beam path (X) has no effect on the measurement, since both f_1 and f_2 would exhibit Doppler shift.

Small motions of the laser head, receiver, interferometer, or retroreflector in a direction perpendicular to the beam path (Y or Z) have no effect on the measurement. The only restriction is that sufficient light returns to the receiver.

Angular motion of the laser head about the Z or Y axis has the effects described below:

- It introduces a measurement error (cosine error).
- It may displace the laser beam so that insufficient light returns to operate the receiver.

Vibration Isolation

Since the system measures only the relative motion between the interferometer and reflector, measurements are not affected by vibration along the beam axis of the laser source or the receiver.

When vibration of the laser head causes displacement of the beam (perpendicular to beam axis) at an interferometer or receiver, the beam signal power can fluctuate. If this fluctuation is too great, insufficient beam signal will arrive at the receiver, causing a “measurement signal error.”

Lockup Period and Automatic Tuning

When the laser head is powered up, the typical lockup period is four minutes. Some laser heads may take up to twenty minutes to lock.

To maintain a *stable frequency* output, Agilent laser heads have thermally-stabilized cavity lengths controlled by automatic tuning circuitry. Thermal stabilization period of the laser heads are listed below:

- Agilent 5517B/C/D Laser Head (non-vented cover) requires a typical warmup period of 90 minutes.

Agilent 5517BL/DL/FL Laser Head (vented cover) requires a typical warmup period of 45 minutes, but only if a fan and exhaust hose are connected to the vented cover; otherwise, the warmup period is 90 minutes.

Beam Shutters

To facilitate alignment and meet safety standards, the laser heads have shutter controls installed at the laser beam exit aperture. The beam may be blocked entirely for safety, reduced for alignment, or unimpeded for normal operation.

The Agilent 5517A, Agilent 5517B/BL/C/D/DL/FL, and Agilent 5519A/B laser heads have different shutter arrangements. The shutter arrangements for each laser head is described in the “Laser Head Descriptions” section in this chapter.

Orientation

An Agilent laser head may be mounted in any orientation as long as its beam enters the optical system parallel to or orthogonal with the machine axes being measured.

When mounting the laser head vertically with the beam directed upward, be careful not to mount an interferometer directly above it, because of heat dissipation from the laser head that may reduce measurement accuracy.

The plane defined by the three mounting feet on the laser head must be parallel to either the bottom or sides of the beam-splitters and beam-bender housings to within ±3°, and to the bottom or sides of the interferometers to within ±1°. This ensures that the polarization axes of the interferometers are oriented properly relative to the polarization vectors of the laser beam (Figure 72). The laser head can be rotated in 90° increments about the beam axis (roll) without affecting the system performance, but the measurement direction sense will change with each 90° rotation.

Although the laser head or the receiver may be rotated in 90° increments about the beam axis (roll), other roll deviations from the four optimum positions degrade the measurement signal. If either the laser head or receiver is rotated 45° about the beam axis, all position information will be lost because the receiver will not be able to distinguish between the two frequencies.

Magnetic Shielding

Agilent laser heads contain a permanent magnet. When installing an Agilent laser measurement system in an application sensitive to magnetic fields, shielding around the laser head may be required.

Pointing Stability

The alignment of the laser beam with respect to the mounting feet (pointing stability) changes slightly during warm-up of the laser head. Beam alignment is then stable once the laser head has reached thermal equilibrium (see NOTE below). This alignment change during warm-up of the laser head is less than 2 arc-minutes (typically 1 arc-minute) for the 6 mm beam.

NOTE

Agilent 5517B/C/D Laser Head (non-vented cover) requires a typical warmup period of 90 minutes.

Agilent 5517BL/DL/FL Laser Head (vented cover) requires a typical warmup period of 45 minutes, but only if a fan and exhaust hose is connected to the vented cover. Otherwise, the warmup period is 90 minutes.

Before aligning the laser, optics, or receiver, ensure the laser head has reached thermal equilibrium. This will assure proper alignment for subsequent power-ups.

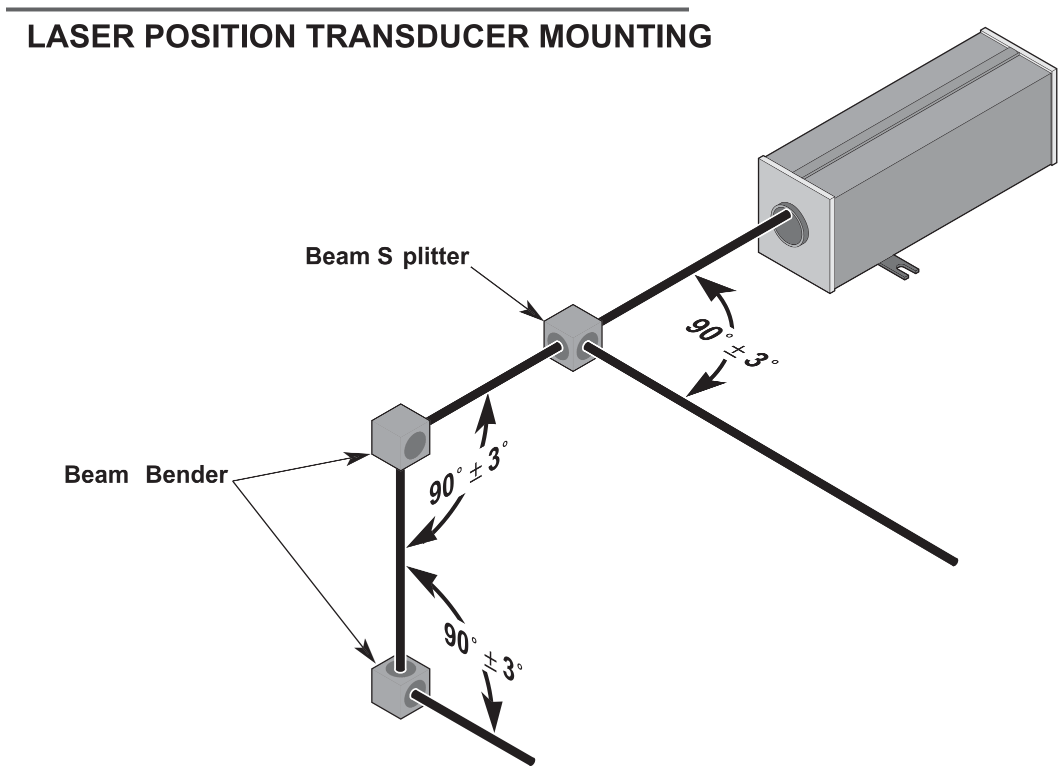


Figure 72 Laser position transducer mounting

The laser heads should not be exposed to ambient temperature change greater than ±5° C during operation to keep pointing stability variations to within a few arc-seconds during measurements.

Maintenance Requirements

Refer to Chapter 7, Maintenance," in Volume I of this manual for this information.

Laser Head Descriptions

Comparison of Laser Heads

Table 70 summarizes the differences between the Agilent 5517A, Agilent 5517B/BL/C/D/DL/FL, and Agilent 5519A/B laser heads (and options). The differences are the package size, reference frequency, beam diameter, and the cover (vented or non-vented).

Agilent 5517A Laser Head

Description

The major structures of the Agilent 5517A Laser Head include the control electronics, the laser tube assembly, the sampler assembly, the reference receiver, and the high voltage power supply. All of the necessary control signals for the operation of the Agilent 5517A are generated internally.

Power requirements are + and –15 Volts. Refer to the "Agilent 5517A Laser Head Specifications" section for more information on power requirements.

The Agilent 5517A Laser Head, shown in Figure 73, is supplied with three mounting screws, M8 × 1.25 × 25 mm, Agilent Part Number 0515-0798.

Cables available as accessories are listed in Chapter 36, "Accessories," of this manual. The three-position shutter on the Agilent 5517A can be set for open, reduced, or closed apertures.

The Agilent 5517A has two rear-panel LED indicators.

The **LASER ON** LED alerts the operator that the laser head is activated and is emitting a laser beam.

About halfway through the warm-up period, the **READY** LED blinks on and off to indicate that the laser is in the process of warming up. When the laser head is ready for use, the **READY** LED remains on. Any necessary retuning is performed automatically and is indicated by the **READY** LED flashing.

Figure 73 Agilent 5517A Laser Head

Mounting and Clearance

The Agilent 5517A Laser Head has three mounting feet with tapped holes (M8 × 1.25) that go completely through the feet and allow mounting on a mounting plate or bulkhead. For measurement-axis alignment purposes, slotted through holes should be provided in the mounting surface.

Aluminum is the preferred material for any mounting surface, since this will match the thermal coefficient of expansion of the laser base. If aluminum cannot be used, kinematic mounting of the rear mounting foot is recommended to minimize stresses due to temperature changes. In addition:

- Allow 50 mm (2 inches) clearance around the laser head for easy servicing.
- Allow at least 125 mm (5 inches) clearance at the back of the laser head for cable connections.
- To maintain good pointing stability, it is good practice to use kinematic mounting principles.

The laser head emits a laser beam containing a vertically polarized component, f_2 (the higher of the two optical frequencies), and a horizontally polarized component f_1. A portion of the emitted beam is directed to the sampler assembly. Most of this sample feeds into the reference receiver and the remainder of the sample is used to control laser tuning. The reference receiver generates the reference frequency signal by mixing the two laser frequencies. The reference frequency is in the range of 1.5 to 2.0 MHz and is a TTL-level square wave. The higher the reference frequency, the higher the slew rate at which the measurement optic can move. When the laser tuning stabilizes, the reference frequency is sent to the system electronics.

The main portion of the beam is directed by system optics to an external receiver where a measurement signal is generated. The measurement and reference signals are compared by the Agilent laser system electronics to generate a displacement measurement signal.

Agilent 5517A Laser Head Specifications

PHYSICAL CHARACTERISTICS

Dimensions: See figure below

Weight: 5.5 Kilograms (12 pounds)

Magnetic Field Strength (Non-Operating):

Does not exceed 5.25 milligauss at a distance of 460 cm (15 ft) from any point on the surface of the packaged Laser Head.

Clearance Required for Cabling: 12.00 cm (4.72 in) beyond back

POWER

Power Input Requirements:

+15 Volts ±0.3 Volts at 2.5 Amperes maximum

–15 Volts ±0.3 Volts at 0.02 Ampere maximum

Heat Dissipation: 23 watts (during operation)
35 watts (during warmup)

Warmup Time: less than 10 minutes (4 minutes typical)

LASER BEAM CHARACTERISTICS

Type: Helium-Neon, Continuous, Two-Frequency

Maximum Beam Power Output: 1 milliwatt

Minimum Beam Power Output: 180 microwatts

Beam Diameter: 6 millimeters (0.25 inch) typical

Vacuum Wavelength Accuracy (3 sigma, lifetime): ±0.1 ppm

Vacuum Wavelength Stability (typical 1 hour): ±0.002 ppm

Vacuum Wavelength Stability (typical lifetime): ±0.02 ppm

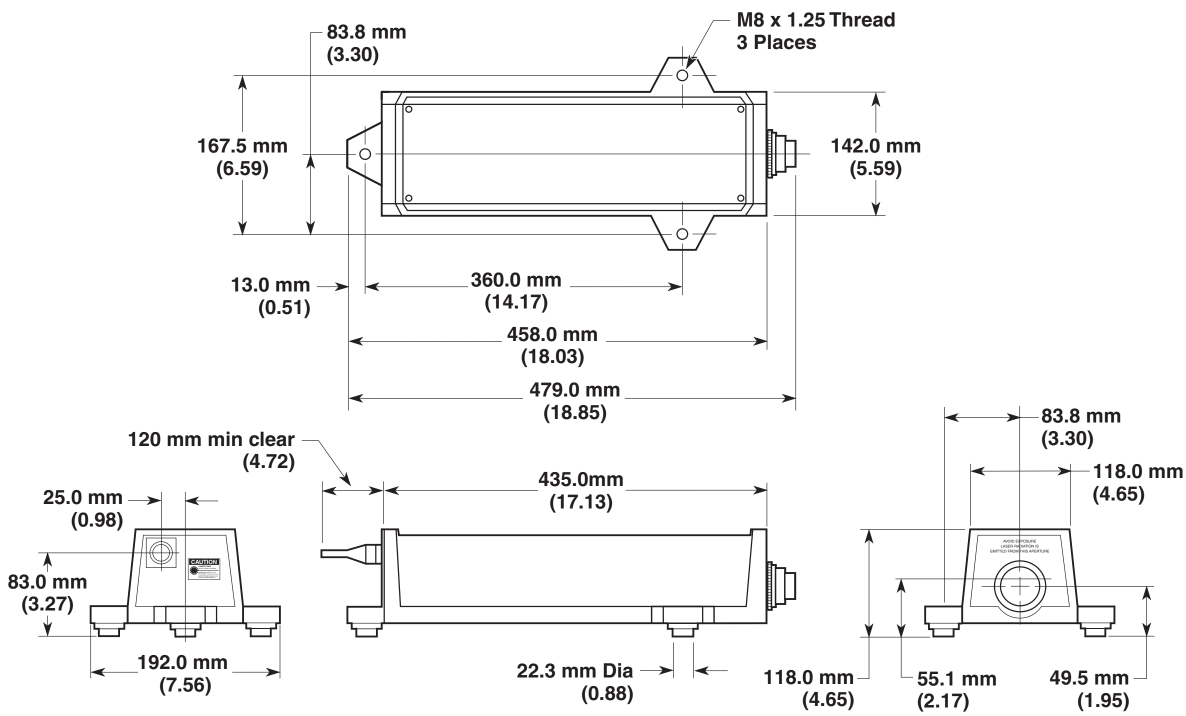
Nominal Vacuum Wavelength: 632.99137 nanometers

Safety Classification:

Class II Laser Product conforming to U.S. National Center for Devices and Radiological Health Regulations 21 CFR 1040.10 and 1040.11.

OUTPUTS

Reference Frequency: 1.5 - 2.0 MHz



Note

This is a Class II Laser Product conforming to Federal Bureau of Radiological Health Regulations 21 CFR 1040.10 and 1040.11.

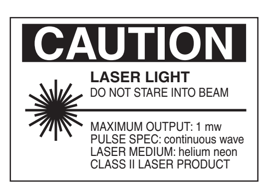


Figure 74 Agilent 5517A Laser Head dimensions

Agilent 5517B/BL/C/D/DL/FL Laser Head

Description

The major structures of the Agilent 5517B/BL/C/D/DL/FL Laser Head (see Figure 75) include the control electronics, the laser tube assembly, the sampler assembly, the reference receiver, and the high voltage power supply. All of the necessary control signals for the operation of the Agilent 5517B/BL/C/D/DL/FL are generated internally.

Power requirements are + and -15 Volts. Refer to the "Agilent 5517B/BL/C/D/DL/FL Laser Head Specifications" section for more information on power requirements.

The 5517B/BL/C/D/DL/FL is similar to the 5517A with respect to laser beam polarizations and current requirements. The 5517B/BL/C/D/DL/FL has a higher reference frequency than the 5517A, allowing faster measurement velocities (slew rates). The 5517B/BL/C/D/DL/FL package is smaller than that of the 5517A.

The *physical* differences between the 5517B/C/D and 5517BL/DL/FL are:

- 5517B/C/D has a non-vented cover (see Figure 75).
- 5517BL/DL/FL has a vented cover for heat isolation (see Figure 75).
- 5517B/C/D beam height is 79.5 mm (see Figure 76 on page 352).
- 5517BL/DL/FL beam height is 80.8 mm (see Figure 77 on page 353).

Figure 75 Agilent 5517B/C/D and 5517BL/DL/FL Laser Heads

Table 71 lists all the options for the 5517B, 5517BL, 5517C, 5517D, 5517DL, and 5517F laser heads.

Cables available as accessories are listed in Chapter 36, "Accessories," of this manual.

The three-position shutter on the 5517B/BL/C/D/DL/FL can be set for open, reduced, or closed apertures.

The 5517B/BL/C/D/DL/FL has four rear-panel indicators.

The **+15V POWER ON** and **-15V POWER ON** LEDs indicate that power has been applied and that the respective fuses are intact.

The **LASER ON** LED alerts the operator that the laser head is activated and is emitting a laser beam.

About halfway through the warm-up period, the **READY** LED blinks on and off to indicate that the laser is in the process of warming up. When the head is ready for use, the **READY** LED remains on. Any necessary retuning is performed automatically and is indicated by the **READY** LED flashing.

The laser head emits a laser beam containing a vertically polarized component, f_2 (the higher of the two optical frequencies), and a horizontally polarized component f_1. A portion of the emitted beam is directed to the sampler assembly. Most of this sample feeds into the reference receiver and the remainder of the sample is used to control laser tuning. The reference receiver generates the reference frequency signal by mixing the two laser frequencies. The reference frequency is in the range of 1.9 to 2.4 MHz and is a TTL-level square wave. The higher the reference frequency, the higher the slew rate at which the measurement optic can move. When the laser tuning stabilizes, the reference frequency is sent to the system electronics.

The main portion of the beam is directed by system optics to an external receiver where a measurement signal is generated. The measurement and reference signals are compared by the Agilent laser system electronics to generate a displacement measurement signal.

Options

Table 71 lists the available options.

Table 71 Available options

Model	Option	Description
5517B	Option A6J	ANSI-NCSL 2540-1-1994 Compliant Calibration
	Option 141	Japanese User's Manual
	Option H10	Optical Power > 400 µW
5517BL	Option AV4	Laser and Optics User's Manual
	Option A6J	ANSI-NCSL 2540-1-1994 Compliant Calibration
	Option H10	Optical Power > 400 µW

Table 71 Available options (continued)

Model	Option	Description
5517C	Option A6J	ANSI-NCSL 2540-1-1994 Compliant Calibration
	Option H03	Optical Power > 300 μW
	Option H05	Optical Power > 240 μW
	Option H07	Optical Power > 400 μW
	Option OBV	Additional User's Manual
	Option 003	3mm beam
	Option 006	6mm beam
	Option 009	9mm beam
	Option 030	Replaces standard feet with three electrically insulated feet.
	Option 038	Delete feet
	Option 039	Standard Mounting
5517D	Option A6J	ANSI-NCSL 2540-1-1994 Compliant Calibration
	Option H01	Optical Power > 300 μW
	Option 030	Replaces standard feet with three electrically insulated feet.
	Option 039	Standard Mounting
5517DL	Option 006	6mm beam
	Option 009	9mm beam
	Option 038	Delete feet
	Option 039	Replaces standard feet with three electrically insulated feet.
5517FL	Option 006	6mm beam
	Option 009	9mm beam
	Option 030	Replaces standard feet with three electrically insulated feet.
	Option 039	Standard feet
	Option 300	9mm beam with 7.2 MHz split frequency

Mounting and Clearance

The Agilent 5517B/BL/C/D/DL/FL Laser Head can be fastened down using the mounting feet or six tapped holes on the base of the head. The mounting feet have clearance slots for 1/4-20 or M6 screws. Alternatively, the mounting feet can be removed and the head fastened using the M4 × 0.7 tapped holes under the base.

You can take advantage of the fact that the laser head output beam is reference to locations on its base. This mounting arrangement requires a specially prepared mounting site for the laser head (see Figure 17 in Chapter 3 in Volume I of this manual).

For measurement-axis alignment purposes, slotted through holes should be provided in the mounting surface. Aluminum is the preferred material for any mounting surface, since this will match the thermal coefficient of expansion of the laser base. If aluminum cannot be used, kinematic mounting of the rear mounting foot is recommended to minimize stresses due to temperature changes. In addition:

- Allow 50 mm (2 inches) clearance around the laser head for easy servicing.
- Allow at least 100 mm (4 inches) clearance at the back of the laser head for cable connections.
- To maintain good pointing stability, it is good practice to use kinematic mounting principles.

Agilent 5517B/BL/C/D/DL/FL Laser Head Specifications

Agilent 5517B/BL Laser Head Specifications

PHYSICAL CHARACTERISTICS	LASER BEAM CHARACTERISTICS
Dimensions (5517B): See Figure 76 on page 352	**Type:** Helium-Neon, Continuous, Two-Frequency
Dimensions (5517BL): See Figure 77 on page 353	**Maximum Beam Power Output:** 1 milliwatt
Weight: 3.4 Kilograms (7.5 pounds)	**Minimum Beam Power Output:** 120 microwatts
Magnetic Field Strength (Non-Operating):	**Beam Diameter:** 6 millimeters (0.25 inch) typical
	Vacuum Wavelength Accuracy (3 sigma, lifetime): ±0.1 ppm
Does not exceed 5.25 milligauss at a distance of 460 cm (15 ft) from any point on the surface of the packaged Laser Head.	**Vacuum Wavelength Stability (typical 1 hour):** ±0.002 ppm **Vacuum Wavelength Stability (typical lifetime):** ±0.02 ppm
Clearance Required for Cabling: 10.16 cm (4 in) beyond back	**Nominal Vacuum Wavelength:** 632.99137 nanometers
POWER	**Safety Classification:**
Power Input Requirements:	Class II Laser Product conforming to U.S.
+15 Volts ±0.3 Volts at 2.2 Amperes maximum	National Center for Devices and Radiological
-15 Volts ±0.3 Volts at 0.02 Ampere maximum	Health Regulations 21 CFR 1040.10 and 1040.11.
Heat Dissipation: 23 watts (during operation)	OUTPUTS
35 watts (during warmup)	**Reference Frequency:** 1.9 - 2.4 MHz
Venting (5517BL Only): Allows forced air cooling to reduce the power dissipated into the application. **Heat exhaust efficiency (typical, depends on envirnomental conditions):** 80%	
Warmup Time: less than 10 minutes (4 minutes typical)	

Agilent 5517C Laser Head Specifications (Standard and 5517C-003)

PHYSICAL CHARACTERISTICS	LASER BEAM CHARACTERISTICS
Dimensions: See Figure 76 on page 352	**Type:** Helium-Neon, Continuous, Two-Frequency
Weight: 3.4 Kilograms (7.5 pounds)	**Maximum Beam Power Output:** 1 milliwatt
Magnetic Field Strength (Non-Operating):	**Minimum Beam Power Output:** 180 microwatts
Does not exceed 5.25 milligauss at a distance of 460 cm (15 ft) from any point on the surface of the packaged Laser Head.	**Beam Diameter:** 6 millimeters, 0.25 inch, typical (Standard) 3 millimeters typical (5517C-003)
Clearance Required for Cabling: 10.16 cm (4 in) beyond back	**Vacuum Wavelength Accuracy (3 sigma, lifetime):** ±0.1 ppm
POWER	**Vacuum Wavelength Stability (typical 1 hour):** ±0.002 ppm
Power Input Requirements:	**Vacuum Wavelength Stability (typical lifetime):** ± 0.02 ppm
+15 Volts ±0.3 Volts at 2.2 Amperes maximum	**Nominal Vacuum Wavelength:** 632.991354 nanometers
-15 Volts ±0.3 Volts at 0.02 Ampere maximum	Safety Classification:
Heat Dissipation: 23 watts (during operation)	Class II Laser Product conforming to U.S.
35 watts (during warmup)	National Center for Devices and Radiological
Warmup Time: less than 10 minutes (4 minutes typical)	Health Regulations 21 CFR 1040.10 and 1040.11.
	OUTPUTS
	Reference Frequency: 2.4 - 3.0 MHz

Agilent 5517C-009 Laser Head Specifications

PHYSICAL CHARACTERISTICS	LASER BEAM CHARACTERISTICS
Dimensions: See Figure 76 on page 352	**Type:** Helium-Neon, Continuous, Two-Frequency
Weight: 3.4 Kilograms (7.5 pounds)	**Maximum Beam Power Output:** 1 milliwatt
Magnetic Field Strength (Non-Operating):	**Minimum Beam Power Output:** 180 microwatts
Does not exceed 5.25 milligauss at a distance of 460 cm (15 ft) from any point on the surface of the packaged Laser Head.	**Beam Diameter:** 9 millimeters typical **Vacuum Wavelength Accuracy (3 sigma, lifetime):** ±0.1 ppm
Clearance Required for Cabling: 10.16 cm (4 in) beyond back	**Vacuum Wavelength Stability (typical 1 hour):** ±0.002 ppm
POWER	**Vacuum Wavelength Stability (typical lifetime):** ±0.02 ppm
Power Input Requirements:	**Nominal Vacuum Wavelength:** 632.991354 nanometers
+15 Volts ±0.3 Volts at 2.2 Amperes maximum	Safety Classification:
–15 Volts ±0.3 Volts at 0.02 Ampere maximum	Class II Laser Product conforming to U.S.
Heat Dissipation: 23 watts (during operation) 35 watts (during warmup)	National Center for Devices and Radiological Health Regulations 21 CFR 1040.10 and 1040.11.
Warmup Time: less than 10 minutes (4 minutes typical)	OUTPUTS **Reference Frequency:** 2.4 - 3.0 MHz

Agilent 5517D/DL Laser Head Specifications

PHYSICAL CHARACTERISTICS	LASER BEAM CHARACTERISTICS
Dimensions (5517D): See Figure 76 on page 352	**Type:** Helium-Neon, Continuous, Two-Frequency
Dimensions (5517DL): See Figure 77 on page 353	**Maximum Beam Power Output:** 1 milliwatt
Weight: 3.4 Kilograms (7.5 pounds)	**Minimum Beam Power Output:** 180 microwatts
Magnetic Field Strength (Non-Operating):	**Beam Diameter:** 6 millimeters, 0.25 inch, typical 9 millimeters,0.35 inch, typical (5517DL-009)
Does not exceed 5.25 milligauss at a distance of 460 cm (15 ft) from any point on the surface of the packaged Laser Head.	**Vacuum Wavelength Accuracy (3 sigma, lifetime):** ±0.1 ppm
Clearance Required for Cabling: 10.16 cm (4 in) beyond back	**Vacuum Wavelength Stability (typical 1 hour):** ±0.002 ppm
POWER	**Vacuum Wavelength Stability (typical lifetime):** ±0.02 ppm
Power Input Requirements:	**Nominal Vacuum Wavelength:** 632.991354 nanometers
+15 Volts ±0.3 Volts at 2.2 Amperes maximum	Safety Classification:
–15 Volts ±0.3 Volts at 0.02 Ampere maximum	Class II Laser Product conforming to U.S.
Heat Dissipation: 23 watts (during operation) 35 watts (during warmup)	National Center for Devices and Radiological Health Regulations 21 CFR 1040.10 and 1040.11.
Venting (5517DL Only): Allows forced air cooling to reduce the power dissipated into the application. **Heat exhaust efficiency (typical, depends on envirnomental conditions):** 80%	OUTPUTS **Reference Frequency (5517D):** 3.4 - 4.0 MHz **Reference Frequency (5517DL):** ≥ 4.4 MHz
Warmup Time: less than 10 minutes (4 minutes typical)	

Agilent 5517FL Laser Head Specifications (Standard, 5517FL-009, and 5517FL-300)

PHYSICAL CHARACTERISTICS

Dimensions: See Figure 77 on page 353

Weight: 3.4 Kilograms (7.5 pounds)

Magnetic Field Strength (Non-Operating):

Does not exceed 5.25 milligauss at a distance of 460 cm (15 ft) from any point on the surface of the packaged Laser Head.

Clearance Required for Cabling: 10.16 cm (4 in) beyond back

POWER

Power Input Requirements:

+15 Volts ±0.3 Volts at 2.2 Amperes maximum
–15 Volts ±0.3 Volts at 0.02 Ampere maximum

Heat Dissipation: 23 watts (during operation)
35 watts (during warmup)

Venting : Allows forced air cooling to reduce the power dissipated into the application. **Heat exhaust efficiency (typical, depends on envirnomental conditions):** 75%

Warmup Time: less than 10 minutes (4 minutes typical)

LASER BEAM CHARACTERISTICS

Type: Helium-Neon, Continuous, Two-Frequency

Maximum Beam Power Output: 1 milliwatt

Minimum Beam Power Output: 65 microwatts

Beam Diameter: 6 millimeters, 0.25 inch, typical
9 millimeters,0.35 inch, typical (5517FL-009)

Vacuum Wavelength Accuracy (3 sigma, lifetime): ±0.1 ppm

Vacuum Wavelength Stability (typical 1 hour): ±0.002 ppm

Vacuum Wavelength Stability (typical lifetime): ±0.02 ppm

Nominal Vacuum Wavelength: 632.991354 nanometers

Safety Classification:

Class II Laser Product conforming to U.S.

National Center for Devices and Radiological

Health Regulations 21 CFR 1040.10 and 1040.11.

OUTPUTS

Reference Frequency: ≥ 7.0 MHz
Reference Frequency (5517FL-300): ≥ 7.2 MHz

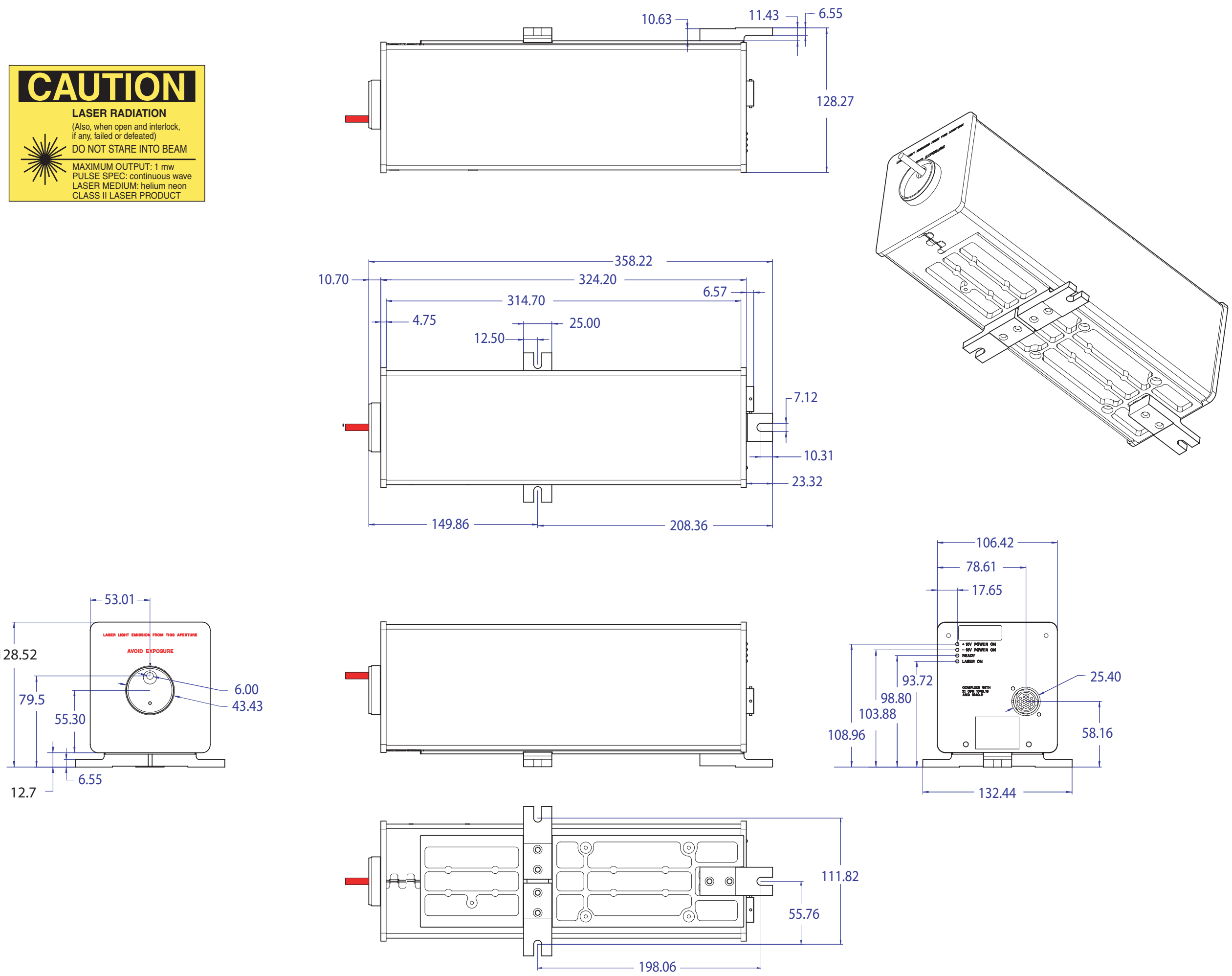


Figure 76 Agilent 5517B/C/D Laser Head dimensions and mounting location

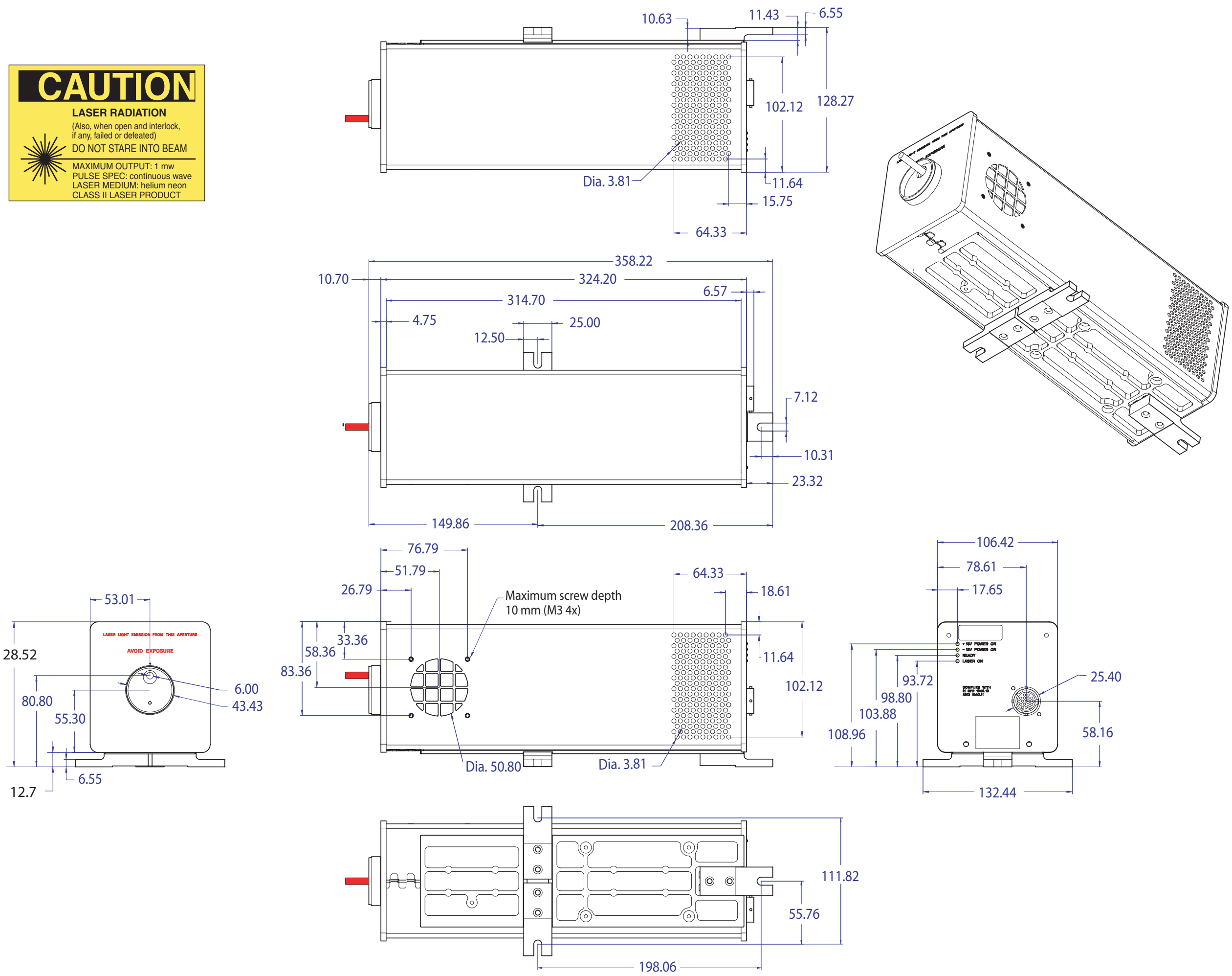
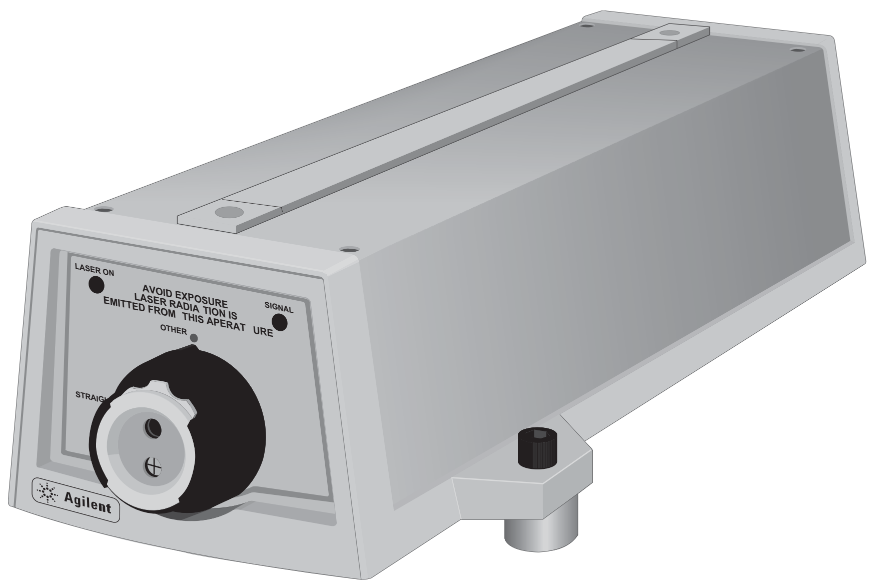


Figure 77 Agilent 5517BL/CL/DL Laser Head dimensions and mounting location

Agilent 5519A/B Laser Head and Receiver

Description

The Agilent 5519A/B Laser Head (see Figure 78), which is a component of the Agilent 5529A/55292A Dynamic Calibrator system, incorporates a helium-neon laser with a beam diameter of 6 mm (20.24 in). It has a wavelength accuracy of ±0.1 ppm (±0.02 ppm if calibrated). The Agilent 5519A/B uses Agilent's two-frequency laser technique that virtually eliminates the problems common to other laser designs, which result from beam intensity changes. The laser head uses a proven long-life tube.



Agilent 5519A/B
Laser Head and Receiver

Figure 78 Agilent 5519A/B Laser Head

The Agilent 5519A and Agilent 5519B differs only in their reference frequency output. The Agilent 5519A reference frequency output is 2.4 MHz to 3.0 MHz. The Agilent 5519B reference frequency output is 3.4 MHz to 4.0 MHz. The higher the reference frequency, the higher the slew rate at which the measurement optic can move.

The Agilent 5519A/B is configured with appropriate optics and system electronics to build a laser calibration system that meets the unique physical layout and measurement requirements of individual applications. The laser accuracy is ideal for machine calibration applications.

The major structures of the Agilent 5519A/B are the control electronics, the laser tube assembly, the sampler assembly, the reference receiver, the measurement receiver, the turret optics, and the high voltage power supply. All of the necessary control signals for the operation of the 5519A/B Laser Head are generated internally. Power requirement is 100 to 240 Vac, 50 to 60 Hz.

The 5519A/B Laser Head, shown in Figure 78, is supplied with:

- two Mounting Screws, M8 X 1.25 X 25 mm, Agilent Part Number 0515-0798
- a Leveling Foot and Locking Nut, Agilent Part Numbers 05518-20316 and 05518-20317, respectively.

Cables available as accessories are listed in Chapter 36, “Accessories,” of this manual.

In addition, the Agilent 5519A/B has a two-position turret ring to configure the head for straightness measurements (requires Agilent 10774A or Agilent 10775A straightness optics) in the STRAIGHTNESS position, and all other measurements in the OTHER position. The three-position shutter on the 5519A/B can be set for open, reduced, or closed apertures. The receiver aperture also has a shutter that contains a cross hairs target in its closed position for use during optical alignment.

The Agilent 5519A/B has three rear-panel LED indicators and two front-panel LED indicators.

The **LASER ON** indicator alerts the operator when the 5519A/B Laser Head is activated and emitting a laser beam. Electrically, this indicator monitors the +15 Volt line on the low voltage power supply output. This indicator is on both the front and rear panels of the 5519A/B

The **SIGNAL** indicator shows when a sufficient laser beam measurement signal is returned to the measurement receiver assembly within the 5519A/B Laser Head. This indicator is on both the front and rear panels of the 5519A/B.

The rear-panel **READY** indicator is extinguished when the 5519A/B Laser Head is in the warm-up mode. It flashes on and off when the 5519A/B Laser Head begins the optical mode and is steady when the 5519A/B Laser Head is ready for use.

Mounting and Clearance

The Agilent 5519A/B Laser Head has three mounting feet with tapped holes (M8 X 1.25) that go completely through the feet and allow mounting on a mounting plate or bulkhead. For measurement-axis alignment purposes, slotted through holes should be provided in the mounting surface. Aluminum is the preferred material for any mounting surface, since this will match the thermal coefficient of expansion of the laser base. If aluminum cannot be used, kinematic mounting of the rear mounting foot is recommended to minimize stresses due to temperature changes. In addition:

- Allow 50 mm (2 inches) clearance around the laser head for easy servicing.
- Allow at least 125 mm (5 inches) clearance at the back of the laser head for cable connections.
- To maintain good pointing stability, it is good practice to use kinematic mounting principles.

Agilent 5519A/B Laser Head Specifications

PHYSICAL CHARACTERISTICS

Dimensions: See figure below

Weight: 5.8 Kilograms (12.5 pounds)

Magnetic Field Strength (Non-Operating):

Does not exceed 5.25 milligauss at a distance of 460 cm (15 ft) from any point on the surface of the packaged Laser Head.

Clearance Required for Cabling: 10 cm (4 in) beyond back

POWER

Power Input Requirements: 100 to 240 Vac, 50 to 60 Hz

Heat Dissipation: 33 watts (during operation)
50 watts (during warmup)

Warmup Time: less than 10 minutes (4 minutes typical)

Altitude Operating Maximum: 4000 M

LASER BEAM CHARACTERISTICS

Type: Helium-Neon, Continuous, Two-Frequency

Maximum Beam Power Output: 1 milliwatt

Minimum Beam Power Output: 180 microwatts

Beam Diameter: 6 millimeters (0.24 inch) typical

Vacuum Wavelength Accuracy (3 sigma, lifetime): ±0.1 ppm

Vacuum Wavelength Stability (typical 1 hour): ±0.002 ppm

Vacuum Wavelength Stability (typical lifetime): ±0.02 ppm

Nominal Vacuum Wavelength: 632.9913540 nanometers

Safety Classification:

Class II Laser Product conforming to U.S.
National Center for Devices and Radiological
Health Regulations 21 CFR 1040.10 and 1040.11.

OUTPUTS

Reference Frequency (5519A): 2.4 - 3.0 MHz
Reference Frequency (5519B): 3.4 to 4.0 MHz

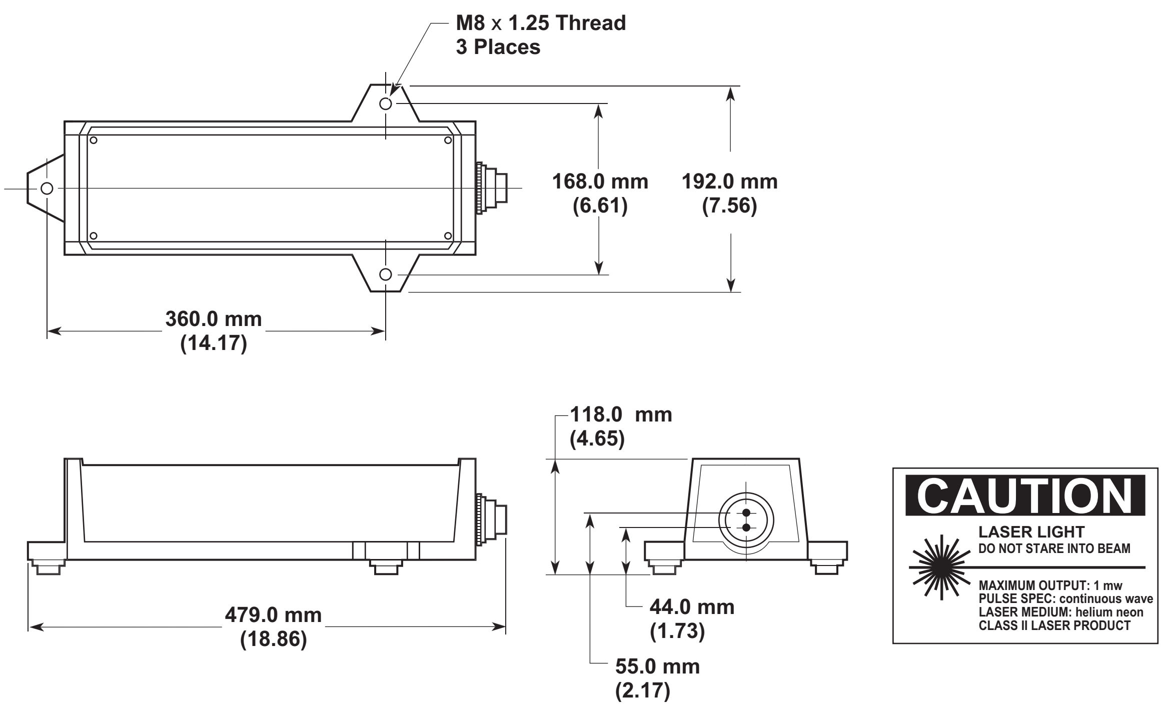


Figure 79 Agilent 5519A/B Laser Head dimensions

17
Beam-Directing Optics

Introduction

This chapter describes the Agilent beam-directing optics available for laser measurement systems.

In general, the beam-splitting and beam-bending optics are used only for making right-angle turns when routing the laser beam within the intended application. The right-angle turns must be aligned parallel to or perpendicular to the mounting plane of the laser head, to minimize polarization effects. This confines beam turning to one of four possible directions. For instance, for a horizontal laser beam, with polarizations oriented vertically and horizontally, the options are up, down, left, and right.

Beam translators are used to ensure that the translated or offset laser beam remains parallel to the original beam direction. The translator is useful whenever a high precision distance measurement with a laser is performed because it can reduce Abbé error.

Table 72 summarizes the beam-directing optics and the Agilent adjustable optics mounts with which they may be used. (The mounts are described in Chapter 36, “Accessories,” of this manual.)

Specification drawings of the optics described in this chapter are provided as part of the descriptions.

The available Agilent Technologies measurement optics are described in Chapter 5, Measurement Optics (General Information),” in Volume I of this manual.

Optics that are 1) not interferometers, and 2) not usually referred to as “beam-directing optics” are described in Chapter 36, “Accessories,” of this manual.

Table 72 Beam-direction optics

Beam-Directing Optics	Order as required to manipulate beam path for your application
Agilent 10567A	Dual Beam Beam Splitter
Agilent 10700A	33% Beam Splitter
Agilent 10700B	4% Beam Splitter
Agilent 10700C	15% Beam Splitter
Agilent 10701A	50% Beam Splitter
Agilent 10707A	Beam Bender
Agilent 10725A	50% Beam Splitter (requires user-supplied mounting hardware)
Agilent 10725B	4% Beam Splitter (requires user-supplied mounting hardware)
Agilent 10725C	15% Beam Splitter (requires user-supplied mounting hardware)
Agilent 10726A	Beam Bender (requires user-supplied mounting hardware)
Agilent 10728A	Plane Mirror
Adjustable Mounts for optics above	Adjustable mounts simplify installation and alignment of optics
Agilent 10710B	Use with Agilent 10700A, 10701A, 10707A
Agilent 10711A	Use with Agilent 10702A, 10706A, 10706B, 10715A, 10716A
Precision Beam Manipulators	Use in multiaxis laser measurement systems
Agilent E1833C	15% Beam Splitter
Agilent E1833E	33% Beam Splitter
Agilent E1833G	50% Beam Splitter
Agilent E1833J	67% Beam Splitter
Agilent E1833M	100% Beam Splitter (beam bender)
Agilent N1203C	Precision Beam Translator
Agilent N1204C	Precision Horizontal Beam Bender
Agilent N1207C	Precision Vertical Beam Bender
Agilent N1208C	33% Beam Splitter
Agilent N1208D	40% Beam Splitter
Agilent N1208E	50% Beam Splitter
Agilent N1208F	66% Beam Splitter
Agilent N1208G	60% Beam Splitter
Agilent N1209A	Risley Prism Translator (RPT) Manipulator

All Agilent laser systems can use the same Agilent 107XX series of optics.

However, keep in mind that the Agilent 10719A and Agilent 10721A interferometers are designed to use the 3 mm (nominal) diameter beam from the Agilent 5517C-003 Laser Head. Any of the beam-directing optics described here can be used in the laser beam delivery system between the laser head and the interferometer(s).

The Agilent 10735A, Agilent 10736A, and Agilent 10736A-001 interferometers can use a laser beam with a (nominal) diameter up to 9 mm. The 9 mm beam, available from an Agilent 5517C-009 Laser head, provides a greater yaw range than either the standard 6 mm beam or the 3 mm beam. Any of the beam-directing optics described here can be used in the laser beam deliver system between the laser head and the interferometer(s). However, when a 9 mm beam is used with any of these beam-directing optics (except for the Agilent 10725A 50% Beam Splitter or the Agilent 10726A Beam Bender), a portion of the beam may be clipped, which will reduce the yaw range of the interferometer(s) receiving that beam.

- The Agilent 10725A beam splitter and the Agilent 10726A beam bender provide the same optical components as the Agilent 10701A beam splitter and the Agilent 10772A Turning Mirror or Agilent 10773A Flatness Mirror, respectively. The difference is that in the Agilent 10701A, Agilent 10772A, and Agilent 10773A, the optical elements are already installed in mounting hardware. The Agilent 10725A beam splitter and Agilent 10726A beam bender require custom user-supplied mounts. The Agilent 10772A Turning Mirror and the Agilent 10773A Flatness Mirror are described in Chapter 36, “Accessories, of this manual.

Use of the Adjustable Mounts

NOTE — The Agilent N1203C, N1204C, and N1207C beam manipulators DO NOT use the adjustable mounts. See "Agilent N1203C, N1204C, and N1207C Beam Manipulators" in this chapter for details on these products.

Aligning an Agilent laser measurement system may require adjusting the position of one of more of its optical components, especially the beam-directing optics in the path(s) between the laser head and the interferometer(s). The Agilent 10710B and Agilent 10711A adjustable mounts should be used to provide the adjustment capability for most optical components.

In general, the alignment procedures are performed with all optical components in place. Your measurement system design should allow for adjustment of the laser, optics, and receivers during alignment.

Vacuum Applications

Vacuum options are available for Agilent beam-directing optics (except those requiring user-supplied mounting hardware) listed in Table 72. Contact Agilent Call Center for information (telephone numbers of various call centers are listed on the "Service and Support" page at the back of this manual). The vacuum option components use vacuum-grade adhesives in their construction, and may be used in vacuum applications.

Use of the Agilent 10725A Beam Splitter, Agilent 10726A Beam Bender, in a vacuum application depends on the materials used in the user-created mounting arrangement. The Agilent bare glass optics are themselves vacuum compatible.

Preventing Depolarization

Caution

CAUTION

If used improperly, all reflective beam splitters and beam benders can depolarize the laser light, which may cause nonlinearity errors in a measurement.

The Agilent laser beam is composed of two optical frequencies in two orthogonal linear polarizations. These polarization directions are aligned parallel to and perpendicular to the plane of the laser head feet.

When a beam splitter or beam bender is used, there will be no depolarization as long as it is installed so that its plane of incidence (the plane defined by the incident and reflected rays) is either parallel to or perpendicular to the polarization vectors (directions) of the incident laser light.

For example, if the polarization states of the incident beam are horizontal and vertical, the beam can be safely reflected *only* in a horizontal or vertical plane (plane of incidence on the beam splitter or bender) without depolarization. If the beam were bent into a plane skewed to the horizontal, the linear polarizations will become elliptical and the optical frequencies will corrupt one another resulting in measurement error.

Note

NOTE

The reflective coatings used in the beam splitters and benders are designed for 90° bends. Using these optics to turn the beam at different angles will degrade optical efficiency.

Agilent 10567A Dual Beam Beam-Splitter

The Agilent 10567A Dual Beam Beam-Splitter (Figure 80) divides the laser beam into two beams perpendicular to each other (see Figure 81) and directs them to two sets of measurement optics. The return beams pass through the Agilent 10567A again and exit parallel to the input beam.

This beam-splitter is typically used for applications where two axes of measurement are required to go through a window into a chamber.

To preserve polarization, see “Preventing Depolarization" on page 362.

To preserve efficiency, see “Note" on page 362.

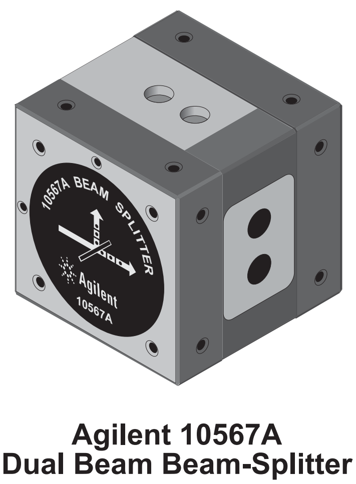


Figure 80 Agilent 10567A Dual Beam Beam-Splitter

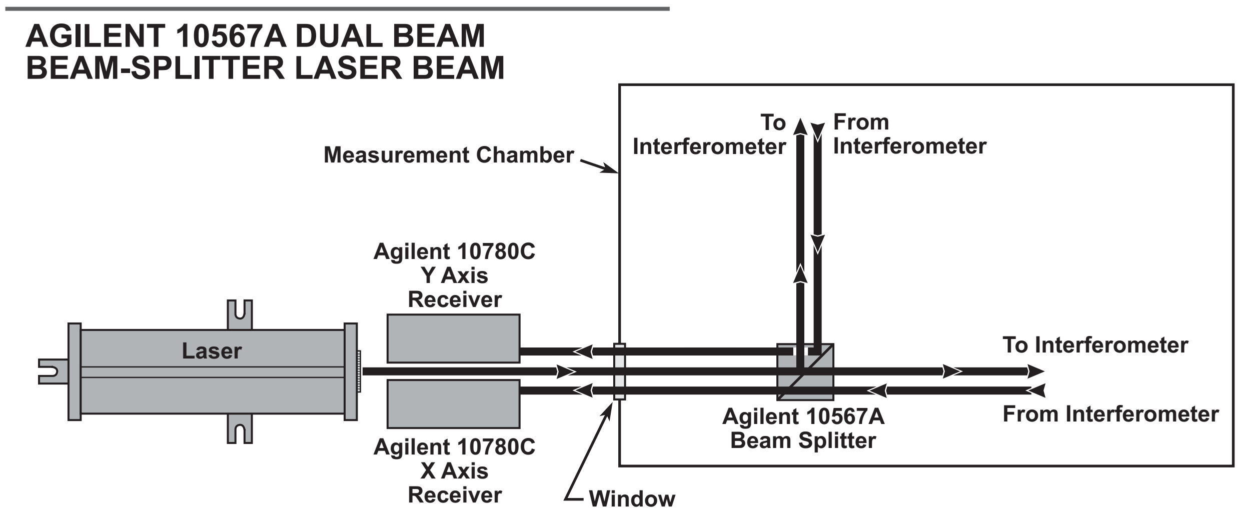


Figure 81 Agilent 10567A Dual Beam Beam-Splitter — laser beam path

Agilent 10567A Dual Beam Beam-Splitter Specifications

Dimensions: See drawings below.

Weight: 325 grams (11.5 ounces)

Materials Used:

Housing: Aluminum
Optics: Optical Grade Glass
Adhesives: Low Volatility (Vacuum Grade)
Coatings: Hard Dielectric

Optical Efficiency:

Typical: 45% (each beam)
Worst Case: 39% (each beam)

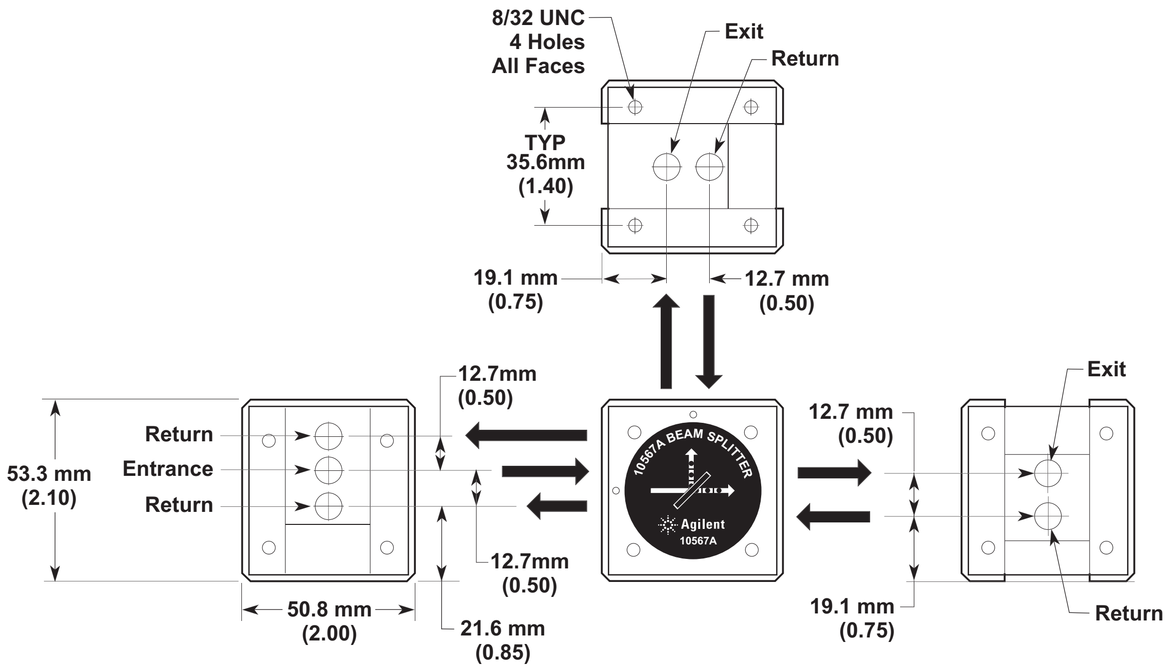


Figure 82 Agilent 10567A Dual Beam Beam-Splitter — dimensions

Agilent 10700A 33% Beam Splitter and 10701A 50% Beam Splitter

Each of these optics directs part of the laser beam along a second axis. Combinations of these optics may be used to split the single laser head beam into multiple parts for multiaxis measurements. The beam splitters are rugged and easy to mount, offering considerable flexibility in their mounting arrangements.

The Agilent 10700A 33% Beam Splitter reflects one-third of the laser beam intensity perpendicular to the original beam direction while the remaining two-thirds continues through the optic.

The Agilent 10701A 50% Beam Splitter operates in a similar manner with a 50% ratio of beam splitting.

By using combinations of these two accessories, the beam may be split into several paths to perform multiaxis measurements. For example, using a 33% and a 50% Beam Splitter, one-third of the laser beam intensity can be directed to each measurement axis in a three-axis machine.

To preserve polarization, see "Preventing Depolarization" on page 362.

To preserve efficiency, see "Note" on page 362.

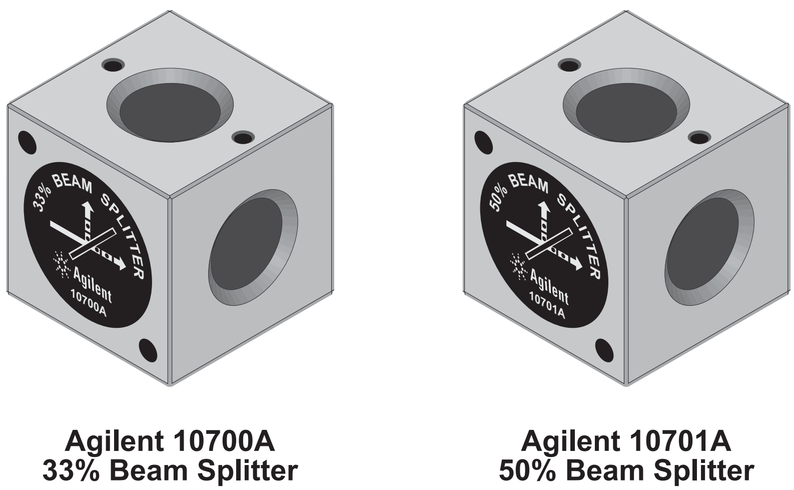


Figure 83 Agilent 10700A 33% Beam Splitter and Agilent 10701A 50% Beam Splitter

Agilent 10700A 33% Beam Splitter Specifications

Dimensions: See drawings below.

Weight: 62 grams (2.2 ounces)

Materials Used:

Housing: Stainless Steel
Optics: Optical Grade Glass
Adhesives: Low Volatility (Vacuum Grade)
Coatings: Hard Dielectric

Optical Efficiency:

Reflective Path: typical 30%, worst case 27%
Transmitted Path: typical 63%, worst case 61%

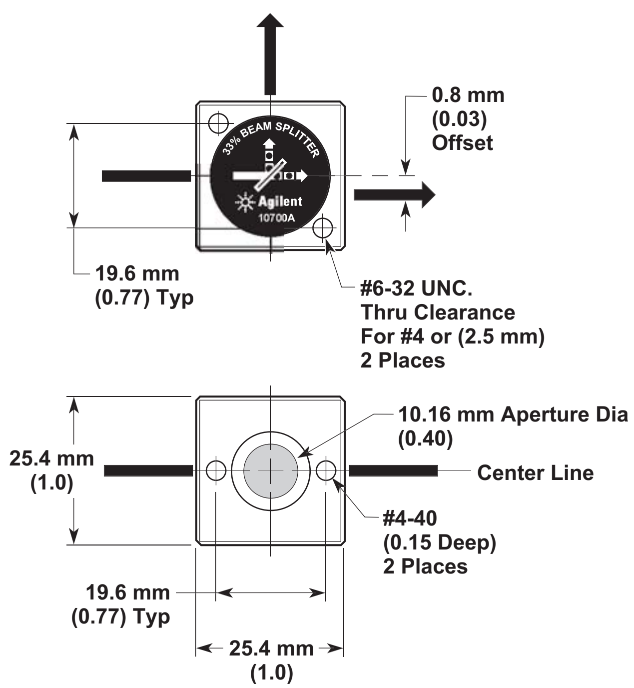


Figure 84 Agilent 10700A 33% Beam Splitter — dimensions

Agilent 10701A 50% Beam Splitter Specifications

Dimensions: See drawings below.

Weight: 62 grams (2.2 ounces)

Materials Used:

Housing: Stainless Steel
Optics: Optical Grade Glass
Adhesives: Low Volatility (Vacuum Grade)
Coatings: Hard Dielectric

Optical Efficiency:

Typical: 45% (each beam)
Worst Case: 39% (each beam)

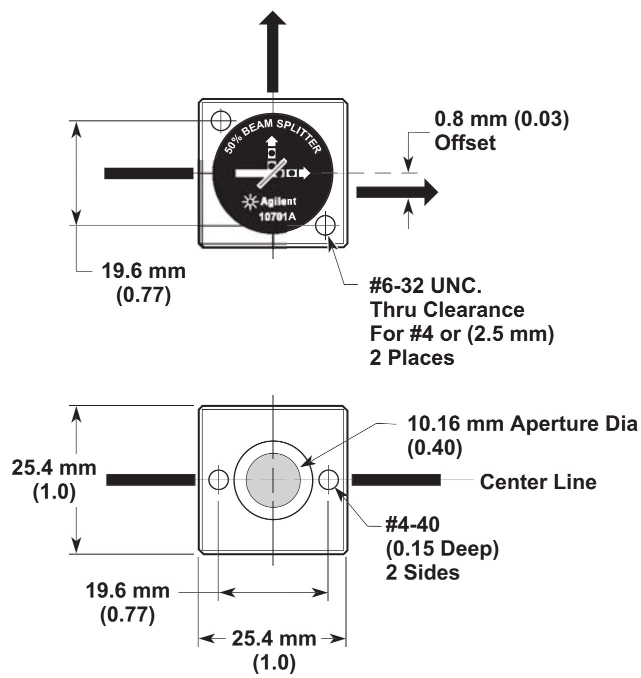


Figure 85 Agilent 10701A 50% Beam Splitter — dimensions

Agilent 10700B 4% Beam Splitter and 10700C 15% Beam Splitter

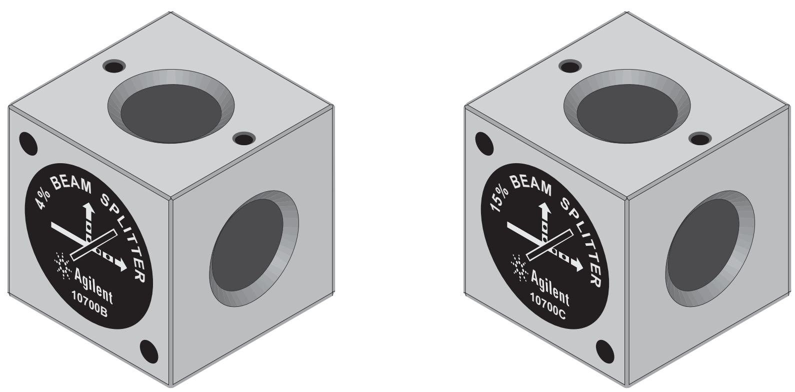
Each of these non-polarizing splitters directs part of the laser beam along a reflected axis. Combinations of beam splitters can be used to split laser beam power so that equal beam power is delivered to each axis in a multiaxis system. The beam splitters are rugged and easy to mount, offering considerable flexibility in their mounting arrangements.

The Agilent 10700B 4% Beam Splitter reflects 4% of the laser beam intensity perpendicular to the original beam direction while the remaining 96% continues through the optic.

The Agilent 10700C 15% Beam Splitter reflects 15% of the laser beam intensity perpendicular to the original beam direction while the remaining 85% continues through the optic.

To preserve polarization, see “Preventing Depolarization" on page 362.

To preserve efficiency, see “Note" on page 362.



Agilent 10700B
4% Beam Splitter

Agilent 10700C
15% Beam Splitter

Figure 86 Agilent 10700B 4% Beam Splitter and Agilent 10700C 15% Beam Splitter

Agilent 10700B 4% Beam Splitter Specifications

Dimensions: See drawings below.

Weight: 62 grams (2.2 ounces)

Materials Used:

Housing: Stainless Steel
Optics: Optical Grade Glass
Adhesives: Low Volatility (Vacuum Grade)
Coatings: Hard Dielectric

Optical Efficiency:

Reflective Path: typical 4%, worst case 3%
Transmitted Path: typical 95%, worst case 94%

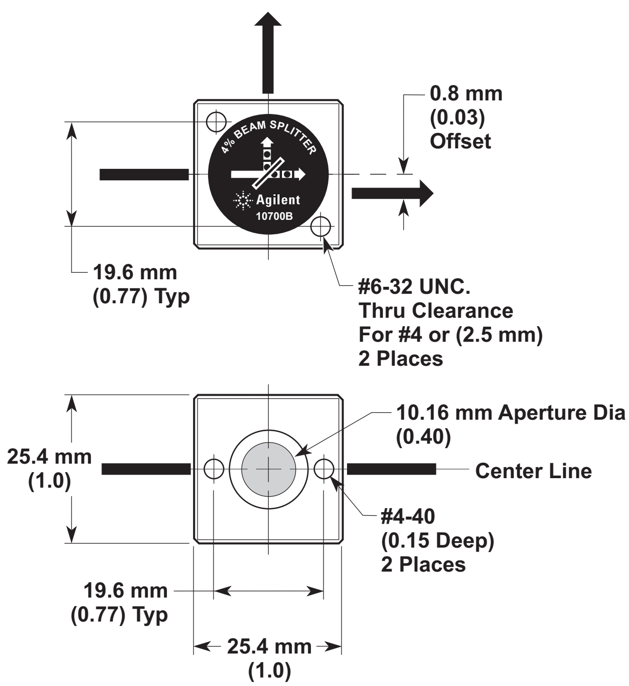


Figure 87 Agilent 10700B 4% Beam Splitter — dimensions

Agilent 10700C 15% Beam Splitter Specifications

Dimensions: See drawings below.

Weight: 62 grams (2.2 ounces)

Materials Used:

Housing: Stainless Steel
Optics: Optical Grade Glass
Adhesives: Low Volatility (Vacuum Grade)
Coatings: Hard Dielectric

Optical Efficiency:

Reflective Path: typical 15%, worst case 9%
Transmitted Path: typical 84%, worst case 78%

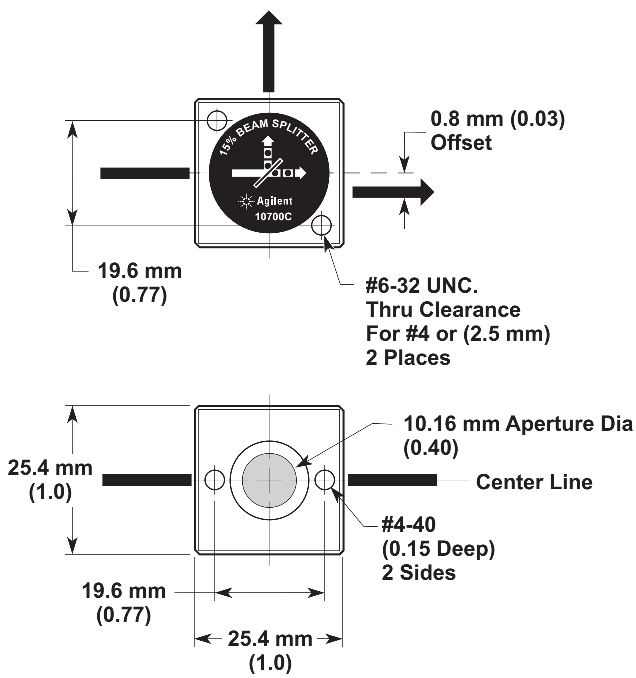


Figure 88 Agilent 10700C 15% Beam Splitter — dimensions

Agilent 10707A Beam Bender

The Agilent 10707A Beam Bender contains a 100% reflectance mirror which turns the direction of an incoming laser beam 90 degrees.

To preserve polarization, see “Preventing Depolarization" on page 362.

To preserve efficiency, see “Note" on page 362.

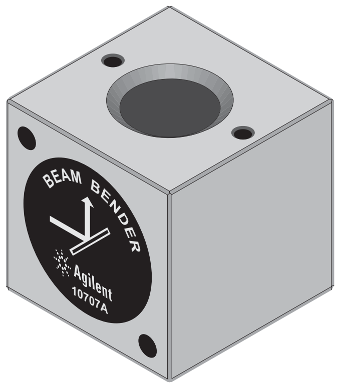


Figure 89 Agilent 10707A Beam Bender

Agilent 10707A Beam Bender Specifications

Dimensions: See drawings below.

Weight: 58 grams (2.1 ounces)

Materials Used:

Housing: Stainless Steel
Optics: Optical Grade Glass
Adhesives: Low Volatility (Vacuum Grade)
Coatings: Hard Dielectric

Optical Efficiency:

Typical: 99%
Worst Case: 98%

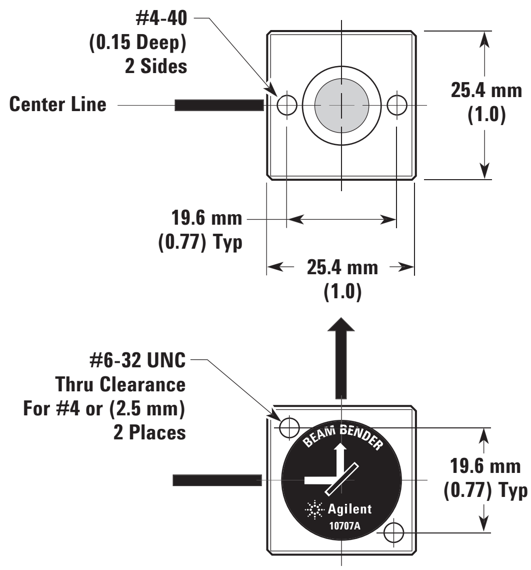


Figure 90 Agilent 10707A Beam Bender — dimensions

Agilent 10725A 50% Beam Splitter and 10726A Beam Bender

The Agilent 10725A 50% Beam Splitter and the Agilent 10726A Beam Bender are designed for use in a laser measurement system that includes an Agilent 10735A or a standard Agilent 10736A Three-axis Interferometer or an Agilent 10736A-001 Three-axis Interferometer with Beam Bender. They are designed to handle the 9 mm beam from an Agilent 5517C-009.

The Agilent 10725A Beam Splitter is the same optical element as that used in the Agilent 10701A (described earlier in this chapter) except that the Agilent 10725A is supplied *without a housing*.

The Agilent 10726A Beam Bender is the same optical element as that used in the Agilent 10772A turning mirror or Agilent 10773A flatness mirror, described in Chapter 36, “Accessories,” except that the Agilent 10726A is supplied *without a housing*.

CAUTION Agilent Technologies does not provide mounting hardware for the Agilent 10725A beam splitter or the Agilent 10726A beam bender. These devices are intended for use in user-designed mounts. The user is responsible for devising a mounting method that does not cause stress in the optic which will result in distortion of the reflected laser wavefronts.

To preserve polarization, see “Preventing Depolarization" on page 362.

To preserve efficiency, see “Note" on page 362.

Agilent 10725A Beam Splitter Specifications

Use: Split a laser beam having a diameter up to 9 mm (nominal). This beam splitter requires a user-supplied mount. This optic can be made vacuum compatible.

Type: Non-polarizing

Dimensions: See drawings below.

Weight: 2 grams (0.07 ounce)

Materials Used: Optic, Fused silica

Optical Efficiency:

Typical: 45% (each beam)

Worst Case: 39% (each beam)

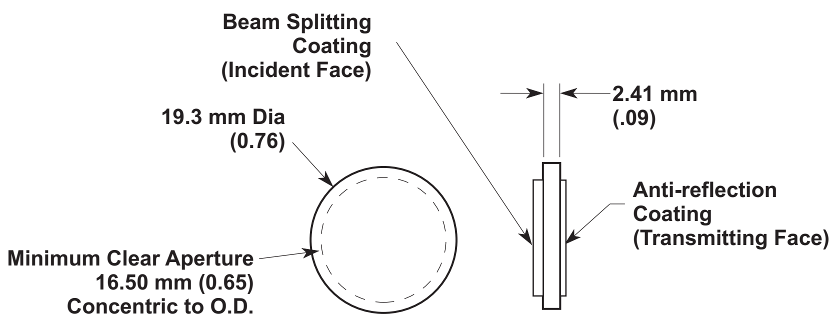


Figure 91 Agilent 10725A 9mm Laser Beam Splitter — dimensions

Agilent 10726A Beam Bender Specifications

Use: Bend a laser beam having a diameter up to 9 mm (nominal). This beam bender requires a user-supplied mount. This optic can be made vacuum compatible.

Dimensions: See drawings below.

Weight: 10 grams (0.35 ounce)

Materials Used: Optic, Fused silica

Optical Efficiency:

Typical: 99%

Worst Case: 98%

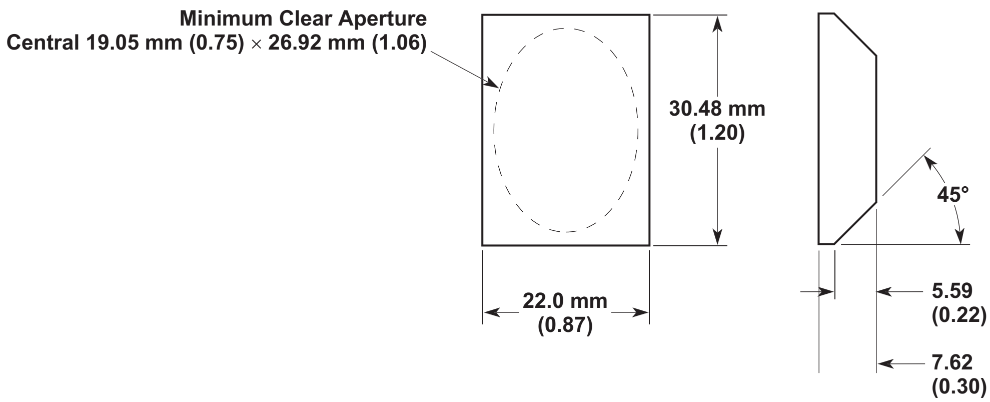


Figure 92 Agilent 10726A 9mm Laser Beam Bender — dimensions

Agilent 10725B 4% and Agilent 10725C 15% Beam Splitters

Each of these bare optics, non-polarizing beam splitter is designed for use in multiaxis laser measurement systems. They are designed to handle the 9 mm beam from an Agilent 5517C-009.

The Agilent 10725B Beam Splitter is the same optical element as that used in the Agilent 10700B (described earlier in this chapter) except that the Agilent 10725B is supplied without a housing. Likewise, the Agilent 10725C Beam Splitter is the same optic as that used in the 10700C minus housing.

CAUTION Agilent Technologies does not provide mounting hardware for the Agilent 10725B/C beam splitters. These devices are intended for use in user-designed mounts. The user is responsible for devising a mounting method that does not cause stress in the optic which will result in distortion of the reflected laser wavefronts.

To preserve polarization, see “Preventing Depolarization" on page 362.

To preserve efficiency, see “Note" on page 362.

Agilent 10725B/C Beam Splitter Specifications

Use: Split a laser beam having a diameter up to 9 mm (nominal). This beam splitter requires a user-supplied mount. This optic can be made vacuum compatible.

Type: Non-polarizing

Dimensions: See drawings below.

Weight: 2 grams (0.07 ounce)

Materials Used: Optic, Fused silica

Optical Efficiency:

10725B —

Reflected Path: Typical 4%; worst case 3%

Transmitted Path: Typical 95%; worst case 94%

10725C —

Reflected Path: Typical 15%; worst case 9%

Transmitted Path: Typical 84%; worst case 78%

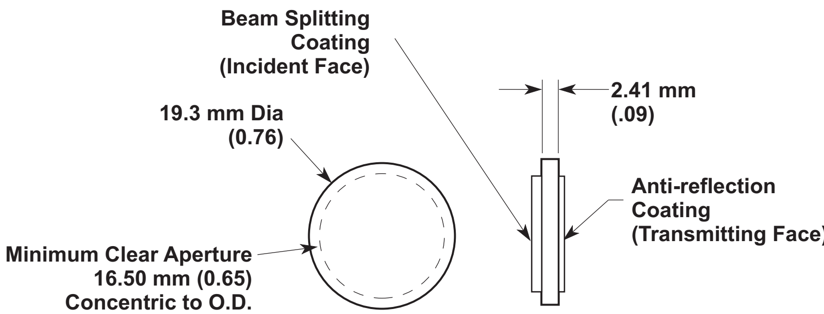


Figure 93 Agilent 10725B/C 9mm Laser Beam Splitter — dimensions

Agilent E1833C/E/G/J/M Bare Beam Splitter

The Agilent E1833C/E/G/J/M are bare beam splitters that can be used for routing the laser beam throughout the laser interferometer system. These splitters require user-supplied mounts and have a clear apeture of 29 mm × 19 mm.

The Agilent E1833C 15% Bare Beam Splitter nominally reflects 15% of the laser beam intensity perpendicular to the original beam direction while the 85% continues through the optic.

The Agilent E1833E 33% Bare Beam Splitter nominally reflects one-third (or 33%) of the laser beam intensity perpendicular to the original beam direction while the remaining two-thirds continues through the optic.

The Agilent E1833G 50% Bare Beam Splitter nominally reflects 50% of the laser beam intensity perpendicular to the original beam direction while the remaining 50% continues through the optic.

The Agilent E1833J 67% Bare Beam Splitter nominally reflects 67% of the laser beam intensity perpendicular to the original beam direction while the remaining 33% continues through the optic.

The Agilent E1833M 100% Bare Beam Splitter (beam bender) nominally reflects 100% of the laser beam intensity perpendicular to the original beam.

To preserve polarization, see “Preventing Depolarization" on page 362.

To preserve efficiency, see “Note" on page 362.

Agilent E1833C/E/G/J/M Bare Beam Splitter Specifications

Use: Split a laser beam having a diameter up to 9 mm (nominal). This beam splitter requires a user-supplied mount. This optic can be made vacuum compatible.

Dimensions: See drawings below.

Weight: 2 grams (0.07 ounce)

Materials Used:

Optics: BK7

Optical Efficiency:

Reflective path:

E1833C: 15% ± 5%

E1833E: 33% ± 5%

E1833G: 50% ± 5%

E1833J: 67% ± 5%

E1833M: 100% -5%

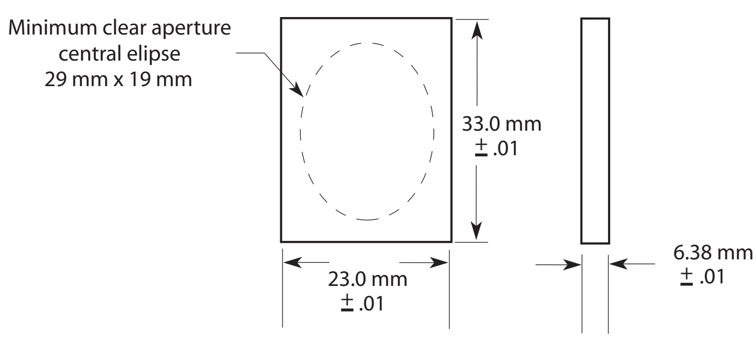


Figure 94 Agilent E1833C/E/G/J/M Bare Beam Splitter — dimensions

Agilent N1203C, N1204C, and N1207C Beam Manipulators

Overview

The purpose of the Agilent N1203C, N1204C, and N1207C beam manipulators (shown in Figure 95) is to precisely bend or translate a laser beam to achieve sub-nanometer distance measurements. The precise bending and translating results in a properly aligned laser beam. An improperly aligned laser system will produce errors. The beam manipulators are very useful in rapid laser system alignment used for precision distance measurements.

The Agilent N1203C Precision Beam Translator is a precision optical mount for a refracting window. The Agilent N1204C Precision Horizontal Beam Bender and Agilent N1207C Precision Vertical Beam Bender are precision optical mounts for bending mirrors. These products are designed to provide high resolution positioning of laser beams for precise distance measurements by the application of *removable tooling* (see “Agilent N1203C/04C/07C Beam Manipulator Accessories” in Chapter 36, “Accessories,” of this manual for details on the adjustment tool kit). Once the adjustment is completed and tools removed, this mount will provide long-term stability of the initial setting in the presence of specified thermal, shock and vibration environments.

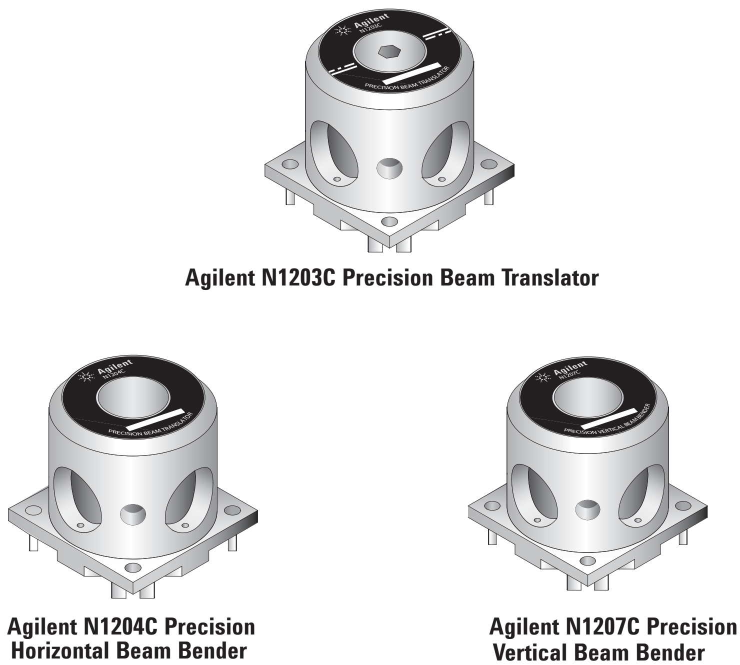


Figure 95 Agilent precision beam manipulators

The Agilent N1203C translates the beam so that the measurement beam is positioned where you want it on the stage mirror. The offset laser beam remains parallel to the original beam direction. The translator is useful whenever a high precision distance measurement with a laser is performed because it can reduce Abbé error.

The Agilent N1204C and N1207C steer the laser beam in angle in either the horizontal or vertical plane. The beam bender’s optical component (a mirror) is intended to turn the laser beam 90° relative to the original beam direction. The beam bender is useful whenever high precision distance measurements with a laser is performed because it can reduce cosine error.

Application simplified

These beam manipulators are easier to use and more durable than previous versions. The manipulators provide more stability to laser measurement systems than previous solutions. The operator merely aligns the manipulator *with removable tools*. The operator need not perform the secondary clamping operation. The manipulators are already clamped.

Stability

Thermal

The Agilent N1203C, N1204C, and N1207C beam manipulators exhibit improved thermal stability since all components of the manipulator are of the same material, and the ball is suspended symmetrically in a spring nest.

The symmetry of this design enables the contact points between the ball and the springs to remain precisely the same as the temperature changes. Hence, as the temperature changes, there is no rotation imparted to the ball.

Mechanical

The beam manipulator feet are designed not to slip due to differential thermal expansion between the stainless steel housing and an Invar mounting plate in the presence of an environmental temperature change of up to 20° C. Thus, there will be no unrecoverable beam displacement due to foot slippage when mounted to any material whose CTE is in the range of 1.6×10^{-6}/° C to 21.8×10^{-6}/° C provided the feet are secured with the specified bolt torque value (see the specifications and characteristic sections for the beam manipulators at the end of this chapter).

Optical Input/Output ports and adjustment access

The Agilent N1203C, N1204C, and N1207C manipulators have six input and output (I/O) ports. There is only one mounting face. From this one mounting, either horizontal or vertical bends in any direction may be accomplished. Adjustment tools may be attached at any of ten access ports, allowing two of the I/O ports for entrance and exit of the laser beam.

See the *Agilent N1203C Precision Beam Translator and Agilent 1204C and N1207C Precision Beam Benders User's Guide* for details on mounting, aligning, adjusting, etc. of these beam manipulators.

Agilent N1203C Precision Beam Translator Specifications and Characteristics

Dimensions:	See Figure 96.
Weight:	920 grams
Materials Used:	Martensitic stainless steel Optical grade glass
Optical Efficiency:	99% typical 98.7% Worst case
Input/Output Clear Aperture:	ϕ 19.0 mm
Input Beam Position Tolerance:	± 5mm (Note: input beam de-centering may limit translation range. See range specification below.)
Beam Translation Range (from input at normal incidence on center of clear aperture):	± 3 mm with ϕ 9 mm beam ± 4.0 mm with ϕ 6 mm beam ± 4.4 mm with ϕ 3 mm beam
Angular Beam Deviation:	± 10 microradian maximum
Beam Translation Sensitivity/Resolution:	1.0 micrometer

Thermal Drift:

$$\text{Translated Beam Displacement per}^\circ C = \frac{\Delta D}{\Delta T} = 100\, nm \text{ per}^\circ C$$

Shift of output beam position is theroretically possible in the presence of a thermal gradient in the assembly, but the refractive translator is quite insensitive to small angular changes. Nevertheless, even these miniscule shifts are transitory and the original position is recovered when the gradient has settled out.

Thermal Stability of Alignment:

Ball to Housing

Beam position alignment is fully recoverable over a slow environmental temperature change of 20° C provided there are no sharp thermal gradients within the assembly (i.e., ΔD/ΔT ~20° C/hr.)

Housing to Mounting Plate

The Manipulator feet are designed not to slip due to differential thermal expansion between the stainless steel housing and an Invar mounting plate in the presence of an environmental temperature change of 20° C. Thus, there should be no unrecoverable beam displacement due to foot slippage when mounted to any material whose CTE is in the range of $1.6 \times 10^{-6}/°$ C to $21.8 \times 10^{-6}/°$ C provided the feet are secured with the specified bolt torque value.

Resonant Frequencies:

Ball and Spring Suspension

The laser beam Manipulator comprises a very stiff, nonlinear spring-mass system. At shock levels below the shock damage threshold it is not possible to excite a free vibration resonance in the ball suspension. This is due to three phenomena:

1. Prestress stiffening due to compression of the springs in final assembly.
2. Stiffening due to geometrical deformation of the beam springs as a result of the compressive load.
3. Frictional damping between ball and springs.

Resonant Frequencies (Continued):

Ball and Spring Suspension (Continued)

The natural resonance of the spring-mass system (350 Hz) is completely supressed by these effects.

The first FFT measured resonance in the assembly is at 3.5 kHz, which is the Ball itself. The next resonance is at 3.7 kHz, which is the Housing:

Thus, there is no resonance which could disturb laser beam alignment or position in the operating environment.

Shock:

Operating: 40 g, half sine, 2.9 ms

A shock load of 40 g, half sine, 2.9 ms will not disturb the alignment of the Ball, Refractive Translator or laser beam.

Non Operating: 60 g, half sine, 2.9 ms

A shock load of 60 g, half sine, 2.9 ms will not damage the Manipulator components, but may disturb alignment of the Ball.

Recommended Mounting Screws:

Four screws M5 × 20 long Alloy Steel; Grade 12.9: Seating Torque is 5 N.m if Cadmium plated, or 6.5 N.m if unplated.

OR

Four screws 10-32 UNF × .75 inches long Alloy Steel: Seating Torque is 39 in-lbs if Cadmium plated, or 51 in-lbs if unplated.

Adjustment Tooling: 5 mm Hex-key wrench

Agilent N1204C Precision Horizontal Beam Bender Specifications and Characteristics

Dimensions:	See Figure 96.
Weight:	920 grams
Materials Used:	Martensitic stainless steel Optical grade glass
Optical Efficiency:	99% typical 97.5% Worst case
Input/Output Clear Aperture:	ϕ 13.0 mm
Input Beam Position Tolerance:	± 1.6 mm for ϕ 9mm beam
Angular Beam Steering Range (from nominal 90°, ϕ 9 mm beam centered on ϕ 13 mm Aperture):	**Yaw: ± 6° (using Adjustment Lever and adapter at ϕ25 mm port)**
	Pitch: ± 3° (using Adjustment Lever and adapter at ϕ25 mm port)
	Yaw: ± 1° (using Adjustment Lever only, at ϕ9 mm port)
	Pitch: ± 0.7° (using Adjustment Lever only, at ϕ9mm port)
Angular Adjustment Sensitivity and Beam Steering Resolution:	10 – 15 μradians (better with operator patience)

Thermal Drift:

With the Manipulator feet on a horizontal surface:

$$Pitch \quad \frac{\Delta P}{\Delta T} = 5\ \mu rad\ per\ ^\circ C$$

$$Yaw \quad \frac{\Delta Y}{\Delta T} = 0.5\ \mu rad\ per\ ^\circ C$$

Drift of beam steering angle can occur in the presence of thermal gradients in the Manipulator assembly. This drift is transitory and alignment is recovered when the gradient has settled out.

Thermal Stability of Alignment:

Ball to Housing

Beam angle steering alignment is recoverable over a slow environmental temperature change of 20° C provided there are no sharp thermal gradients within the assembly (i.e., ΔT/Δt ~20° C/hr.)

Housing to Mounting Plate

The Manipulator feet are designed not to slip due to differential thermal expansion between the stainless steel housing and an Invar mounting plate in the presence of an environmental temperature change of 20° C. Thus, there should be no unrecoverable misalignment due to foot slippage when mounted to any material whose CTE is in the range of $1.6 \times 10^{-6}/^\circ C$ to $21.8 \times 10^{-6}/^\circ C$ provided the feet are secured with the specified bolt torque value.

Resonant Frequencies:

Ball-Spring Suspension

The laser beam Manipulator comprises a very stiff, nonlinear spring-mass system. At shock levels below the shock damage threshold it is not possible to excite a free vibration resonance in the ball suspension. This is due to three phenomena:

1. Prestress stiffening due to compression of the springs in final assembly.
2. Stiffening due to geometrical deformation of the beam springs as a result of the compressive load.
3. Frictional damping between ball and springs.

The natural resonance of the spring-mass system (350 Hz) is completely supressed by these effects.

The first FFT measured resonance in the assembly is at 3.5 kHz, which is the Ball itself. The next resonance is at 3.7 kHz, which is the Housing:

Thus, there is no resonance which could disturb laser beam alignment or position in the operating environment.

Mirror-Spring Suspension

The Mirror is held against three mounting pads machined into the Ball by spring forces opposite the pads. This spring mass system is not free to vibrate unless the Mirror is separated from the contact with pads. It requires a shock load of 280 g (far in excess of the shock damage threshold) to separate the Mirror from the Ball. Thus, it is not possible in practice to excite a resonance.

Note: The *calculated* resonance for the Mirror./Spring system *if the ball were free* to oscillate is 340 Hz.

Shock

Operating: 40 g, half sine, 2.9 ms

A shock load of 40 g, half sine, 2.9 ms will not disturb the alignment of the Ball, Mirror or laser beam.

Non Operating: 60 g, half sine, 2.9 ms

A shock load of 60 g, half sine, 2.9 ms will not damage the Manipulator components, but may disturb alignment.

Recommended Mounting Screws:

Four screws M5 × 20 long Alloy Steel; Grade 12.9: Seating Torque is 5 N.m if Cadmium plated, or 6.5 N.m if unplated.

OR

Four screws 10-32 UNF × .75 inches long Alloy Steel: Seating Torque is 39 in-lbs if Cadmium plated, or 51 in-lbs if unplated.

Angular Adjustment Tool Leverage: Lever rotatation : ball rotation = 2.9 : 1

Agilent N1207C Precision Vertical Beam Bender Specifications and Characteristics

Dimensions:	See Figure 96.
Weight:	920 grams
Materials Used:	Martensitic stainless steel Optical grade glass
Optical Efficiency:	99% typical 97.5% Worst case
Input/Output Clear Aperture:	ϕ 13.0 mm
Input Beam Position Tolerance:	± 1.6 mm for ϕ 9mm beam
Angular Beam Steering Range (from nominal 90°, ϕ 9 mm beam centered on ϕ 13 mm Aperture):	**Yaw: ± 3° (using Adjustment Lever and adapter at ϕ25 mm port)** Pitch: ± 6° (using Adjustment Lever and adapter at ϕ25 mm port) Yaw: ± 0.7° (using Adjustment Lever only, at ϕ9 mm port) Pitch: ± 1° (using Adjustment Lever only, at ϕ9mm port)
Angular Adjustment Sensitivity and Beam Steering Resolution:	10 – 15 μradians (better with operator patience)

Thermal Drift:

With the Manipulator feet on a horizontal surface:

$$Pitch \quad \frac{\Delta P}{\Delta T} = 5\ \mu rad\ per\ ^\circ C$$

$$Yaw \quad \frac{\Delta Y}{\Delta T} = 0.5\ \mu rad\ per\ ^\circ C$$

Drift of beam steering angle can occur in the presence of thermal gradients in the Manipulator assembly. This drift is transitory and alignment is recovered when the gradient has settled out.

Thermal Stability of Alignment:

Ball to Housing

Beam angle steering alignment is recoverable over a slow environmental temperature change of 20° C provided there are no sharp thermal gradients within the assembly (i.e., ΔT/Δt ~20° C/hr.)

Housing to Mounting Plate

The Manipulator feet are designed not to slip due to differential thermal expansion between the stainless steel housing and an Invar mounting plate in the presence of an environmental temperature change of 20° C. Thus, there should be no unrecoverable misalignment due to foot slippage when mounted to any material whose CTE is in the range of 1.6×10^{-6}/° C to 21.8×10^{-6}/° C provided the feet are secured with the specified bolt torque value.

Resonant Frequencies:

Ball-Spring Suspension

The laser beam Manipulator comprises a very stiff, nonlinear spring-mass system. At shock levels below the shock damage threshold it is not possible to excite a free vibration resonance in the ball suspension. This is due to three phenomena:

1. Prestress stiffening due to compression of the springs in final assembly.
2. Stiffening due to geometrical deformation of the beam springs as a result of the compressive load.
3. Frictional damping between ball and springs.

The natural resonance of the spring-mass system (350 Hz) is completely supressed by these effects.

The first FFT measured resonance in the assembly is at 3.5 kHz, which is the Ball itself. The next resonance is at 3.7 kHz, which is the Housing:

Thus, there is no resonance which could disturb laser beam alignment or position in the operating environment.

Mirror-Spring Suspension

The Mirror is held against three mounting pads machined into the Ball by spring forces opposite the pads. This spring mass system is not free to vibrate unless the Mirror is separated from the contact with pads. It requires a shock load of 280 g (far in excess of the shock damage threshold) to separate the Mirror from the Ball. Thus, it is not possible in practice to excite a resonance.

Note: The *calculated* resonance for the Mirror./Spring system *if the ball were free* to oscillate is 340 Hz.

Shock

Operating: 40 g, half sine, 2.9 ms

A shock load of 40 g, half sine, 2.9 ms will not disturb the alignment of the Ball, Mirror or laser beam.

Non Operating: 60 g, half sine, 2.9 ms

A shock load of 60 g, half sine, 2.9 ms will not damage the Manipulator components, but may disturb alignment.

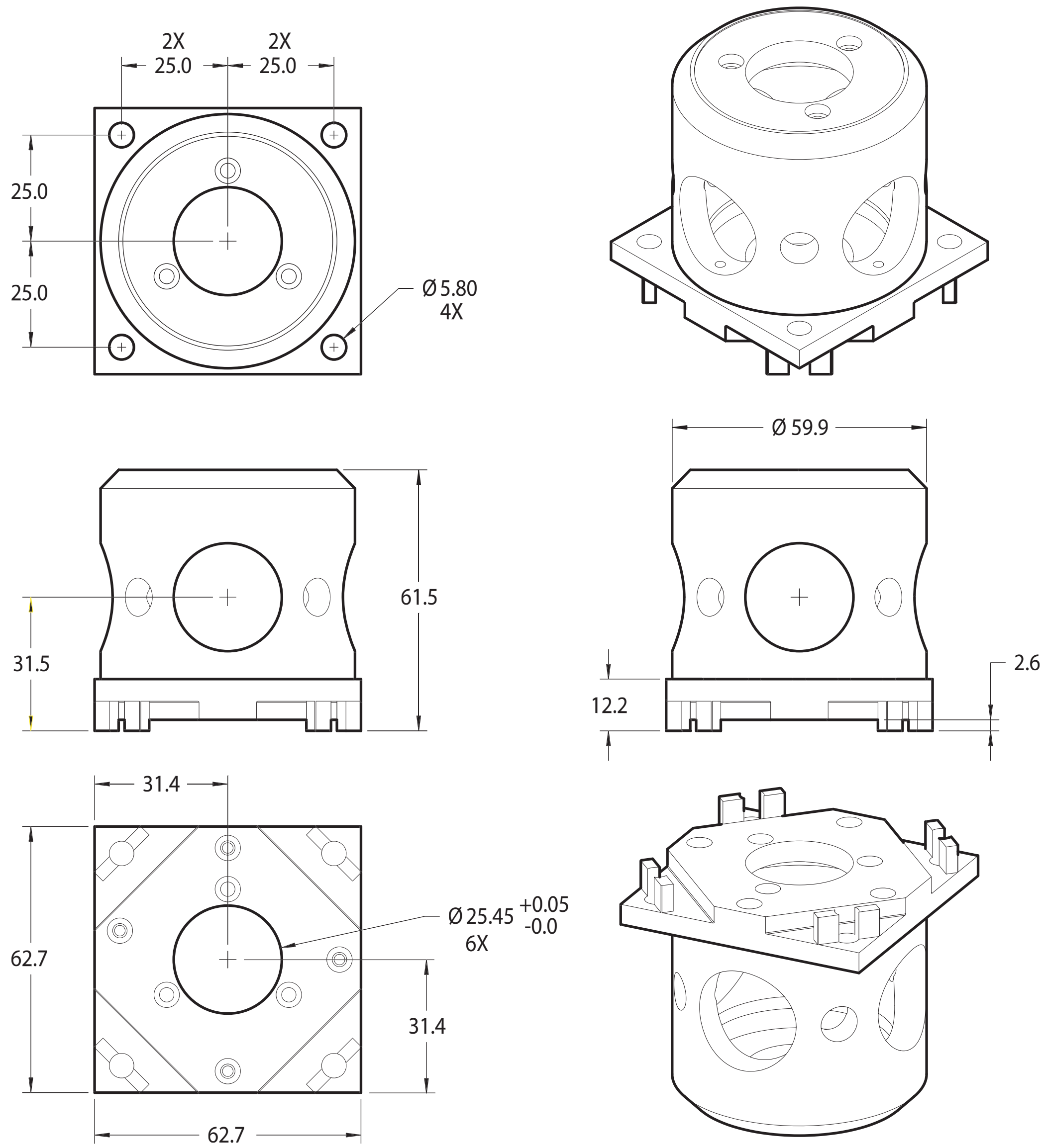
Recommended Mounting Screws:

Four screws M5×20 long Alloy Steel; Grade 12.9: Seating Torque is 5 N.m if Cadmium plated, or 6.5 N.m if unplated.

OR

Four screws 10-32 UNF × .75 inches long Alloy Steel: Seating Torque is 39 in-lbs if Cadmium plated, or 51 in-lbs if unplated.

Angular Adjustment Tool Leverage: Lever rotatation : ball rotation = 2.9 : 1



Unless otherwise specified, dimensions are in millimeters (mm).

Figure 96 Agilent N1203C/N1204C/N1207C beam manipulator dimensions

Agilent N1208C/D/E/F/G Bare Beam Splitter

The Agilent N1208C/D/E/F/G are bare beam splitters that can be used for routing the laser beam throughout the laser interferometer system. These splitters require user-supplied mounts and can handle beam diameters up to 9 mm (nominal).

The Agilent N1208C 33% Bare Beam Splitter nominally reflects one-third (or 33%) of the laser beam intensity perpendicular to the original beam direction while the remaining two-thirds continues through the optic.

The Agilent N1208D 40% Bare Beam Splitter nominally reflects 40% of the laser beam intensity perpendicular to the original beam direction while the remaining 60% continues through the optic.

The Agilent N1208E 50% Bare Beam Splitter nominally reflects 50% of the laser beam intensity perpendicular to the original beam direction while the remaining 50% continues through the optic.

The Agilent N1208F 66% Bare Beam Splitter nominally reflects 66% of the laser beam intensity perpendicular to the original beam direction while the remaining 34% continues through the optic.

The Agilent N1208G 60% Bare Beam Splitter nominally reflects 60% of the laser beam intensity perpendicular to the original beam direction while the remaining 40% continues through the optic.

To preserve polarization, see “Preventing Depolarization" on page 362.

To preserve efficiency, see “Note" on page 362.

Agilent N1208C/D/E/F/G Bare Beam Splitter Specifications

Use: Split a laser beam having a diameter up to 9 mm (nominal). This beam splitter requires a user-supplied mount. This optic can be made vacuum compatible.

Dimensions: See drawings below.

Weight: 2 grams (0.07 ounce)

Materials Used:

Optics: Fused silica

Coatings: Hard Dielectric

Optical Efficiency:

Reflective path:	Transmitted path:
N1208C: 33% ± 6%	66% ± 6%
N1208D: 40% ± 6%	56% ± 6%
N1208E: 50% ± 6%	49% ± 6%
N1208F: 66% ± 6%	33% ± 6%
N1208G: 60% ± 6%	39% ± 6%

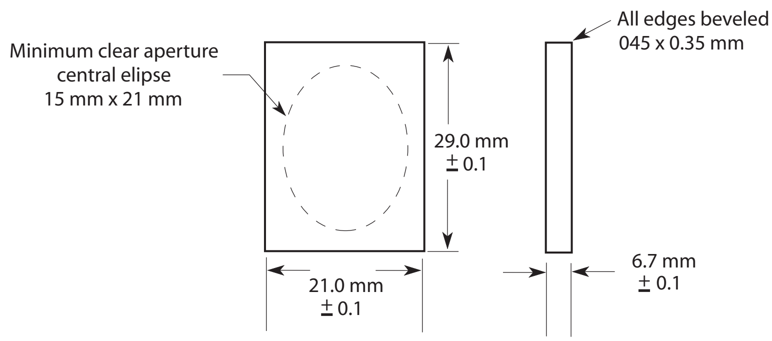


Figure 97 Agilent N1208C/D/E/F/G Bare Beam Splitter — dimensions

Agilent N1209A Risley Prism Translator (RPT) Manipulator

Overview

The purpose of the Agilent N1209A RPT Manipulator (see Figure 98) is to provide you with a means of quickly making precise translation and angular adjustments on a laser beam. This manipulator can precisely translate and steer a laser beam for measurements that require extreme accuracy in applications where you do not want to spend a great deal of time aligning the laser beam.

The Agilent N1209A RPT Manipulator provides high resolution over a large range in a compact, lightweight package with high mechanical stability. The laser beam can quickly be bent and translated by elements in a single package, using separate controls, enabling you to place the beam at the desired angle and location in space. No special tools or mounting pins are required.

The Agilent N1209A RPT Manipulator is easy to use and provides both translation and angular adjustments at an affordable cost. The transmissive design provides excellent long-term stability during temperature and humidity fluctuations and is suited for applications requiring up to 3 mm of translation and 18 milliradians of angular adjustment.

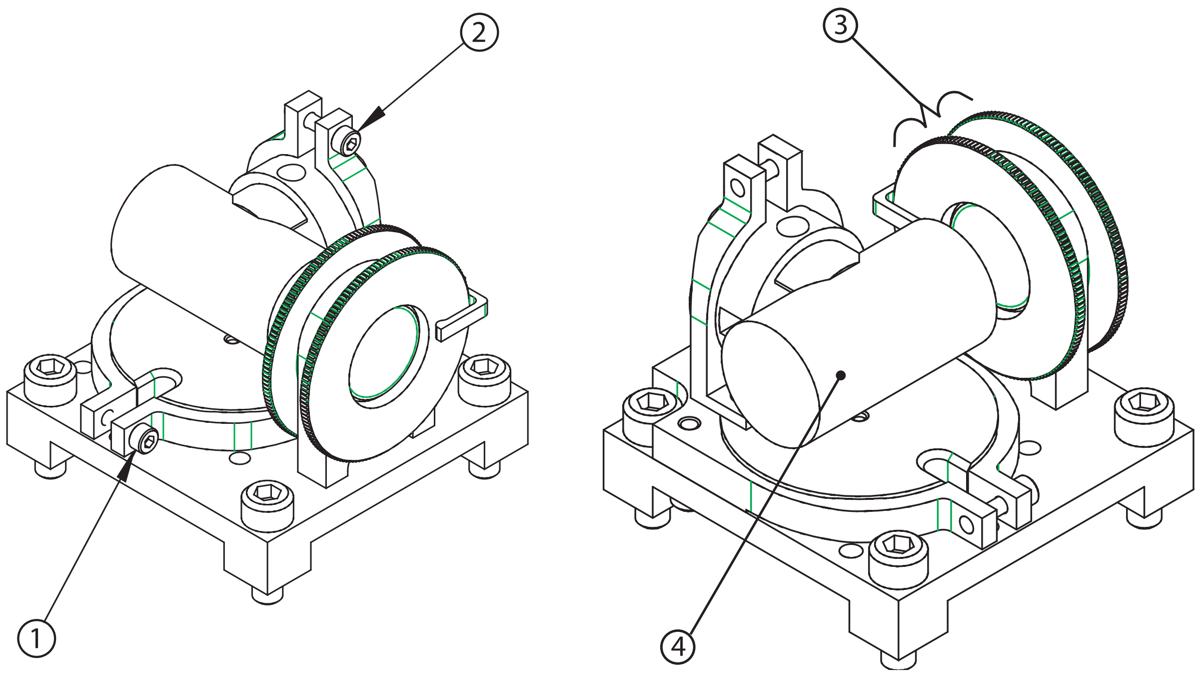


Figure 98 Agilent N1209A RPT Manipulator

1 Yaw clamping screw

2 Pitch clamping screw

3 Risley prism set

4 Translator optic

Elements in the Agilent N1209A RPT Manipulator

The Agilent N1209A RPT Manipulator is comprised of:

- a Risley prism set
- a translator optic

The Risley prism set is used to adjust the angle of the beam.

The translator optic is set to translate the beam horizontally and vertically.

Thermal stability

The RPT manipulator can be fastened to most materials without concern for the difference between material thermal expansion coefficients due to the transmissive design.

Optical input/output ports and adjustment access

The Agilent N1209A RPT Manipulator has one input port and one output port. There is only one mounting face. An adjustment tool is used to adjust the pitch and yaw of the translator optic. The Risley prism set is adjusted by hand.

Adjustment tools

Customer-supplied hardware

- 4 mm hex-key wrench
- 2 mm hex-key wrench

A customer-supplied 4 mm hex-key wrench is needed to adjust the pitch and yaw of the translator optic. A 2 mm hex-key wrench is used to tighten the locking screws after making adjustments.

See the *Agilent N1209A Risley Prism Translator (RPT) Manipulator User's Guide* for details on mounting, aligning, adjusting, etc. of this beam manipulator.

Agilent N1209A RPT Manipulator Specifications

Physical Characteristics	
Dimensions	See Figure 99.
Weight	350 grams
Resonant Frequency	>500 Hz
Material	
Glass	BK7
Metal	416 stainless, passivated
Thermal Drift	
Translation	<100 nm/°C
Angle	<10 mradians/°C
Optical Efficiency	>95%
Risley Prism Clear Aperture	16 mm
Translator Clear Aperture	19 mm
Beam Translation Range	± 3 mm radial
Beam Translation Resolution	20 microns
Maximum Angular Beam Deviation	18 milliradians
Angular Beam Resolution	<30 microradians
Recommended Mounting Screws	
Four screws M5×20 long Alloy Steel; Grade 12.9	Seating Torque is 5 N.m if Cadmium plated, or 6.5 N.m if unplated.
OR	
Four screws 10-32 UNF × 0.75 inches long Alloy Steel	Seating Torque is 39 in-lbs if Cadmium plated, or 51 in-lbs if unplated.
Adjustment Tooling	4 mm and 2 mm hex-key wrenches
Locking Screw Torque	M2.5 screws at 0.56N.m (5 in-lbs)

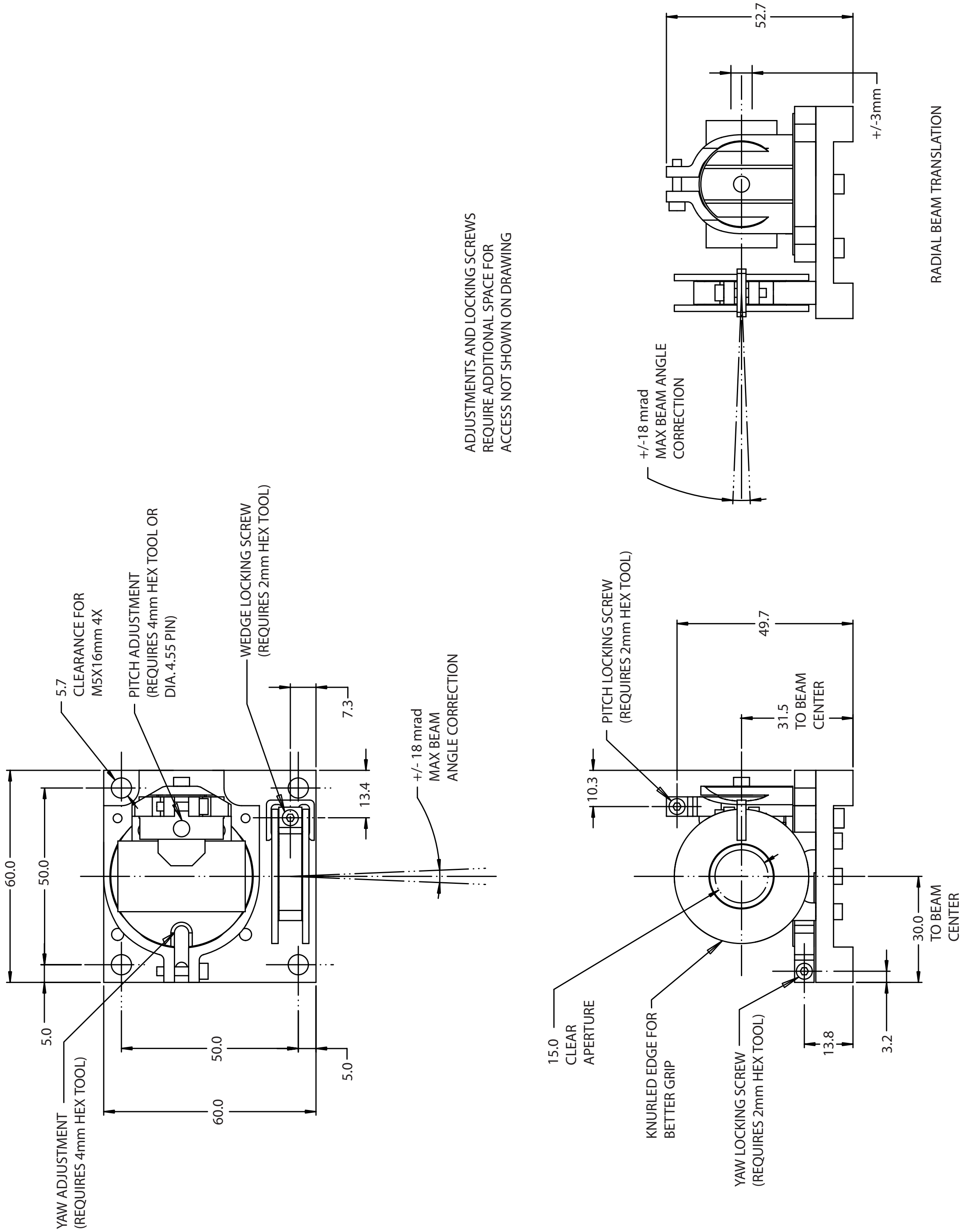


Figure 99 Agilent N1209A RPT manipulator dimensions

18
Agilent 10702A and 10766A Linear Interferometers, and Agilent 10703A and 10767 Retroreflectors

Introduction

This chapter describes:

- the Agilent 10702A Linear Interferometer, including the Agilent 10702A-001 Linear Interferometer with Windows
- the Agilent 10703A Retroreflector
- the Agilent 10766A Linear Interferometer
- the Agilent 10767A Retroreflector
- use of the Agilent 10722A Plane Mirror Converter
- use of the Agilent 10723A High Stability Adapter

Description

The Agilent 10702A Linear Interferometer (see Figure 100) and the Agilent 10766A Linear Interferometer are intended for general-purpose applications. Designed for use with a separate cube corner reflector, these products are paired with the Agilent 10703A Retroreflector (see Figure 100) or the Agilent 10767A Retroreflector (see Figure 103), respectively.

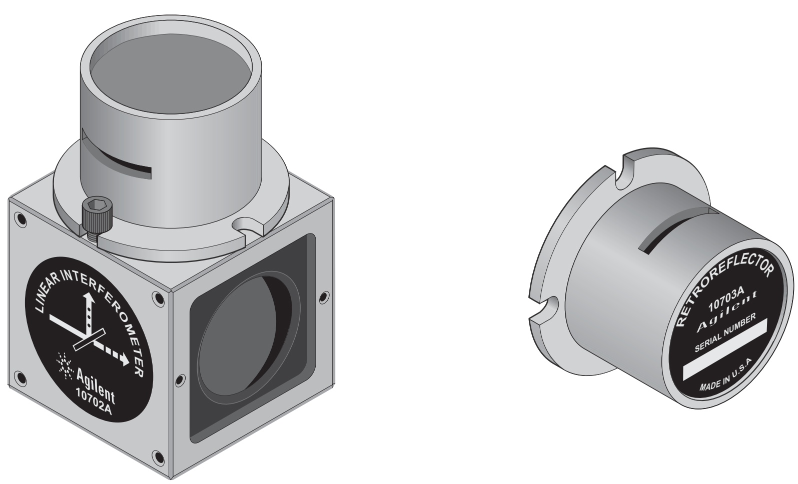


Figure 100 Agilent 10702A Linear Interferometer Agilent 10702A-001 Linear Interferometer with Windows

The Agilent 10702A Linear Interferometer, being the simplest interferometer, should be used whenever possible. The measurement retroreflector for this interferometer is the Agilent 10703A Retroreflector. Displacement is measured between the interferometer and the retroreflector (cube corner). Either one or both can move. If the linear interferometer must move, the Agilent 10702A-001 Linear Interferometer with Windows must be used (see Figure 101).

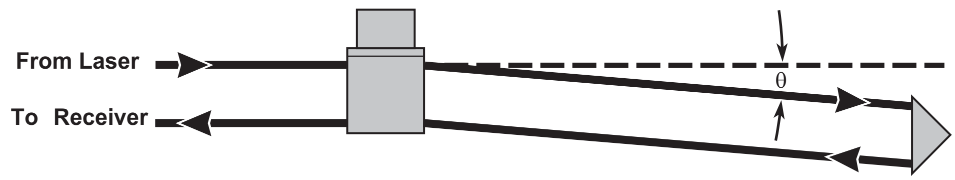
Normally, one optic is mounted on a moving part and the other is mounted on a fixed part and the displacement between the two is measured. A diagram of this is shown in Figure 102. Note that for multi-axis installations each axis must be mechanically independent of the other. In other words, motion in the Y-axis should have no effect on the alignment of the X-axis optics.

The Agilent 10766A Linear Interferometer (see Figure 103) is optically identical to the Agilent 10702A-001 Linear Interferometer with Windows. However, in order to withstand the handling and repeated installations of calibrator-type applications, the Agilent 10766A interferometer has a more-robust housing than the Agilent 10702A Option 001 interferometer (which is intended for laser transducer measurement system applications). Also, the Agilent 10766A interferometer has metric dimensions and metric threads, whereas the Agilent 10702A interferometer does not.

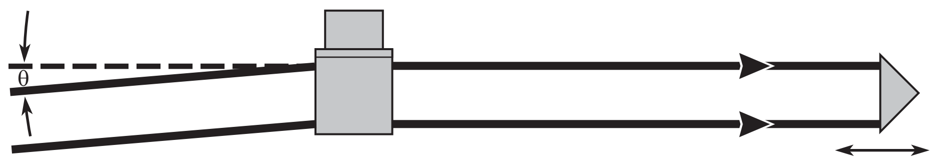
Similarly, the Agilent 10767A Linear Retroreflector (see Figure 103) is optically identical to the Agilent 10703A Retroreflector. However, in order to withstand the handling and repeated installations of calibrator-type applications, the Agilent 10767A retroreflector has a more-robust housing than the Agilent 10703A retroreflector (which is intended for laser transducer measurement system applications). Also, the Agilent 10767A interferometer has metric dimensions and metric threads, whereas the Agilent 10703A interferometer does not.

The Agilent 10722A Plane Mirror Converter (see Figure 104) is a quarter-wave plate accessory for the Agilent 10702A interferometer. With the Agilent 10722A converter and an additional Agilent 10703A Retroreflector, the Agilent 10702A interferometer can be converted to an Agilent 10706A Plane Mirror Interferometer. This configuration allows measurements of axial displacement of a plane mirror.

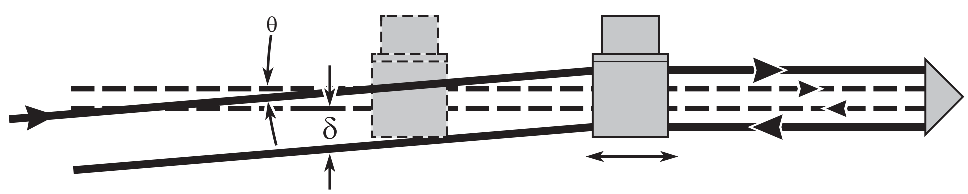
With the Agilent 10722A Plane Mirror Converter and the Agilent 10723A High Stability Adapter, the Agilent 10702A Linear Interferometer can be converted to an Agilent 10706B High Stability Plane Mirror Interferometer. This configuration also allows measurements of axial displacement of a plane mirror. The Agilent 10723A adapter is discussed in Chapter 20, “Agilent 10706A Plane Mirror Interferometer,” of this manual. The High-stability Plane Mirror Interferometer is described in Chapter 21 of this manual.



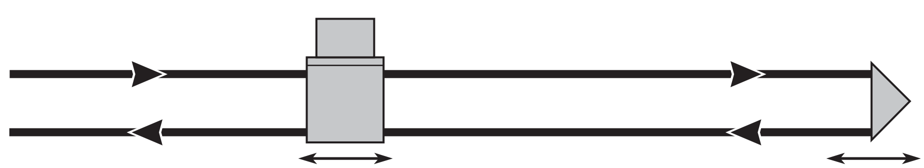
If the Agilent 10702A Linear Interferometer is placed in a beam which has been aligned parallel to the motion of travel, the outgoing beam can be deflected by as much as 30 arc-minutes (θ) due to the incoming-outgoing beam parallelism specifications of the Agilent 10702A interferometer. This could cause not only cosine error but also possible loss of signal during movement of the Agilent 10703A Retroreflector.



To compensate for this, alignment is performed with the Agilent 10702A Linear Interferometer in place. This allows the laser beam to be aligned parallel to the motion of travel to minimize cosine error and maximize signal. Since the incoming beam is now not parallel to the motion of travel, the Agilent 10702A Linear Interferometer must remain stationary. (See below).



If the Agilent 10702A Linear Interferometer, instead of the Agilent 10703A Retroreflector, is moved during the measurement, the beam in the measurement path will remain parallel, but will be displaced. This displacement δ will occur at the receiver, causing a decrease and eventual loss of signal, depending on the distance traveled.



If motion of the linear interferometer is required, the Agilent 10702A-001 Linear Interferometer withWindows should be used. This provides special wedge windows which makes the outgoing beam parallel to the incoming beam. This allows motion by either the Agilent 10703A Retroreflector or the Agilent 10702A-001 Linear Interferometer.

Figure 101 Agilent 10702A-001 Linear Interferometer with Windows

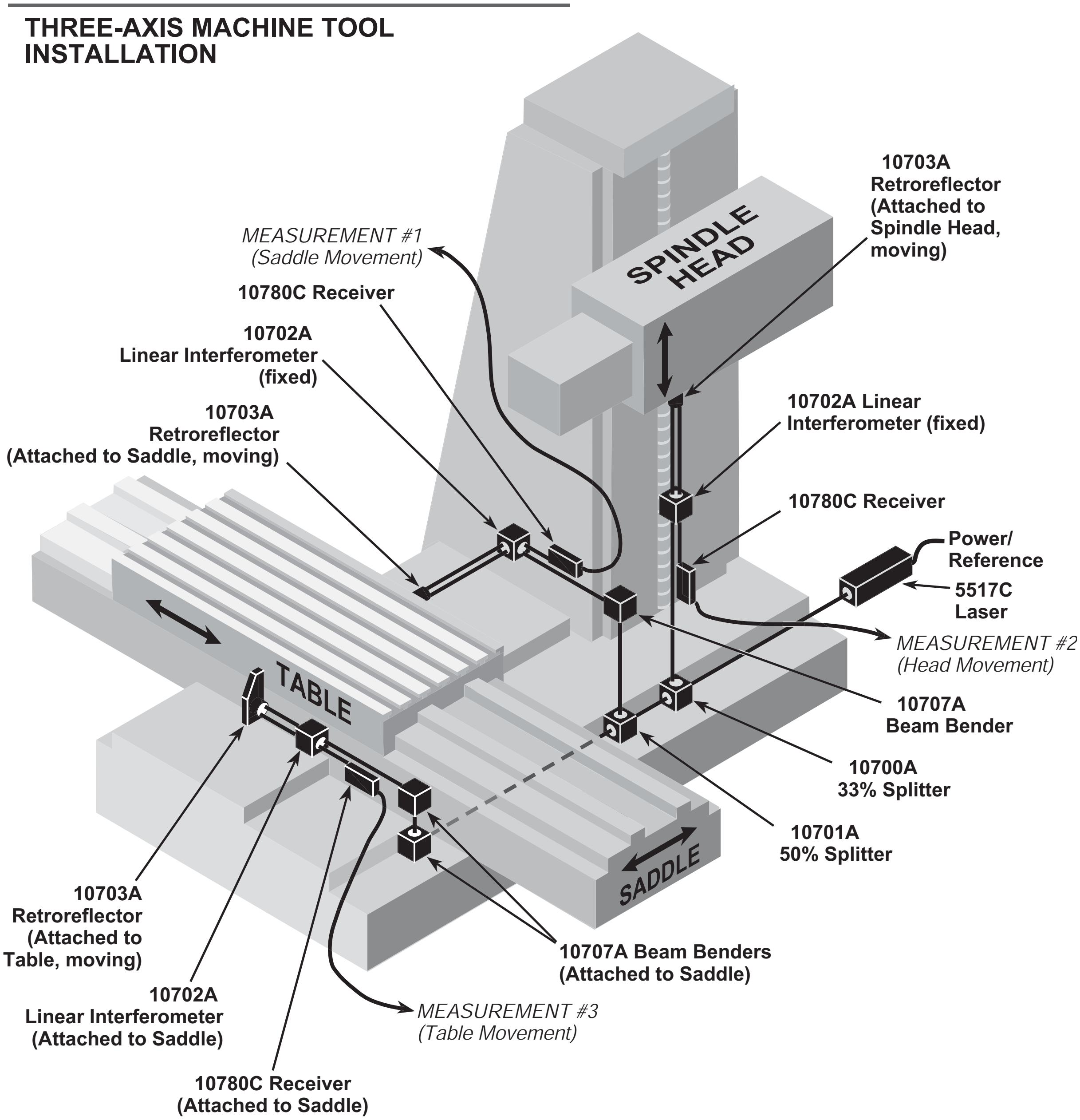
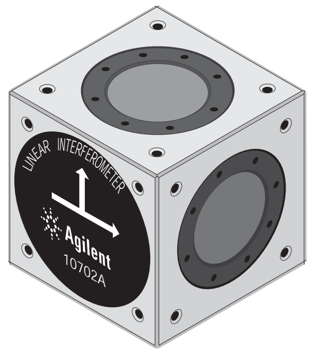
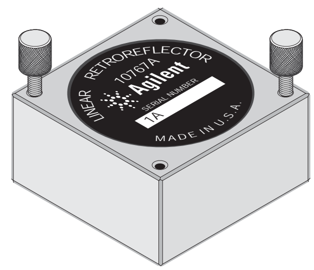


Figure 102 Three-axis machine tool Installation



Agilent 10766A
Linear Interferometer



Agilent 10767A
Linear Retroreflector

Figure 103 Agilent 10766A Linear Interferometer and Agilent 10767A Linear Retroreflector

Agilent 10722A
Plane Mirror Converter

Figure 104 Agilent 10722A Plane Mirror Converter

Laser Beam Path

The beam from the laser head is split at the surface of a polarizing beam-splitter.

One frequency, f_B, is reflected to the reference cube corner mounted on the housing (Figure 105). See the “Measurement Direction Sense” section in Chapter 5, “Measurement Optics (General Information),” for explanation of f_A and f_B beam paths.

The second frequency, f_A, is sent to the Agilent 10703A Retroreflector and returned parallel to, but displaced from, the outgoing beam.

Both frequencies then recombine with the polarizing beam splitter and travel back along a common axis to the photodetector in the receiver. One frequency includes a Doppler frequency shift whenever there is a relative motion between the Agilent 10703A Retroreflector and the Agilent 10702A Linear Interferometer. Rotating the interferometer 90° about the axis of the input beam switches which optical frequency is in the measurement path, thus changing the direction sense.

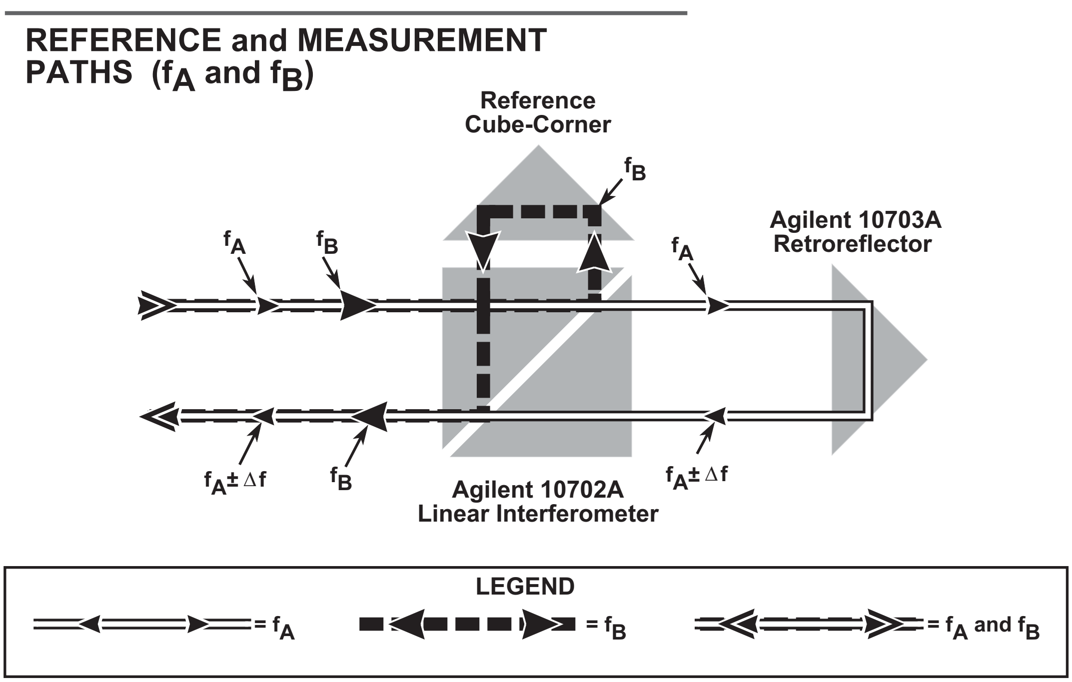


Figure 105 Linear interferometer laser beam path

Differential measurements

A differential measurement is one in which both the reference beam and the measurement beam travel to external reflectors (either cube corners or mirrors) outside the interferometer housing. This allows measurement of the relative positions of the two external mirrors, either or both of which may be moving. Viewed another way, this allows measuring the motion of one reflector relative to a reference datum elsewhere in the machine, external to the interferometer itself. This is unlike the typical interferometer configuration because usually the reference beam path length does not change; in differential configurations, it can.

Take care during design and layout of a differential measurement to avoid introduction of alignment errors, thermal or mechanical instabilities, and potential deadpath problems. Both reflectors (reference and measurement) should be of the same type (cube corner or plane mirror); this minimizes thermal drift problems with ambient temperature changes.

To use an Agilent 10702A or Agilent 10766A interferometer in a differential measurement configuration, the reference cube corner can simply be detached from the interferometer housing and attached to the reference surface of interest. This is shown in Figure 106. Be aware that all installation and alignment requirements for the measurement reflector now apply also to the reference reflector.

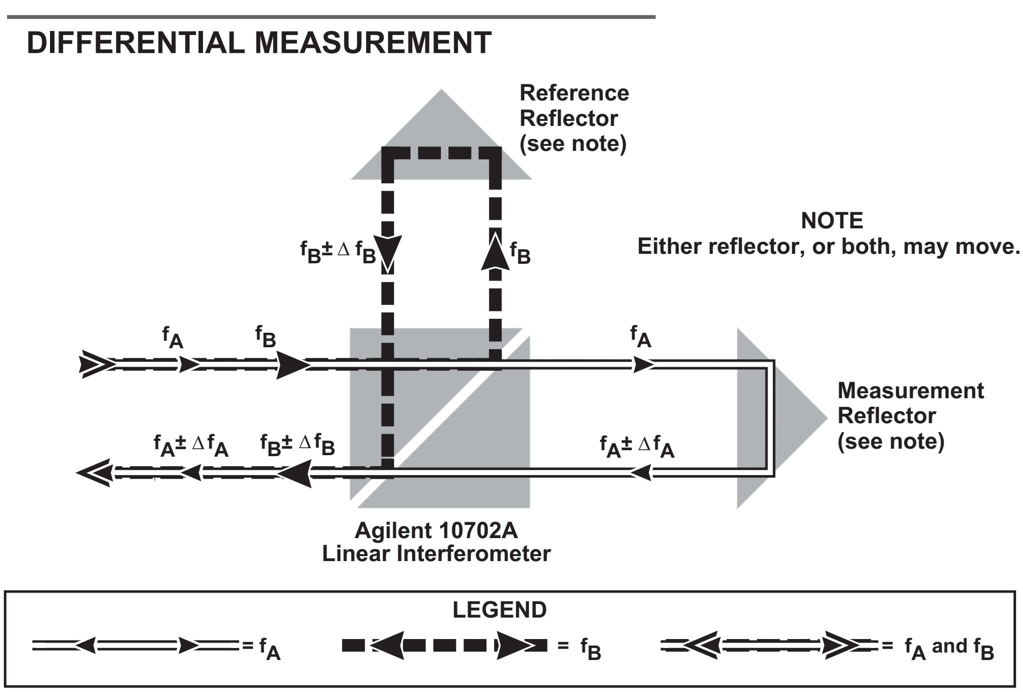


Figure 106 Differential measurements with the Agilent 10702A

Special Considerations

Effect of optics on measurement direction sense

The orientation and configuration of the interferometers affects the measurement direction sense. The direction sense depends on which frequency is in the measurement path of the interferometer. For example, if f_1 (lower frequency) is in the reference path and the optics are moving away from each other, the fringe counts will be INCREASING. This corresponds to using an Agilent 5517A, or Agilent 5517B/BL/C/D/DL/F Laser Head (mounting feet in horizontal plane) with an Agilent 10702A Linear Interferometer mounted with labels facing up and down (see Figure 105). Interchanging f_1 and f_2 (perhaps by rotating the interferometer 90°) in this example will result in the fringe counts DECREASING.

The optical schematic for the interferometers, in Figure 105, shows the reference and measurement laser beam paths for these interferometers.

As with the laser heads, when the interferometers are rotated 90°, the measurement direction sense will change. This rotation causes switching of frequencies in the measurement path.

Configuration effects

Many of the distance-measuring interferometers can be configured to turn the beam at right angles. When configuring the linear, single-beam, and plane mirror interferometers to turn the beam, the measurement direction sense will be changed. This is because the measurement reference paths are switched on the interferometers, therefore changing the direction sense.

Moving interferometer instead of reflector

When moving the interferometer instead of the measurement reflector is required, the Agilent 10702A-001 (or Agilent 10766A) interferometer should be used. In practice, for alignment reasons, these are two of the few interferometers that can be moved while making measurements. For a detailed explanation of the beam alignment problems involved with a moving-interferometer setup, see Figure 101.

NOTE If a right-angle beam bend is made through the Agilent 10702A interferometer, it must be the fixed component.

Mounting

Vibration considerations

To achieve the highest possible measurement accuracy, be sure your measurement system design and installation provide sufficient and appropriate isolation of the optical components from the effects of vibration. See Chapter 3, “System Design Considerations,” and Chapter 4, “System Installation and Alignment,” in Volume I of this manual for more information.

Adjustable mounts

The optical elements inside these Agilent laser measurement system optics are not precisely referenced to their housings. In most applications involving these optics, a few simple alignments during system installation can usually provide equal or better alignment than referencing the optics to their housings. Therefore, slight positioning adjustments of the unreferenced interferometers, beam splitters, and beam benders are needed for proper system alignment.

Positioning adjustments for the Agilent 10702A interferometer can be provided by using an Agilent 10711A Adjustable Mount.

Positioning adjustments for the Agilent 10766A interferometer can be provided by using an Agilent 10785A Height Adjuster and Post (a base plate accessory, Agilent 10784A, for the post is available), where appropriate. These mounting arrangements allow adjustment of pitch and yaw of any attached optic. (Roll adjustment is typically not required, and can usually be avoided by careful optical system layout.)

Fasteners

The Agilent 10702A interferometer is supplied with mounting screws to mount it on the Agilent 10711A Adjustable Mount.

The Agilent 10785A Height Adjuster and Post, and the Agilent 10767A Linear Retroreflector, include captive hardware necessary for mounting and aligning the Agilent 10766A Laser Interferometer.

Installation

Pre-installation checklist

In addition to reading chapters 2 through 4, and Chapter 12, "Accuracy and Repeatability," (in Volume I of this manual), complete the following items before installing a laser positioning system into any application.

- ☐ Complete Beam Path Loss Calculation (see Calculation of signal loss" in Chapter 3, "System Design Considerations," in Volume I of this manual).
- ☐ Determine the direction sense for each axis, based on the orientation of the laser head, beam-directing optic, and interferometer. Enter the direction sense for each axis into the measurement system electronics. (See Chapter 16, "Laser Heads," Chapter 11, "Principles of Operation," and Chapter 12, "Accuracy and Repeatability," in Volume I of this manual.
- ☐ Provide for aligning the optics, laser head, and receiver(s) on the machine. (Ideally, you want to be able to translate beam in two directions and rotate beam in two directions for each interferometer input. This typically takes two adjustment optics with proper orientations.)
- ☐ Be sure to allow for transmitted beam offset of beam splitters (Agilent 10700A and Agilent 10701A) in your design. (See the offset specifications under the "Specifications" heading at the end of this chapter.)

Refer to Chapter 4, "System Installation and Alignment," in Volume I of this manual for installation instructions.

Alignment

Alignment aids

Alignment aids for these interferometers are listed in Chapter 4, "System Installation and Alignment," in Volume I and Chapter 36, "Accessories," of this manual.

Procedure

Refer to Chapter 4, "System Installation and Alignment," in Volume I of this manual for alignment instructions.

Specifications and Characteristics

Specifications describe the device's warranted performance. Supplemental characteristics (indicated by TYPICAL or NOMINAL) are intended to provide non-warranted performance information useful in applying the device.

The basic optical resolution using a linear interferometer is one half wavelength (0.316 micron, 12.26 microinches).

Using electronic resolution extension, the system resolution is increased significantly. Depending on the system, an additional resolution extension factor of 32 (for Agilent 10885A and 10895A) or 256 (for Agilent 10897B and 10898A) is usually available.

Interferometer	Fundamental Optical Resolution	System Resolution 1 (see NOTE)	System Resolution 2 (see NOTE)
Agilent 10702A	λ /2 (316.5 nm, 12.5 µin)	λ /64 (10.0 nm, 0.4 µin)	λ /512 (1.2 nm, 0.047 µin)
Agilent 10766A	λ /2 (316.5 nm, 12.5 µin)	λ /64 (10.0 nm, 0.4 µin)	λ /512 (1.2 nm, 0.047 µin)

NOTE

The system resolution 1 is based on using 32X electronic resolution extension. This is available with the Agilent 10885A and Agilent 10895A electronics.

The system resolution 2 is based on using 256X electronic resolution extension. This is available with the Agilent 10897C and Agilent 10898A electronics.

Agilent 10702A Linear Interferometer Specifications

Dimensions: see figure below

Weight: 232 grams (8.2 ounces)

Materials Used:

- Housing: Stainless Steel (416)
- Apertures: Plastic (Nylon)
- Optics: Optical Grade Glass
- Adhesives: Low Volatility (Vacuum Grade)

Maximum Angular Beam Deviation: ± 30 arc-minutes

Optical Efficiency (including Agilent 10703A Reflector):

- Typical: 75%
- Worst Case: 71%

Fundamental Optical Resolution: λ /2

Non-linearity Error: <4.2 nm (0.17 µin)

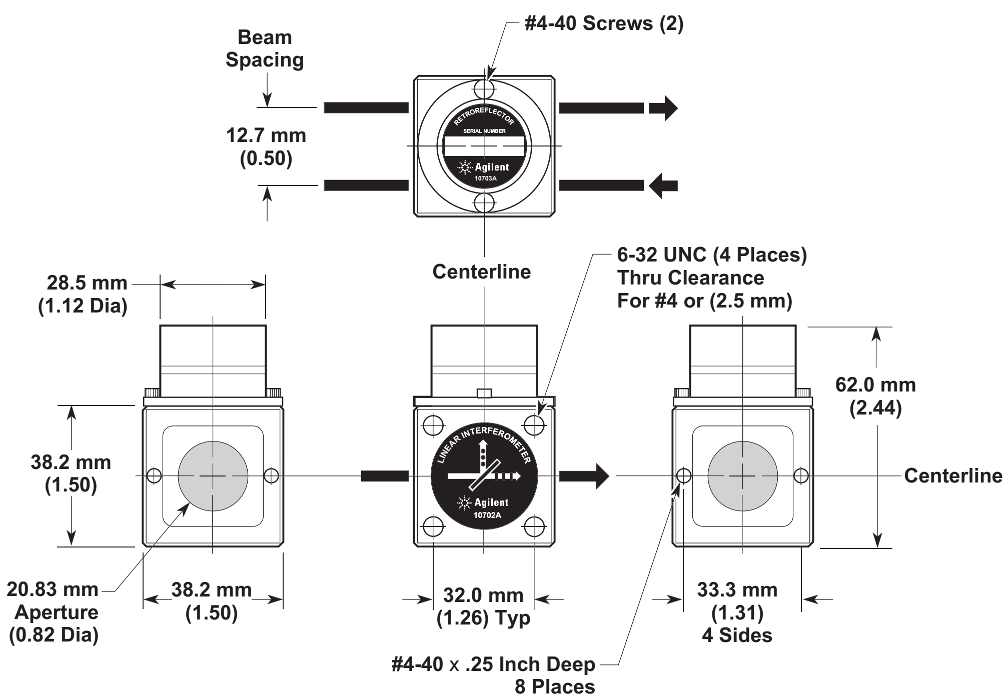


Figure 107 Agilent 10702A Linear Interferometer — dimensions

Agilent 10702A-001 Linear Interferometer with Windows Specifications

Dimensions: see figure below

Weight: 246 grams (8.7 ounces)

Materials Used:

Housing: Stainless Steel (416)
Apertures: Plastic (Nylon)
Optics: Optical Grade Glass
Adhesives: Low Volatility (Vacuum Grade)

Maximum Angular Beam Deviation: ± 30 arc-seconds

Optical Efficiency (including Agilent 10703A Reflector):

Typical: 73%
Worst Case: 69%

Fundamental Optical Resolution: λ /2

Non-linearity Error: <4.2 nm (0.17 µin)

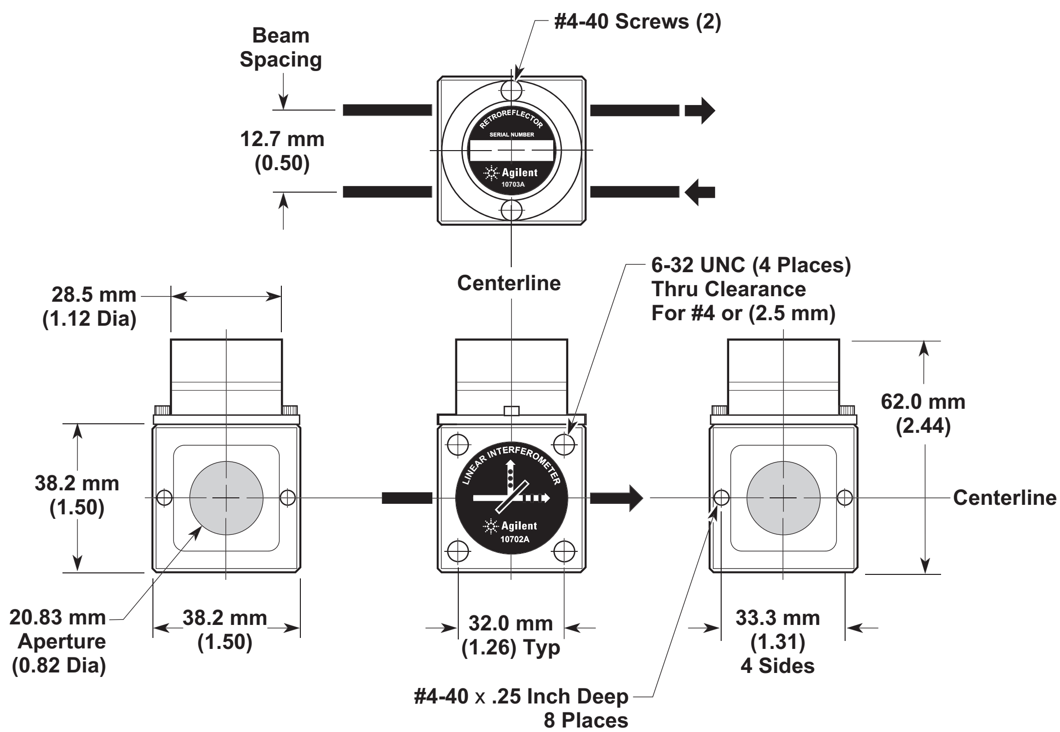


Figure 108 Agilent 10702A-001 Linear Interferometer with Windows — dimensions

Agilent 10703A Retroreflector Specifications

Dimensions: see figure below

Weight: 41.5 grams (1.5 ounces)

Materials Used:

Housing: Stainless Steel (416)
Optics: Optical Grade Glass
Adhesives: Low Volatility (Vacuum Grade)

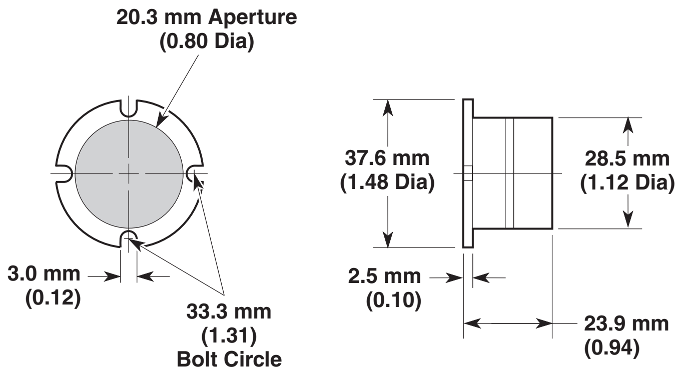


Figure 109 Agilent 10703A Retroreflector — dimensions

Agilent 10713B 1-Inch Cube Corner Specifications

Dimensions: See drawings below.

Weight: 11.4 grams (0.4 ounces)

Nodal Point Depth: 12.57 mm (0.495 inch)

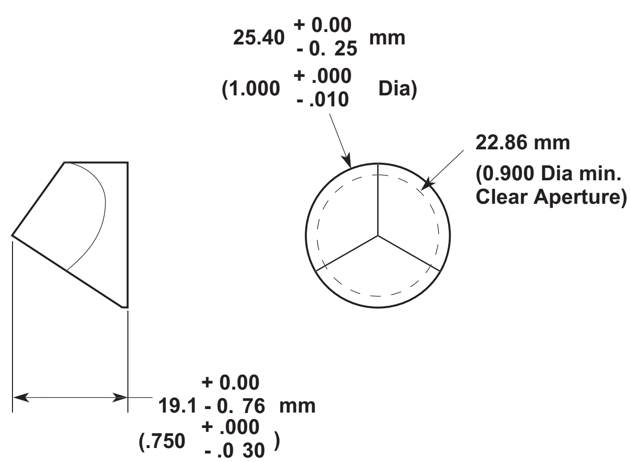


Figure 110 Agilent 10713B 1-Inch Cube Corner, no housing — dimensions

Agilent 10766A Linear Interferometer Specifications

Dimensions: see figure below

Weight: 312 grams (11 ounces)

Materials Used:

Housing: Stainless Steel (416)
Apertures: Plastic (Nylon)
Optics: Optical Grade Glass
Adhesives: Low Volatility (Vacuum Grade)

Optical Efficiency (interferometer combination plus remote Agilent 10767A Retroreflector):

Typical: 73%
Worst Case: 69%

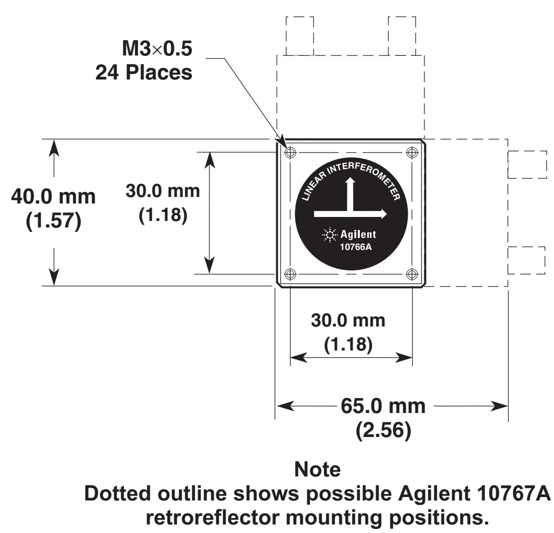


Figure 111 Agilent 10766A Linear Interferometer — dimensions

Agilent 10767A Retroreflector Specifications

Dimensions: see figure below

Weight: 224 grams (7.9 ounces)

Materials Used:

Housing: Stainless Steel (416)
Apertures: Plastic (Nylon)
Optics: Optical Grade Glass
Adhesives: Low Volatility (Vacuum Grade)

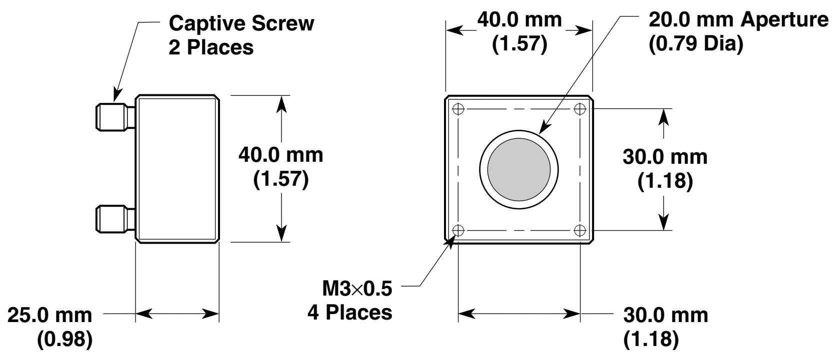


Figure 112 Agilent 10767A Linear Retroreflector — dimensions

19
Agilent 10705A Single Beam Interferometer and Agilent 10704A Retroreflector

Description

The Agilent 10705A Single Beam Interferometer (see Figure 113) is intended for use in low-mass or limited-space applications. This Interferometer is designed for use with the Agilent 10704A Retroreflector (see Figure 113).

The single beam interferometer is called that because the outgoing and returning beams are superimposed on each other, giving the appearance of only one beam traveling between the interferometer and the retroreflector.

Functionally, this interferometer operates like a linear interferometer, but is preferred when space for optics and beam paths is limited.

The Agilent 10704A Retroreflector is a cube corner, but is considerably smaller and lighter than the Agilent 10703A Retroreflector.

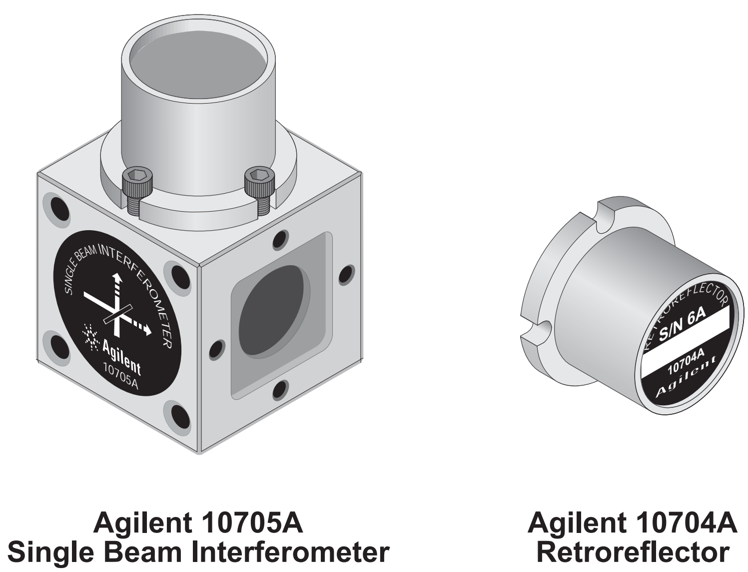


Figure 113 Agilent 10705A Single Beam Interferometer and Agilent 10704A Retroreflector

When using a single-beam interferometer, the receiver is usually mounted perpendicular to the measurement beam, and the interferometer held stationary. An optical schematic diagram of this interferometer is shown in Figure 114.

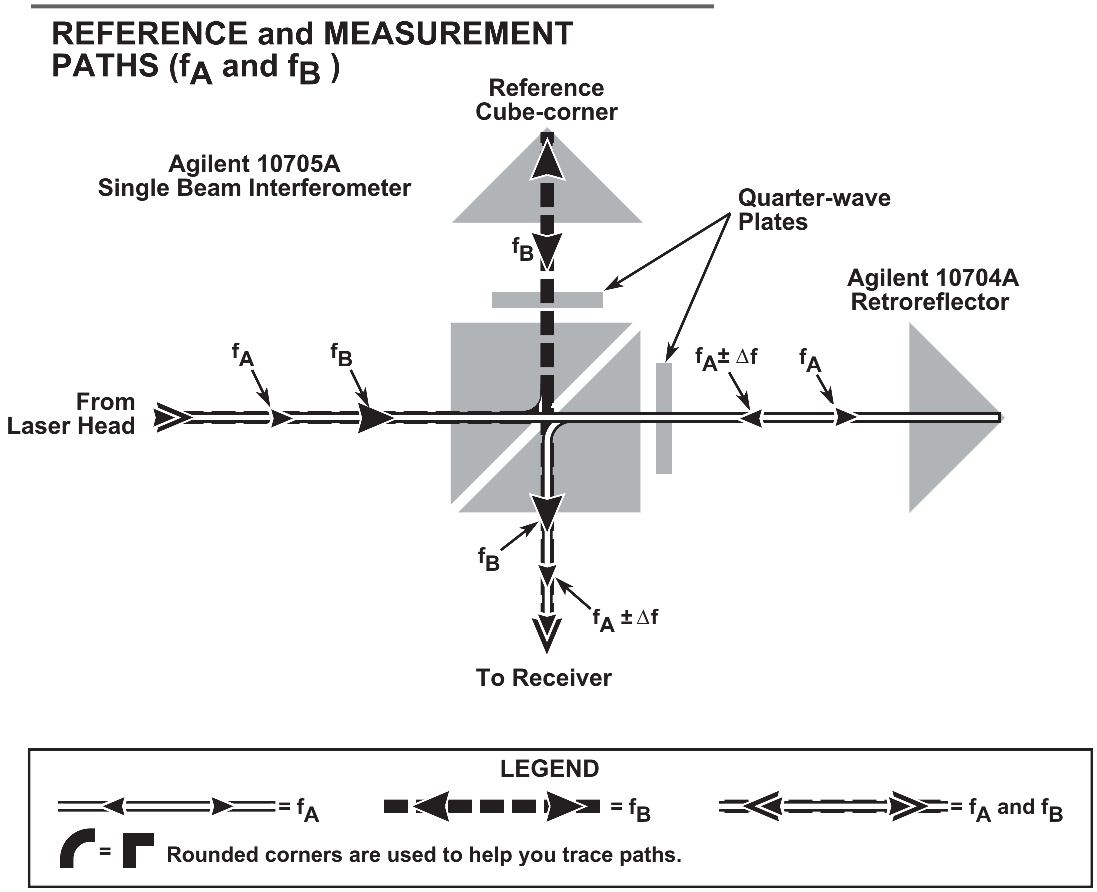


Figure 114 Single Beam Interferometer — laser beam path

Laser beam path

A polarizing beam-splitter reflects f_B to the reference cube corner and transmits f_A to the Agilent 10704A Retroreflector (Figure 114). The return path is superimposes on the outgoing path. Since both beams leaving the beam-splitter pass through a quarter-wave plate, the returning polarizations are rotated through 90°. This causes f_B to be transmitted and f_A ±Δf to be reflected so that they are directed coaxially to the receiver along a path perpendicular to the input beam. Rotating the interferometer 90° switches which optical frequency is in the measurement path, and thus changes the direction sense.

Differential measurements

A differential measurement is one in which both the reference beam and the measurement beam travel to external reflectors outside the interferometer housing. This allows measurement of the relative positions of the two external mirrors, either or both of which may be moving. Viewed another way, this allows measuring the motion of one reflector relative to a reference datum elsewhere in the machine, external to the interferometer itself. This is unlike the typical interferometer configuration because usually the *reference* beam path length does not change; in differential configurations, it can.

Take care during design and layout of a differential measurement to avoid introduction of alignment errors, thermal or mechanical instabilities, and potential deadpath problems. Both reflectors (reference and measurement) should be of the same type (cube corner or plane mirror); this minimizes thermal drift problems with ambient temperature changes.

To use an Agilent 10705A Interferometer in a differential measurement configuration, the reference cube corner can simply be detached from the interferometer housing and attached to the reference surface of interest. This is shown, using an Agilent 10702A Interferometer for the example, in Figure 7A-7. Be aware that all installation and alignment requirements for the measurement reflector now apply also to the reference reflector.

Plane mirror measurements

The special option C01-10705A interferometer is an Agilent 10705A interferometer specially modified to allow its use with plane mirrors or highly reflective surfaces. The C01-10705A modification removes one quarter-wave plate, resulting in an optical configuration similar to that of the Agilent 10706A Plane Mirror Interferometer (described in Chapter 20 of this manual); this configuration requires one Agilent 10704A retroreflector. The C01-10705A interferometer's receiver signal is separated by an Agilent 10700A or Agilent 10701A Beam Splitter.

Typical measurement mirror alignment requirements for the C01-10705A (as a function of distance) are the same as those for the Agilent 10706A Plane Mirror Interferometer. Agilent 10706A interferometer specifications are given in Chapter 20 of this manual.

Special Considerations

Effect of optics on measurement direction sense

The orientation and configuration of the interferometer affects the measurement direction sense. The direction sense depends on which frequency is in the measurement path of the interferometer. For example, if f_1 (lower frequency) is in the measurement path and f_2 (higher frequency) is in the reference path and the optics are moving away from each other, the fringe counts will be INCREASING. Interchanging f_1 and f_2 (perhaps by rotating the interferometer 90°, the measurement direction sense will change. This rotation causes switching of frequencies in the measurement path.

Configuration effects

The Agilent 10705A interferometer can be configured to turn the beam at right angles. Be aware that doing this will cause the measurement direction sense to be changed because the measurement reference paths are exchanged.

Mounting

Adjustable mounts

Agilent 10710B Adjustable Mount provides a convenient means of mounting, aligning, and securely locking in position, the Agilent 10705A interferometer. Since the mount allows some tilt and yaw adjustment, the need for custom fixturing is minimized. This mount allows the optic mounted on it to be rotated about its optical centerline, simplifying installation.

Chapter 4, “System Installation and Alignment,” in this manual shows how to install an optic in various orientations, using an adjustable mount.

Fasteners

The Agilent 10705A interferometer is designed to be used with an Agilent 10710B Adjustable Mount, and is supplied with English mounting hardware.

Adapter plate

The Agilent 10705A-080 Adapter Plate adds an easy mounting surface to the interferometer for mounting the remote lens assemblies of the Agilent 10780F, Agilent E1708A, and Agilent E1709A remote receivers directly to the interferometer.

Installation

Pre-installation checklist

In addition to reading chapters 2 through 4, and Chapter 12, “Accuracy and Repeatability,” (in Volume I of this manual), complete the following items before installing a laser positioning system into any application.

- ☐ Complete Beam Path Loss Calculation (see Calculation of signal loss” in Chapter 3, “System Design Considerations,” in Volume I of this manual).
- ☐ Determine the direction sense for each axis, based on the orientation of the laser head, beam-directing optic, and interferometer. Enter the direction sense for each axis into the measurement system electronics. (See Chapter 16, “Laser Heads,” Chapter 11, “Principles of Operation,” and Chapter 12, “Accuracy and Repeatability,” in Volume I of this manual.
- ☐ Provide for aligning the optics, laser head, and receiver(s) on the machine. (Ideally, you want to be able to translate beam in two directions and rotate beam in two directions for each interferometer input. This typically takes two adjustment optics with proper orientations.)
- ☐ Be sure to allow for transmitted beam offset of beam splitters (Agilent 10700A and Agilent 10701A) in your design. (See the offset specifications under the “Specifications” heading at the end of this chapter.)

Refer to Chapter 4, “System Installation and Alignment,” in Volume I of this manual for installation instructions.

Alignment

Alignment aids

Alignment aids for these interferometers are listed in Chapter 4, “System Installation and Alignment,” in Volume I and Chapter 36, “Accessories,” of this manual.

Procedure

Refer to Chapter 4, “System Installation and Alignment,” in Volume I of this manual for alignment instructions.

Specifications and Characteristics

Specifications describe the device’s warranted performance. Supplemental characteristics (indicated by TYPICAL or NOMINAL) are intended to provide non-warranted performance information useful in applying the device.

The basic optical resolution using a linear interferometer is one half wavelength (0.316 micron, 12.26 microinches).

Using electronic resolution extension, the system resolution is increased significantly. Depending on the system, an additional resolution extension factor of 32 (for Agilent 10885A and 10895A) or 256 (for Agilent 10897C and 10898A) is usually available.

Interferometer	Fundamental Optical Resolution	System Resolution 1 (see NOTE)	System Resolution 2 (see NOTE)
Agilent 10705A	λ /2 (316.5 nm, 12.5 µin)	λ /64 (10.0 nm, 0.4 µin)	λ /512 (1.2 nm, 0.047 µin)

NOTE

The system resolution 1 is based on using 32X electronic resolution extension. This is available with the Agilent 10885A and Agilent 10895A electronics.

The system resolution 2 is based on using 256X electronic resolution extension. This is available with the Agilent 10897C and Agilent 10898A electronics.

Agilent 10705A Single Beam Interferometer Specifications

Dimensions: see figure below

Weight: 85.5 grams (3.0 ounces)

Materials Used:

Housing: Stainless Steel (416)
Apertures: Plastic (Nylon)
Optics: Optical Grade Glass
Adhesives: Low Volatility (Vacuum Grade)

Maximum Angular Beam Deviation: ± 30 arc-minutes

Optical Efficiency (including Agilent 10703A Reflector):

Typical: 62%
Worst Case: 59%

Fundamental Optical Resolution: λ /2

Non-linearity Error: <4.2 nm (0.17 µin)

Thermal Drift Coefficient:

0.05 micron/°C, typical
0.005 micron/°C, minimum
0.110 micron/°C, maximum

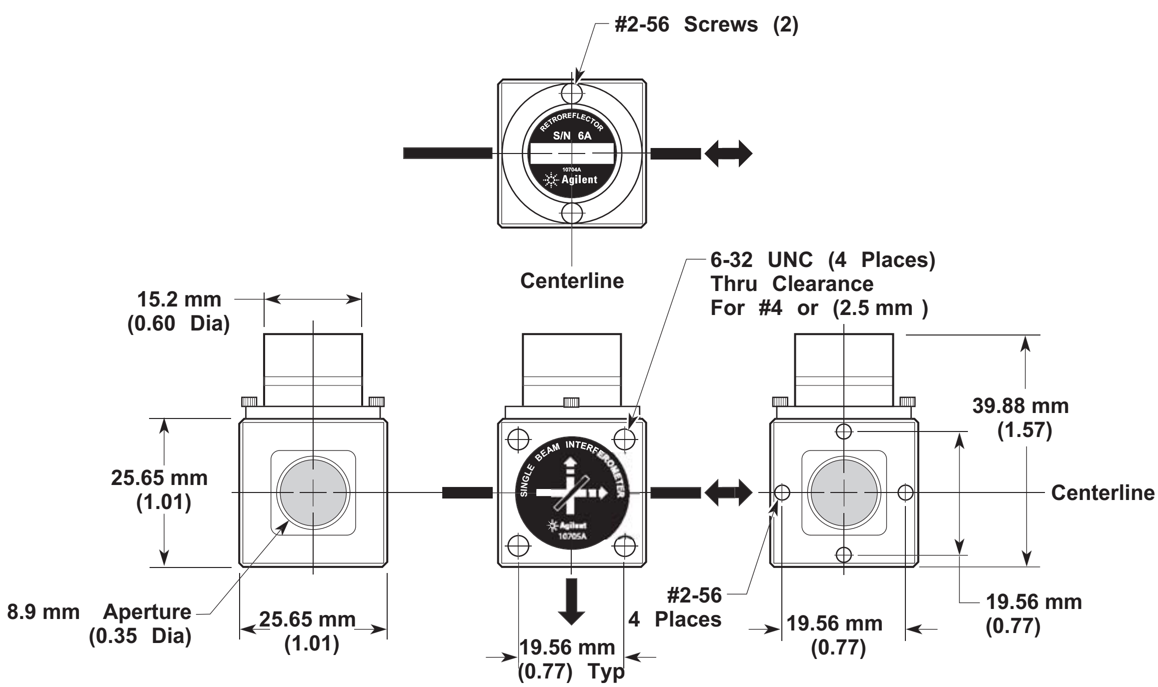


Figure 115 Agilent 10705A Single Beam Interferometer — dimensions

Agilent 10704A Retroreflector Specifications

Dimensions: see figure below

Weight: 10.5 grams (0.37 ounce)

Materials Used:

Housing: Stainless Steel (416)
Optics: Optical Grade Glass
Adhesives: Low Volatility (Vacuum Grade)

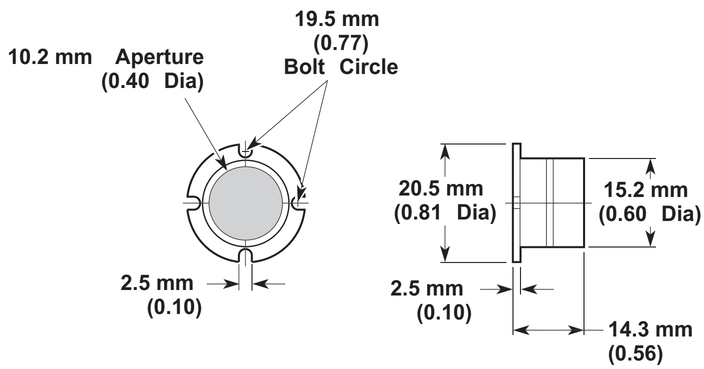


Figure 116 Agilent 10704A Retroreflector — dimensions

Agilent 10713C 1/2-Inch Cube Corner Specifications

Dimensions: see figure below

Weight: 1.4 grams (0.05 ounce)

Nodal Point Depth: 6.33 mm (0.248 inch)

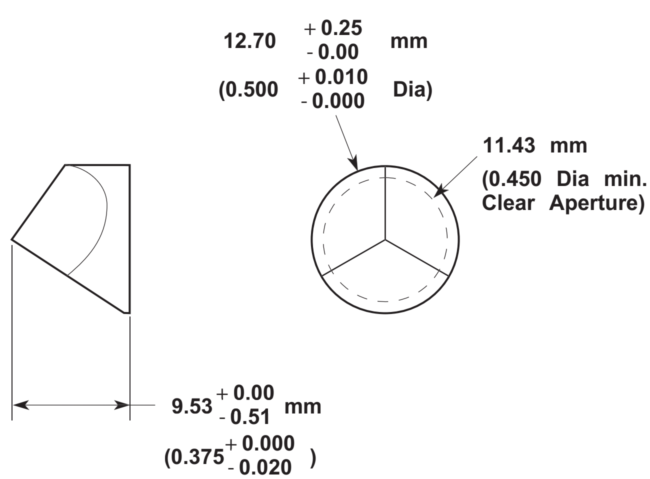


Figure 117 Agilent 10713C 1/2-Inch Cube Corner, no housing — dimensions

Agilent 10713D 1/4-Inch Cube Corner Specifications

Dimensions: see figure below

Weight: 0.2 grams (0.007 ounce)

Nodal Point Depth: 3.14 mm (0.123 inch)

Angular Deviation: 2 inches (arc second)

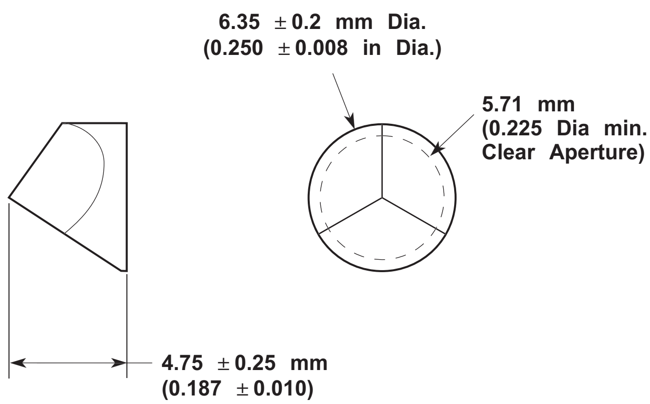


Figure 118 Agilent 10713D Cube Corner, no housing — dimensions

20
Agilent 10706A Plane Mirror Interferometer

Description

This chapter describes:

- the Agilent 10706A Plane Mirror Interferometer
- the Agilent 10723A High Stability Adapter

The Agilent 10706A Plane Mirror Interferometer can be used with a plane mirror reflector to obtain distinct advantages.

The unique contribution of the Agilent 10706A Plane Mirror Interferometer (see Figure 119) is its tolerance of angular misalignment of the plane mirror reflector. A simple linear interferometer would require a plane mirror to remain perpendicular to the laser beam within several arc-seconds; otherwise, the interference fringes would not be detectable. With the Agilent 10706A interferometer, angular deviations of minutes of arc are commonly acceptable.

With this measurement optic, interference fringes are detectable even though the measurement beam is not at perfect right angles to the mirror. Therefore, several valuable applications become possible. For example, in a two-axis laser measurement system, the X reflector can be allowed to move in the Y direction without affecting the signal strength or the X measurement. Consequently, both reflectors of a two-axis system can be mounted on the same moving part to minimize Abbé offset error. Defining the measuring point as the point where the two axis beams cross, the measurement is essentially independent of yaw of the moving stage. Such a design is shown in Figure 120.

Compare the system shown in Figure 120 to a two-axis system using linear or single-beam interferometers. The X-axis retroreflector must be mounted on a part of the stage that moves in the X direction and not in the Y direction. Also, the Y-axis retroreflector must be mounted on a different part of the stage that is allowed to move in the Y direction and not in the X direction. These constraints prevent two-axis measurements from being made on the same part of the stage. Further, there will be some geometry error in the system if it is not perfectly rigid.

The Agilent 10706A Plane Mirror Interferometer uses a flat mirror reflector. For X-Y stage applications, the user must provide the mirror(s). For single-axis applications, the Agilent 10724A Plane Mirror Reflector may be used. This device is described more fully in Chapter 36, “Accessories,” of this manual.

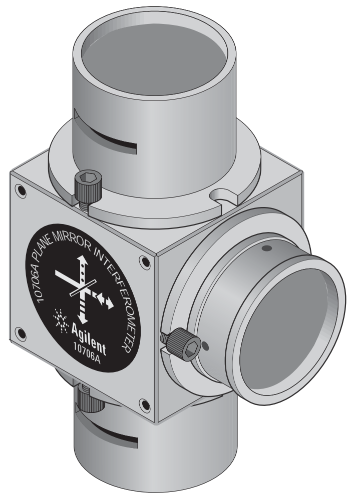


Figure 119 Agilent 10706A Plane Mirror Interferometer

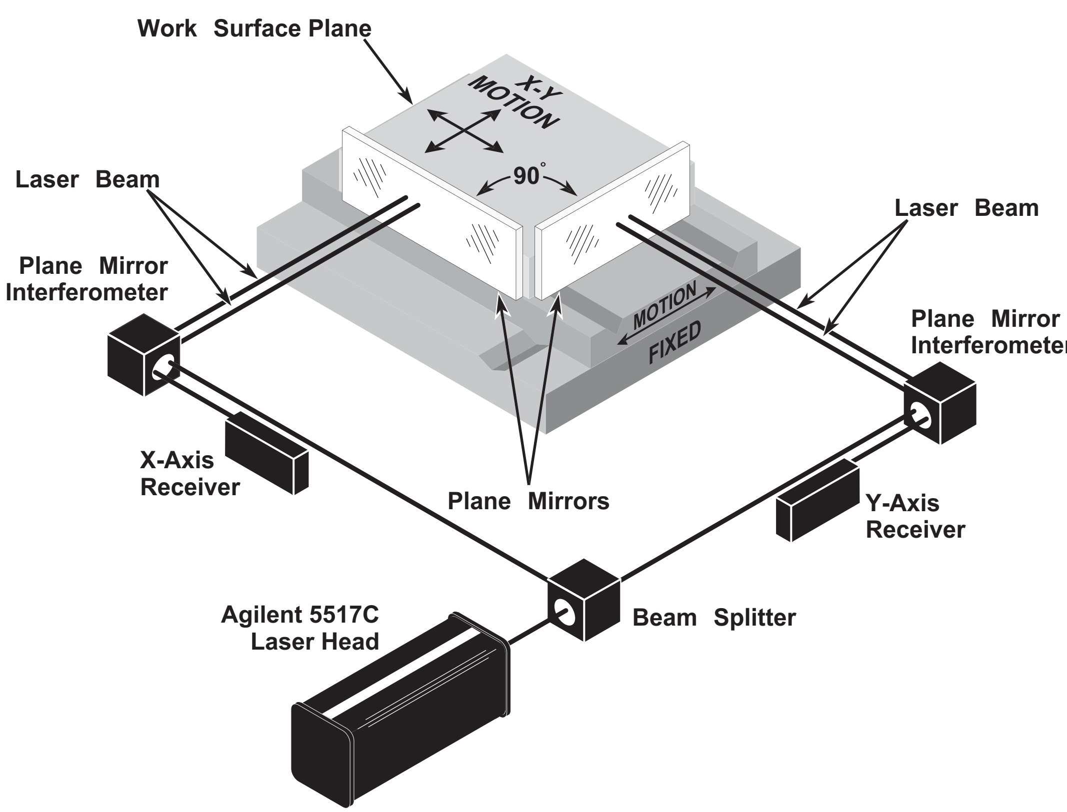


Figure 120 X-Y Stage measurement with Agilent 10706A Plane Mirror Interferometer

In an Agilent 10706A interferometer, the measurement beam travels twice between the interferometer and the plane mirror, thus the resolution of the measurement is twice that of the linear or single beam interferometers. With 32X electronic resolution extension, this results in a resolution of λ /128 (5 nanometers or 0.2 microinch) with the plane mirror interferometer, compared to λ /64 (10 nanometers or 0.4 microinch) with the linear or single beam interferometers.

The Agilent 10706A interferometer can be converted to the Agilent 10706B high-stability interferometer configuration by retrofitting the Agilent 10706A with an Agilent 10723A High Stability Adapter. Information for the conversion is contained later in this chapter. The Agilent 10706B interferometer is described in Chapter 21 of this manual.

Laser beam paths

For purposes of this discussion, the laser beam input is through the interferometer's Aperture B, and the output to the receiver is through Aperture A (see Figure 121).

After entering Aperture B, the beam from the laser head is split at the surface of a polarizing beam-splitter.

One frequency (f_B) enters the interferometer's reference path, which directs it to the reference cube corner and then out to the receiver.

The second frequency (f_A) enters the interferometer's measurement path. This beam is transmitted out to the plane mirror reflector and is reflected back on itself (Figure 121). The interferometer's quarter-wave plate causes the polarization of the return frequency to be rotated through 90° so that $f_A \pm \Delta f$ is reflected out a second time where it is Doppler shifted again. The polarization of $f_A \pm 2\Delta f$ is rotated again through 90° so it is now transmitted back to the receiver. Resolution doubling is inherent because of the double Doppler shift.

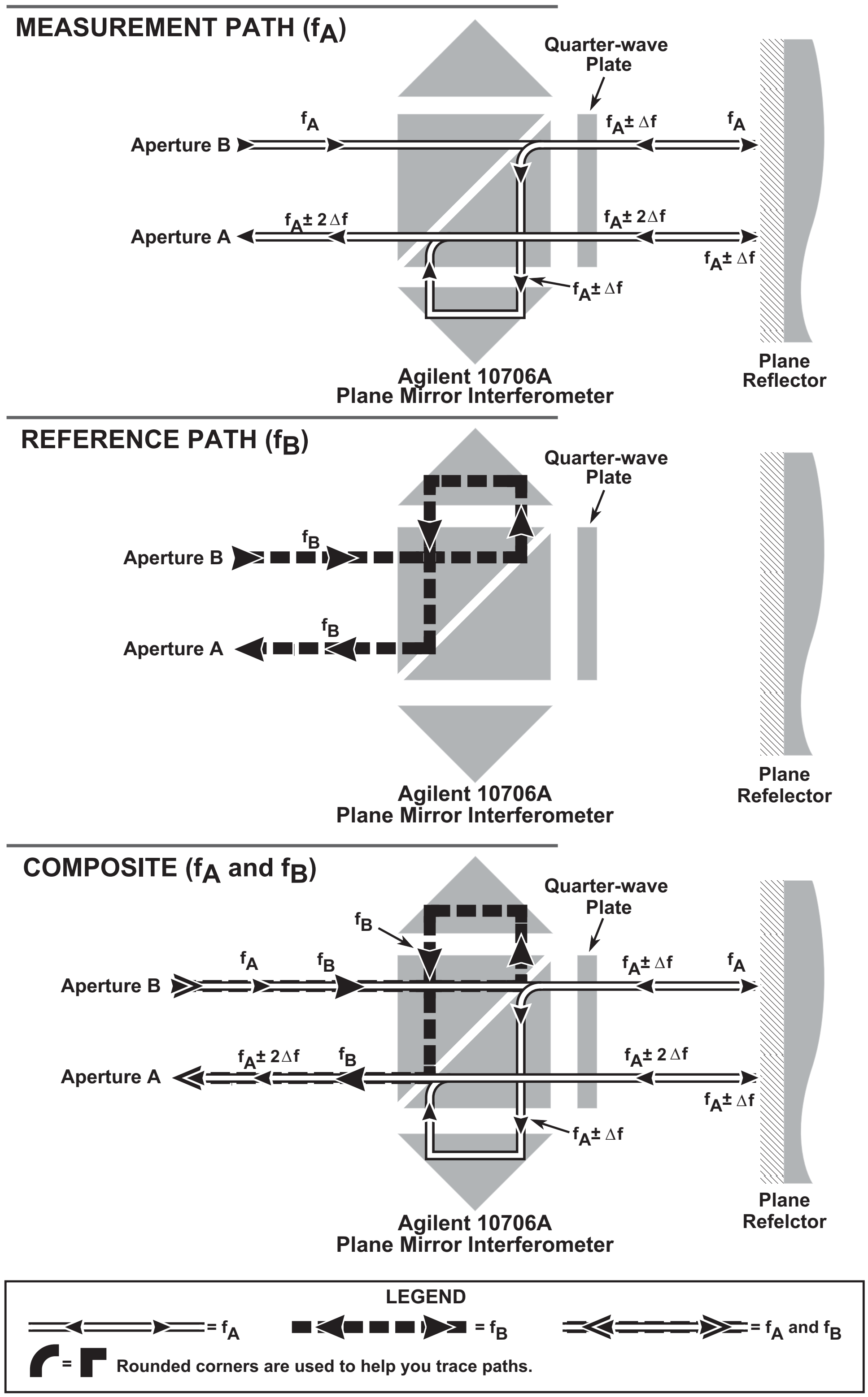


Figure 121 Plane mirror interferometer laser beam path

Special Considerations

Differential measurements

A general discussion of differential measurements using laser interferometers is given in the introduction to this section.

To use the Agilent 10706A interferometer in a differential configuration: 1) replace the reference cube Corner (or high-stability adapter) with the Agilent 10722A Plane Mirror Converter, and 2) attach the reference plane mirror to the reference surface of interest. This is shown in Figure 122. Be sure to install and align the reference reflector the same as you would the measurement reflector.

Turned configuration

To reduce the number of beam benders for this application, the interferometer can be configured to turn the beam. This is done by interchanging the reference cube corner and the plane mirror converter. Figure 123 shows a reconfigured Plane Mirror Interferometer that turns the beam. Note the location of the plane mirror converter with respect to the arrows on the label.

In this configuration (Figure 123), the laser measurement beam is turned to the left. When the measurement beam needs to be turned to the right (as Figure 123, X-axis), the interferometer is rotated 180° about the incoming beam's optical axis.

NOTE With this change in configuration, the measurement direction sense will change (see the "Effect of optics on measurement direction sense" section in Chapter 3, "System Design Considerations," in Volume I of this manual).

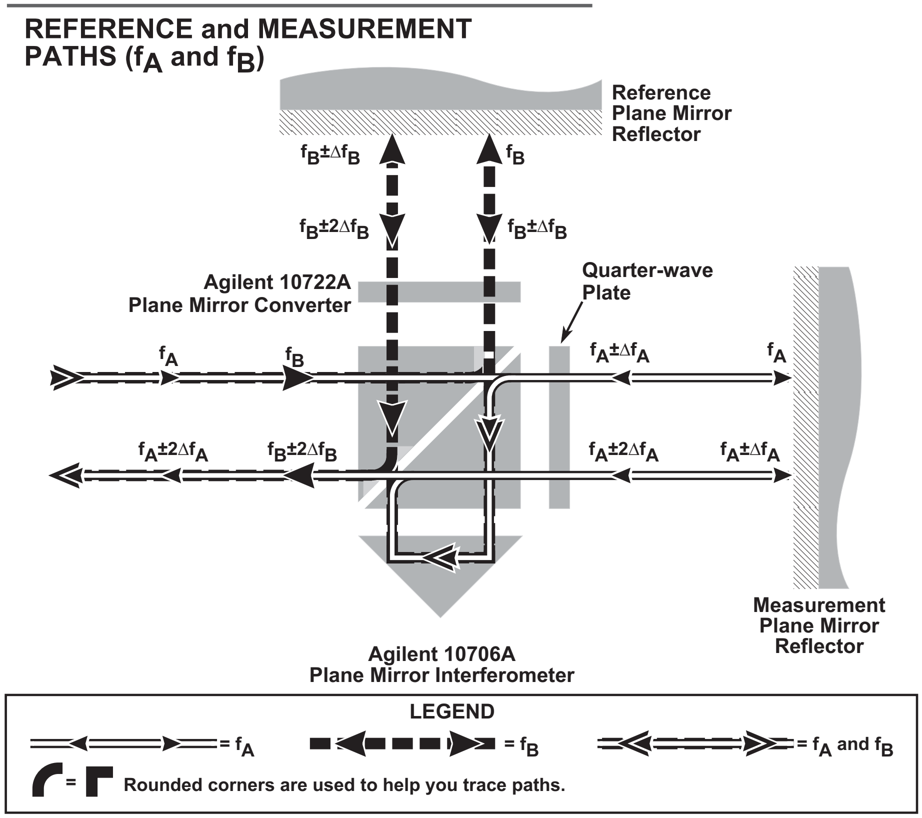


Figure 122 Differential measurements with the Agilent 10706A

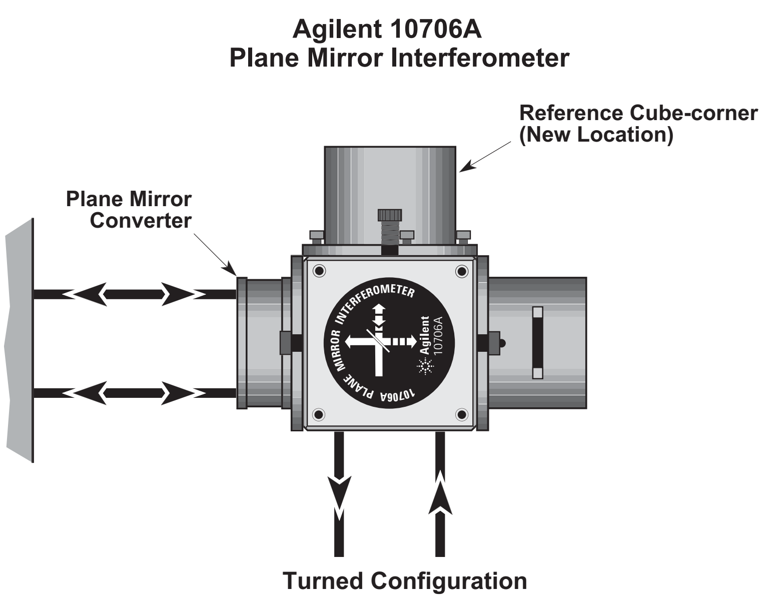


Figure 123 Differential measurements with the Agilent 10706A

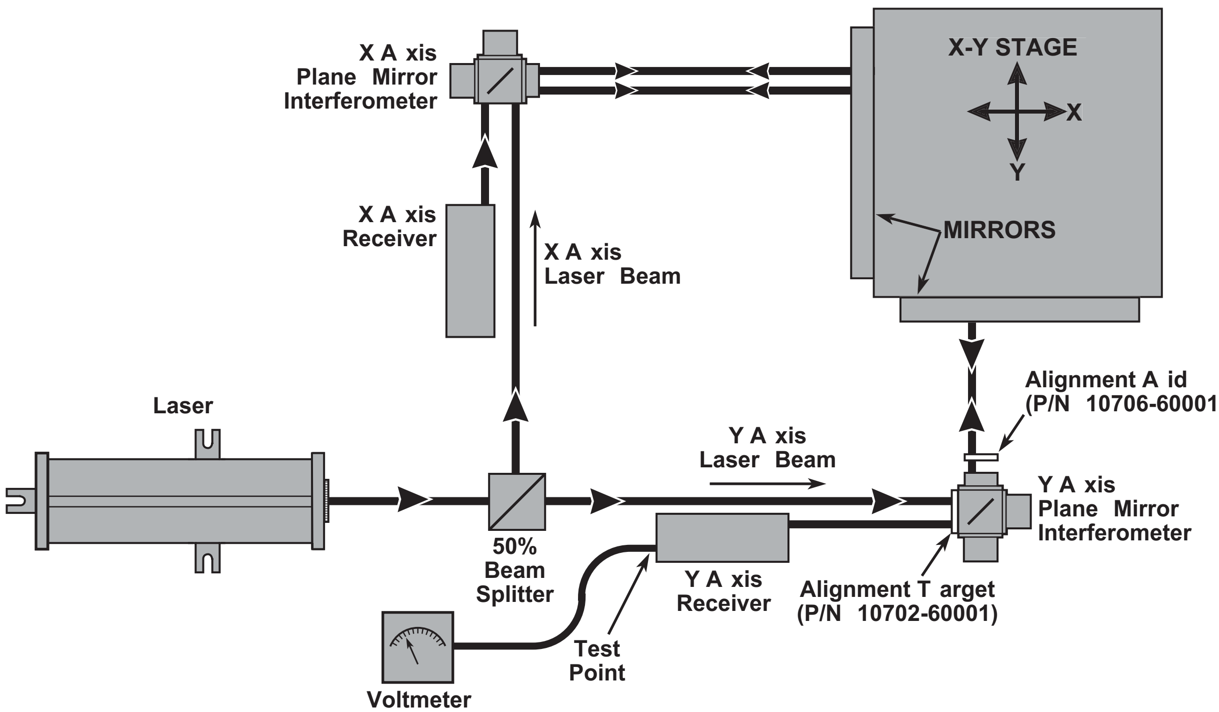


Figure 124 Agilent 10706A Plane Mirror Interferometer—alignment

Mounting

Adjustable mounts

The Agilent 10711A Adjustable Mount provides a convenient means of mounting, aligning, and securely locking the Agilent 10706A interferometer in position. Since the mount allows some tilt and yaw adjustment, the need for custom fixturing is minimized. The mount allows the interferometer to be rotated about its centerline, simplifying installation.

Fasteners

The Agilent 10706A interferometer is supplied with English mounting hardware, which is required to fasten it to its adjustable mount.

Adapter plate

The Agilent 10706A-080 Adapter Plate adds an easy mounting surface to the interferometer for mounting the remote lens assemblies of the Agilent 10780F, Agilent E1708A, and Agilent E1709A remote receivers directly to the interferometer.

Installation

Pre-installation check

In addition to reading chapters 2 through 4, and Chapter 12, “Accuracy and Repeatability,” (in Volume I of this manual), complete the following items before installing a laser positioning system into any application.

- ☐ Complete Beam Path Loss Calculation (see Calculation of signal loss” in Chapter 3, “System Design Considerations,” in Volume I of this manual).
- ☐ You must supply the plane mirror reflectors if the Agilent 10724A Plane Mirror Reflector will not work for your installation. See Chapter 12, “Accuracy and Repeatability,” Chapter 17, “Beam-Directing Optics,” or Chapter 5, “Measurement Optics (General Information),” in Volume I of this manual for mirror specifications.
- ☐ Determine the direction sense for each axis, based on the orientation of the laser head, beam-directing optic, and interferometer. Enter the direction sense for each axis into the measurement system electronics. (See Chapter 16, “Laser Heads,” Chapter 11, “Principles of Operation”, and Chapter 12, “Accuracy and Repeatability,” in Volume I of this manual.
- ☐ Provide for aligning the optics, laser head, and receiver(s) on the machine. (Ideally, you want to be able to translate beam in two directions and rotate beam in two directions for each interferometer input. This typically takes two adjustment optics with proper orientations.)
- ☐ Be sure to allow for transmitted beam offset of beam splitters (Agilent 10700A and Agilent 10701A) in your design. (See the offset specifications under the “Specifications” heading at the end of this chapter.)

Alignment

General

This procedure covers specifically the alignment of the Agilent 10706A Plane Mirror Interferometer as applied to an X-Y positioning system using flat mirrors as measurement reflectors.

It is assumed that:

1 the mirror surfaces are flat to within the tolerances required for operation of the plane mirror interferometer. (Refer to the recommendations under the "Specifications" heading at the end of this chapter), and

2 the mirror surfaces have been aligned perpendicular to each other and their respective directions of travel.

Figure 124 illustrates the most common 2-axis plane mirror interferometer installation. The interferometers have been configured to turn the beam in this example.

The alignment of the plane mirror interferometer uses the autoreflection alignment technique described in Chapter 4, "System Installation and Alignment," in Volume I of this manual. In most cases, the accuracy demands of the X-Y positioning devices used, along with the relatively short travels encountered, dictate that the high accuracy alignment technique described in the autoreflection alignment procedure be used.

The alignment procedure follows the instructions for using the alignment aids, which begin below.

Alignment aids

Figure 125 shows the two alignment aids supplied with the Agilent 10706A Plane Mirror Interferometer:

- Alignment Target, Agilent Part Number 10702-60001
- Alignment Aid, Agilent Part Number 10706-60001

Both aids are magnetic to simplify positioning on the interferometer.

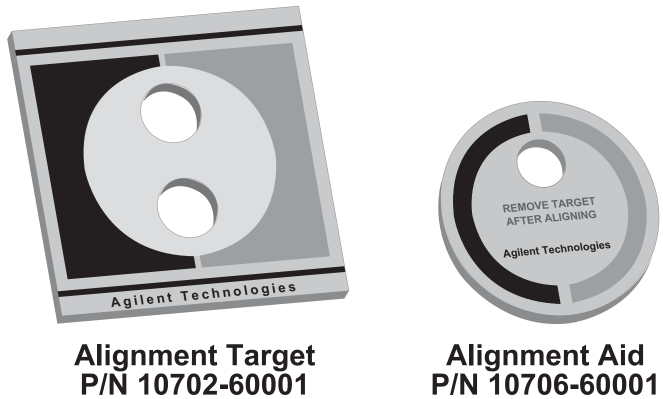


Figure 125 Agilent 10706A Interferometer — alignment aids

The Alignment Target (Agilent Part Number 10702-60001) is used on the input side of the interferometer to properly position the beam in the aperture.

The Alignment Aid (Agilent Part Number 10706-60001) is placed on the output aperture of the interferometer to allow autoreflection. This aid contains a quarter-wave plate to reflect the measurement beam back on itself and return it to the laser head without offset.

The Alignment Aid must be positioned to transmit the primary measurement beam. This is the first of the two measurement beams that travel between the Agilent 10706A interferometer and the plane mirror reflector. To identify the primary beam, block one of the two measurement beams; if the other beam also disappears, the beam you blocked is the primary measurement beam.

Alignment procedure

This procedure describes the alignment of Agilent 10706A Plane Mirror Interferometers used on an X-Y stage application. (See Figure 124)

NOTE Steps 1 through 11 constitute the Y-axis alignment.

1 Place the interferometer alignment target on the laser side of the Y-axis plane mirror interferometer and place the receiver alignment target on the receiver (Figure 126, position 1). Place a piece of opaque material such as translucent tape between the Y-axis plane mirror interferometer and the mirror.

2 Adjust the laser head until the laser beam 1) passes through the 50% beam splitter, 2) enters one hole of the interferometer alignment target, and 3) exits the other hole centered on the receiver alignment target. Fasten the laser head securely.

3 Select the small aperture of the laser head and install the alignment aid on the output of the plane mirror interferometer in the correct orientation (the hole transmits the first pass of the measurement beam to the measurement mirror). Remove the opaque material from between the plane mirror interferometer and the mirror.

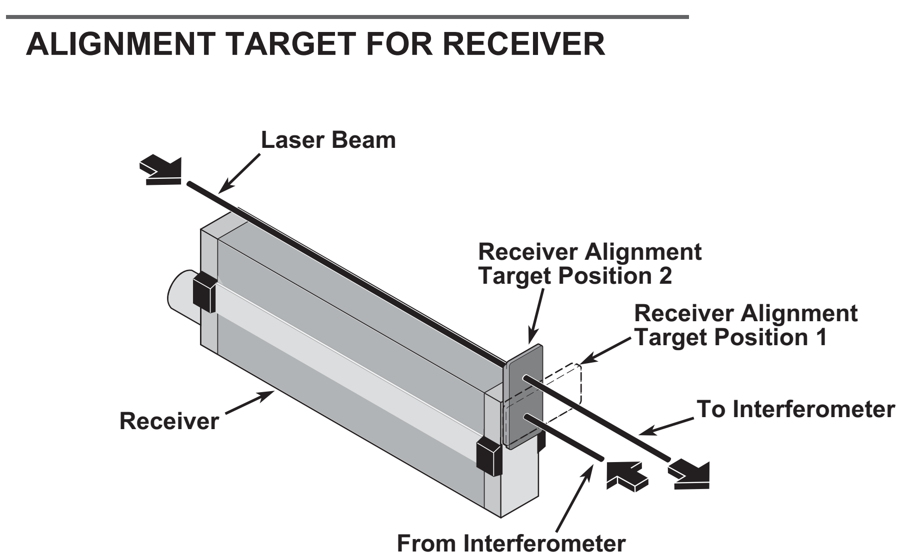


Figure 126 Receiver and receiver alignment target

4 The laser beam will now exit the interferometer and be reflected by the mirror back upon itself into the interferometer. Pitch and yaw the plane mirror interferometer until the beam reflected from the mirror returns upon itself through the plane mirror interferometer and back to the small aperture of the laser head. Slight lateral translations of the plane mirror interferometer may be required to ensure that the reference beam is still centered on the receiver alignment target. If the distance between the mirror and the laser head is at least 0.5 meter (20 inches), the formula below determines the cosine error based on the offset of the return beam at the laser head.

$$E = \frac{S^2}{8D^2}$$

where:

E is the cosine error value

S is the offset of the returning beam (in micrometers or microinches)

D is the measured (displacement) distance (in millimeters or inches)

For example, if the distance measured is 600 mm and it results in a 1.2-mm (1200-micrometer) offset, cosine error (E) will be:

$$= \frac{(1200)^2}{(8) \times (600)^2} = 0.5ppm\ (0.5\ micrometer\ per\ meter\ of\ travel)$$

NOTE For high accuracy alignment or for installations where there is less than 0.5 meter (20 inches) between the laser and mirror, perform steps 5 through 7.

5 Remove the receiver target and plane mirror interferometer alignment target and select the large aperture of the laser head. Do not remove the plane mirror interferometer alignment aid on the output side of the plane side of the plane mirror interferometer.

6 With a fast-responding voltmeter (preferably an analog type) attached to the receiver test point, pitch and yaw the plane mirror interferometer until a signal is received on the receiver. (The voltmeter will suddenly jump to some value greater than 0. 25 volt.) This is a critical adjustment and may initially require great care.

7 Adjust the plane mirror interferometer in pitch and yaw until the voltmeter reading (which may be fluctuating) is maximum. Now carefully readjust the interferometer until the voltage reading suddenly drops back down to about 0.3 volt.

NOTE

The alignment should be adjusted such that the voltage reading from the receiver test point occurs just below the sudden jump up in voltage. If the alignment is fixed to sustain this peaked voltage, system operation will be degraded.

This aligns the laser beam to within ±1.2 arc-minutes to the direction of travel, resulting in a cosine error of approximately 0.05 ppm. That is 0.05 micron per meter of travel (0.05 microinch per inch) of cosine error.

8 Fasten the plane mirror interferometer (Y-axis) securely, preserving the alignment.

9 Monitor the voltage reading along the complete travel of the stage (Y-axis). The voltage should not jump up to the previous maximum voltage reading. If the voltage does jump, readjust the interferometer until the voltage reading suddenly drops back down to about 0.3 volt.

10 Remove the plane mirror interferometer alignment target and alignment aid. The reference beam and the measurement beam must be centered on the receiver alignment target.

11 Remove the receiver alignment aids and rotate the turret on the laser head to the large aperture. Verify that the LED indicator on the receiver is lighted and the voltage at the receiver test point is between 0.6 and 1.3 Vdc.

NOTE

Steps 12 through 20 constitute the X-axis alignment.

12 With the laser head turret in the large aperture position, place the plane mirror interferometer alignment target on the laser head side of the X-axis plane mirror interferometer and the receiver alignment target on the receiver (Figure 126, position 1). Place a piece of opaque material between the X-axis plane mirror interferometer and the mirror.

13 Pitch and yaw the 50% beam splitter until the laser beam enters one hole of the plane mirror interferometer alignment target and exits the other, centered on the receiver alignment target (do not adjust the laser head). Slight lateral translations of the 50% beam splitter may be necessary to ensure there is no beam clipping. Fasten the 50% beam splitter securely.

14 Select the small aperture on the front turret of the laser head and install the alignment aid on the output of the plane mirror interferometer in the correct orientation (the hole transmits the first pass of the measurement beam to the measurement mirror). Remove the opaque material from between the plane mirror interferometer and the mirror.

15 The laser beam now exits the interferometer and is reflected by the mirror back upon itself and into the interferometer. Pitch and yaw the plane mirror interferometer until the beam reflected from the mirror returns

through the plane mirror interferometer and back to the small aperture of the laser head. Slight lateral translations of the plane mirror interferometer may be required to ensure that the reference beam is still centered on the receiver alignment target. If the distance between the mirror and the laser head is at least 0.5 meter (20 inches), the formula given earlier in this alignment procedure will determine the cosine error based on the offset of the return beam at the laser.

NOTE For high accuracy alignment or for installation where there is less than 0. 5 meter (20 inches) between the laser and mirror, perform steps 16 through 18.

16 Remove the receiver alignment target and plane mirror interferometer alignment target and select the large aperture of the laser head. Do not remove the plane mirror interferometer alignment aid on the output side of the plane mirror interferometer.

17 With a fast-responding voltmeter attached to the receiver's test point, pitch and yaw the plane mirror interferometer until a signal is received on the receiver. (The voltmeter will suddenly jump to some value greater than 0.25 volt.) This is a critical adjustment and may initially require great care to achieve the desired result.

18 Adjust the plane mirror interferometer in pitch and yaw until the voltmeter reading (which may be fluctuating) is maximum. Now carefully readjust the interferometer until the voltage reading suddenly drops back down to about 0.3 volt.

NOTE The alignment should be adjusted such that the voltage reading from the receiver test point occurs just below the sudden jump up in voltage. If the alignment is fixed to sustain this peaked voltage, system operation will be degraded.

This aligns the laser beam to within ±1.2 arc-minutes to the direction of travel, resulting in a cosine error of approximately 0.05 ppm. That is 0.05 micron per meter of travel (0.05 microinch per inch) of cosine error.

19 Fasten the plane mirror interferometer (X-axis) securely, preserving the alignment.

20 Monitor the voltage reading along the complete travel of the stage (x-axis). The voltage should not jump up to the previously peaked voltage reading. If the voltage does jump, readjust the interferometer until the voltage reading suddenly drops down to about 0.3 volt.

21 Remove the plane mirror interferometer alignment target and alignment aid. The reference beam and the measurement beam must be centered on the receiver alignment target.

22 Remove the receiver alignment aids and rotate the turret on the laser head to the large aperture. Verify the LED indicator on the receiver is lighted and the voltage at the receiver test point is between 0.6 and 1.3 Vdc.

Specifications and Characteristics

Specifications describe the device's warranted performance. Supplemental characteristics (indicated by TYPICAL or NOMINAL) are intended to provide non-warranted performance information useful in applying the device.

Plane mirror systems have a basic optical resolution of one quarter wavelength (0. 158 micron, 6.23 microinches).

Using electronic resolution extension, the system resolution is increased significantly. Depending on the system, an additional resolution extension factor of 32 (for Agilent 10885A and 10895A) or 256 (for Agilent 10897C and 10898A) is usually available.

Interferometer	Fundamental Optical Resolution	System Resolution 1 (see NOTE)	System Resolution 2 (see NOTE)
Agilent 10706A	λ /4 (158.2 nm, 6.2 µin)	λ /128 (5.0 nm, 0.2 µin)	λ /1024 (0.62 nm, 0.024 µin)

NOTE

The system resolution 1 is based on using 32X electronic resolution extension. This is available with the Agilent 10885A and Agilent 10895A electronics.

The system resolution 2 is based on using 256X electronic resolution extension. This is available with the Agilent 10897C and Agilent 10898A electronics.

Agilent 10706A Plane Mirror Interferometer Specifications

Weight: 308 grams (10.9 ounces)

Dimensions: see figure below

Materials Used: same as Agilent 10702A Interferometer

Optical Efficiency: (including a 98% efficient plane mirror reflector):

Typical: 70%

Worst Case: 54%

Fundamental Optical Resolution: λ /4

Non-linearity Error: <2.2 nm (0.09 µin)

PLANE MIRROR (MEASUREMENT MIRROR) SPECIFICATIONS

Reflectance: 98% for 633 nanometers at normal incidence (minimum 80%)

Flatness: Depending on the application and accuracy requirements of the application, mirror flatness may range from λ /4 to λ /20; i.e., 0.16 to 0.03 µmeters (6 to 1.2 µinches).

NOTE: Flatness deviations will appear as measurement errors when the mirror is translated across the beam. Mount should be kinematic so as not to bend mirror. If accuracy requirements demand it, mirror flatness might be calibrated (scanned and stored in the system controller) to be used as a correction factor.

Optical Surface Quality: 60 — 40 per MIL-0-13830

MIRROR ALIGNMENT REQUIREMENTS VS DISTANCE:

Maximum Angular Misalignment: Depends on distance between interferometer and plane mirror.

Typical values are:

±6 arc-minutes for 152 mm (6 inches)

±3 arc-minutes for 305 mm (12 inches)

±1.5 arc-minutes for 508 mm (20 inches)

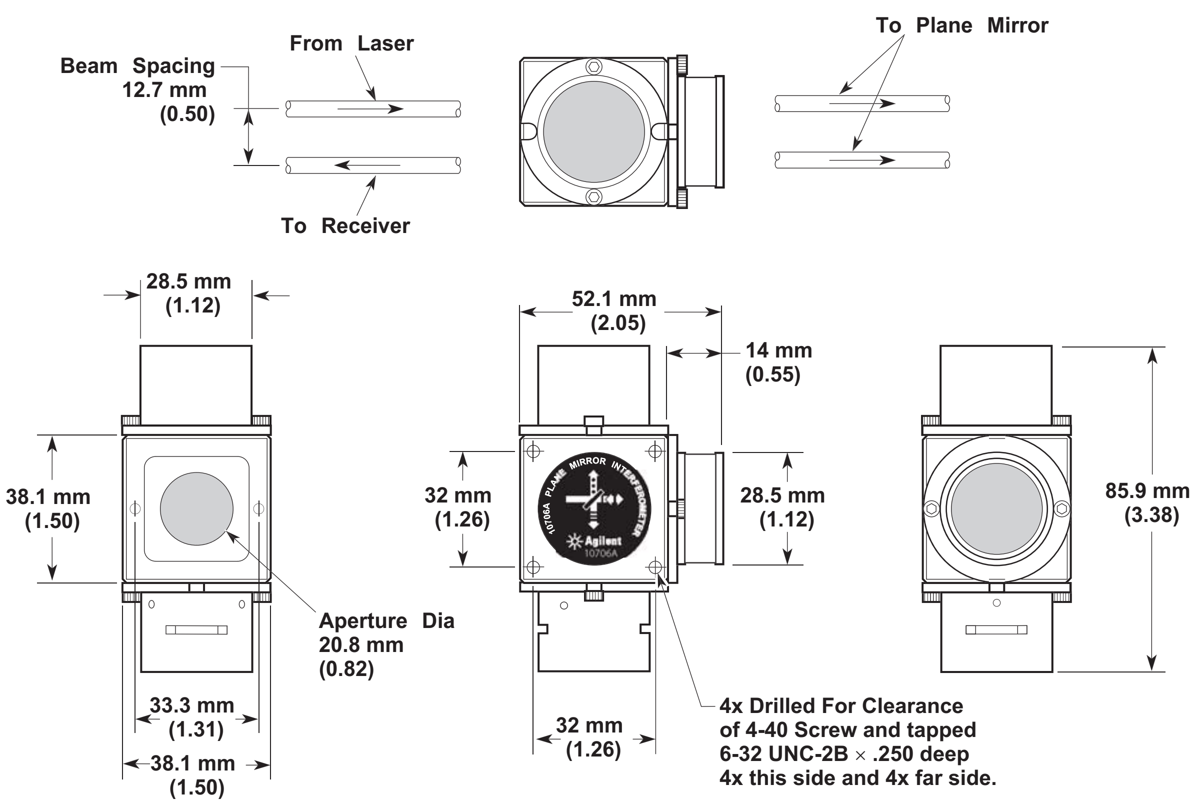


Figure 127 Agilent 10706A Plane Mirror Interferometer — dimensions

Agilent 10722A Plane Mirror Converter Specifications

Weight: 34.3 grams (1.2 ounces)

Dimensions: see figure below

Materials Used:

Housing: 416 Stainless Steel

Optics: Optical Grade Glass

Clear Aperture: 0.900 in

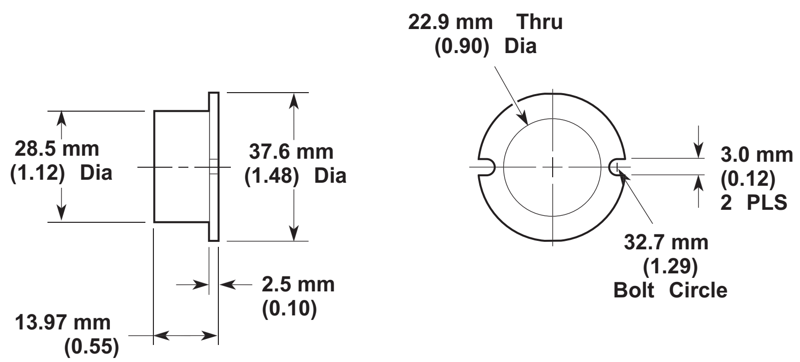


Figure 128 Agilent 10722A Plane Mirror Converter — dimensions

Agilent 10723A High Stability Adapter Specifications

Weight: 48.8 grams (1.7 ounces)

Dimensions: see drawings below

Materials Used:

Housing: Stainless Steel

Cap: Plastic (Nylon)

Optics: Optical Grade Glass

Adhesives: Low Volatility (Vacuum Grade)

For Specifications of an upgraded Agilent 10706A (replacement of reference cube corner with Agilent 10723A), see Agilent 10706B Specifications (in Chapter 21 of this manual).

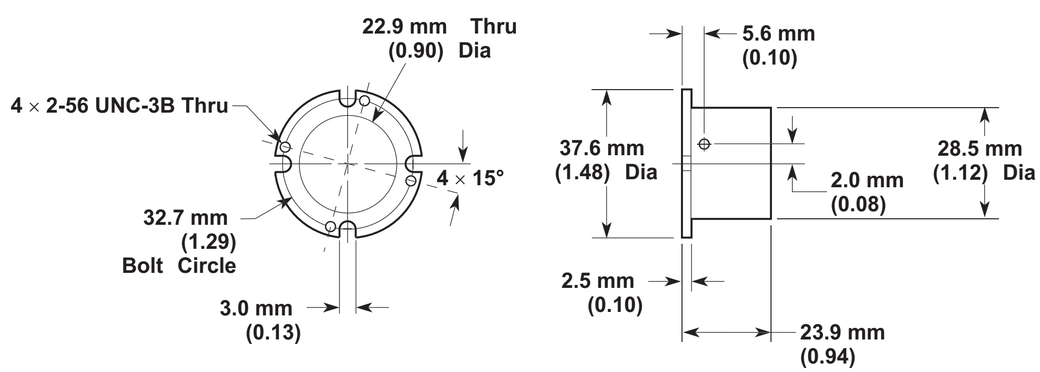


Figure 129 Agilent 10723A High Stability Adapter — dimensions

Agilent 10724A Plane Mirror Reflector Specifications

Weight: 50 grams (1.8 ounces)

Dimensions: see figure below

Materials Used: 416 Stainless Steel

Reflectivity: 98% at 633 nanometers at normal incidence

Flatness: λ /10 (at 633 nanometers)

Installed Angular Adjustment Range: Pitch/Yaw 1° configurations

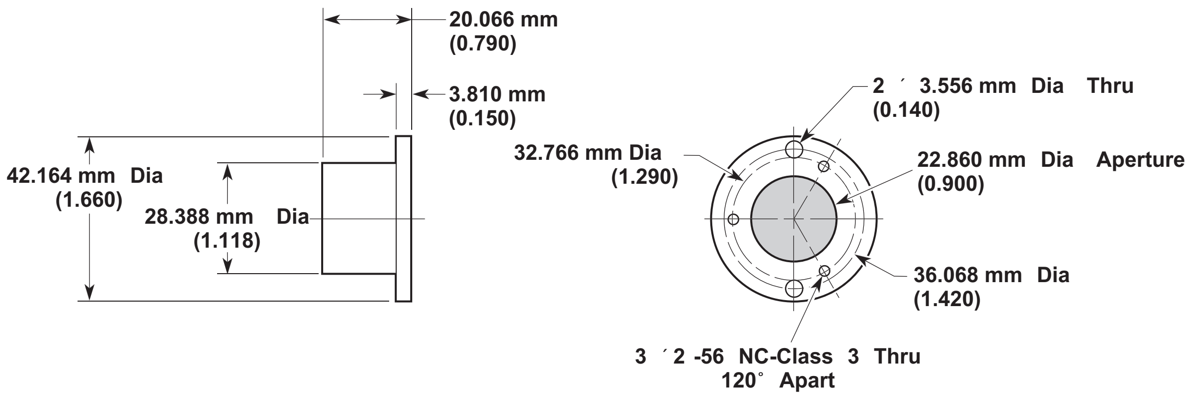


Figure 130 Agilent 10724A Plane Mirror Reflector — dimensions

Converting to High-Stability Plane Mirror Interferometer

General

The Agilent 10706A Plane Mirror Interferometer can be converted to a version having improved thermal stability equivalent to the Agilent 10706B High Stability Plane Mirror Interferometer by replacing the REFERENCE cube corner with an Agilent 10723A High Stability Adapter (see Figure 129).

Instructions for the conversion are given below.

To convert an Agilent 10706A Plane Mirror Interferometer to the Agilent 10706B configuration

NOTE The Agilent 10723A adapter MUST be installed in place of the REFERENCE cube corner on the Agilent 10706A interferometer. If it is inadvertently installed on the other side, the thermal stability will become worse. Refer to Figure 131 for the proper installation orientation.

1 Refer to Figure 131 and positively identify the position in which to install the Agilent 10723A adapter. Note that in either configuration, the Agilent 10723A adapter replaces the REFERENCE CUBE-CORNER (Agilent 10703A Retroreflector).

2 Remove the REFERENCE CUBE-CORNER and store it in a safe place.

3 Refer to Figure 131. If the interferometer is in the straight-through configuration, proceed to step 5 and install the Agilent 10723A adapter using the mounting screws that were used to mount the Reference Cube-Corner.

   If the interferometer is in the turned configuration, use the new hardware supplied with the Agilent 10723A adapter to mount the adapter as described in step 4.

4 Using the hex key provided, install the four 2-56 × 3/16 inch long screws into the holes on the flange of the Agilent 10723A adapter housing. Be sure they do not protrude through the flange.

   a Equip both 4-40 × 1/2 inch long mounting screws with a compression spring and use them to install the Agilent 10723A adapter in place of the removed Reference Cube-Corner. Either set of mounting slots may be used to attached the High Stability Adapter to the interferometer.

b Tighten both mounting screws until the head of each just begins to compress the spring. Then tighten each screw two turns to properly compress each spring.

c Continue to step 5.

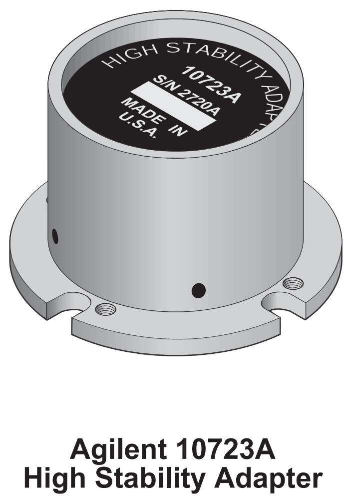


Figure 131 Agilent 10723A High Stability Adapter

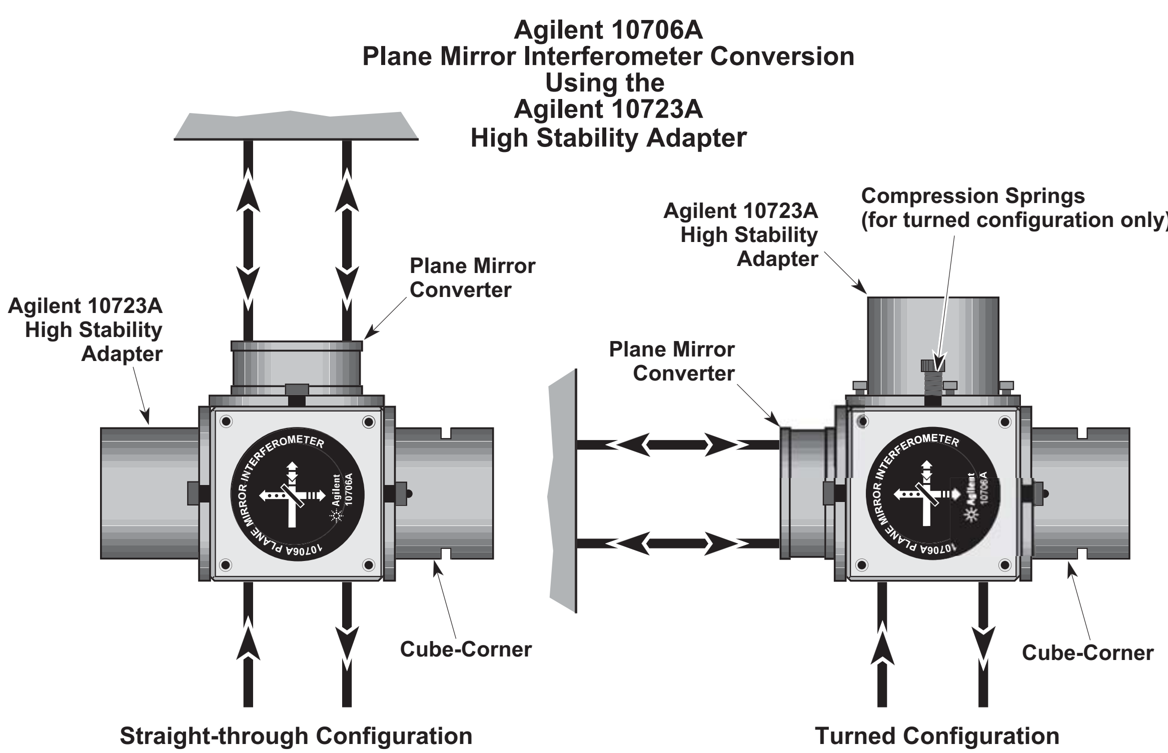


Figure 132 Agilent 10706A Conversion Using the Agilent 10723A

5 Install the Agilent 10723A High Stability Adapter in place of the removed reference cube corner. Either set of mounting slots may be used to attach the High Stability Adapter to the interferometer.

6 Refer to Figure 131. Locate and remove the PLANE MIRROR CONVERTER.

7 The black plastic bezel under the plane mirror converter must be removed to allow access for an Alignment Aid during setup. The bezel is secured with silicone adhesive, but can be easily removed. Place the blade of a small screwdriver under the lip of the bezel and pry the bezel out. PRY THE SCREWDRIVER AWAY FROM THE BEAM SPLITTER GLASS, TAKING CARE THAT IT DOES TO COME IN CONTACT WITH OR SCRATCH THE OPTIC. Discard the bezel.

8 Replace the plane mirror converter that was removed in step 4.

This completes the conversion. The converted interferometer must be realigned as described in the alignment sections for the Agilent 10706B High Stability Plane Mirror Interferometer in Chapter 21 of this manual.

21
Agilent 10706B High Stability Plane Mirror Interferometer

Description

The Agilent 10706B High Stability Plane Mirror Interferometer (see Figure 133) is an improved version of the Agilent 10706A interferometer. It offers very high thermal stability. Its thermal drift is typically 1/12 that of a conventional plane mirror interferometer.

The Agilent 10706B High Stability Plane Mirror Interferometer uses plane mirror reflectors. For X-Y stage applications, the user must provide the mirror(s).

Using plane mirror reflectors allows for a marked improvement in measurement stability, thereby reducing the designer's error budget. Existing system designs can be easily upgraded, since the Agilent 10706B interferometer is an exact functional replacement for the Agilent 10706A interferometer, and is the same size and weight. It can be used in the same applications as the Agilent 10706A interferometer, but requires different alignment techniques. See the “Alignment” section later in this chapter for alignment procedures.

Externally, and in its use, the Agilent 10706B interferometer is identical to the Agilent 10706A Plane Mirror Interferometer described in the previous chapter (Chapter 20). Internally, however, the design and configuration of the Agilent 10706B interferometer’s optical elements differs from that of the Agilent 10706A interferometer. You can see this difference by comparing the laser path drawings for the two interferometers.

In addition to the material presented in this chapter, you should also read about the Agilent 10706A interferometer in Chapter 20 of this manual.

Laser beam paths

Figure 134 shows the optical schematic for the Agilent 10706B High Stability Plane Mirror Interferometer.

Note that the usual reference beam cube corner (see the Agilent 10706A laser beam path schematic in Chapter 20 of this manual) has been replaced with a quarter-wave plate with a high-reflectance coating on the back. In this configuration, the measurement and reference beams have the same optical path length through glass, which virtually eliminates measurement errors due to the temperature changes in the optic. The remaining thermal errors are due to mechanical tolerances in the geometry of the device. Typically, the Agilent 10706B exhibits drift of 0.04 micron per degree C of optics temperature change.

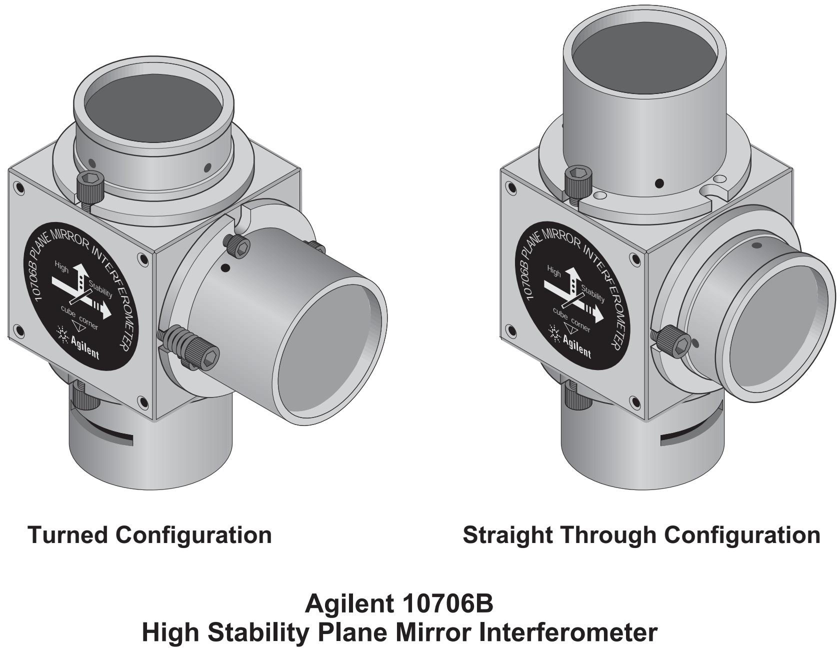


Figure 133 Agilent 10706B High Stability Plane Mirror Interferometer

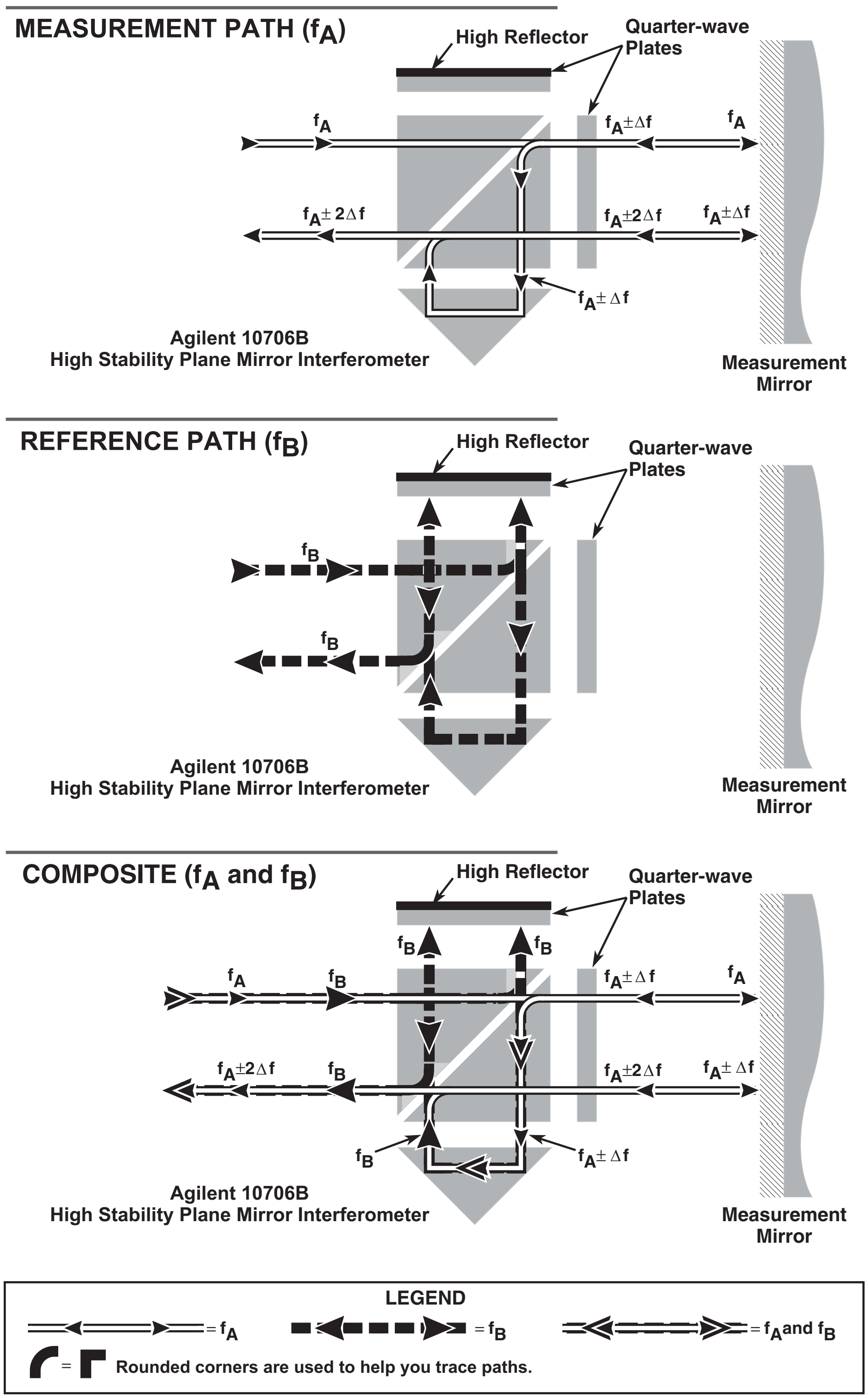


Figure 134 Agilent 10706B High Stability Plane Mirror Interferometer, optical schematic

Special Considerations

See the Agilent 10706A “Special Considerations” information in Chapter 20 of this manual.

Mounting

Adjustable mounts

The Agilent 10711A Adjustable Mount provides a convenient means of mounting, aligning, and securely locking the Agilent 10706B interferometer in position. Since the mount allows some tilt and yaw adjustment, the need for custom fixturing is minimized. The mount allows the interferometer to be rotated about its centerline, simplifying installation.

Fasteners

The Agilent 10706B interferometer is supplied with English mounting hardware, which is required to fasten it to its adjustable mount.

Adapter plate

The Agilent 10706A-080 Adapter Plate adds an easy mounting surface to the interferometer for mounting the remote lens assemblies of the Agilent 10780F, Agilent E1708A, and Agilent E1709A remote receivers directly to the interferometer.

Installation

Refer to the Agilent 10706A interferometer “Installation” information in Chapter 20 of this manual.

Alignment

The alignment procedure for the Agilent 10706B High Stability Plane Mirror Interferometer is similar to that for the Agilent 10706A, except for an additional alignment of the High Stability Adapter.

The alignment procedure follows the instructions for reconfiguring the Agilent 10706B interferometer and using the alignment aids, which begin below.

Straight-Through Configuration

The Agilent 10706B High Stability Plane Mirror Interferometer is shipped in the straight-through configuration as shown in Figure 135. Note the location of the plane mirror converter and high stability adapter with respect to the graphics on the label.

Turned Configuration

The Agilent 10706B interferometer can be configured to turn the beam to reduce the number of beam-bending optics, as shown in Figure 135. This is done by interchanging the high stability adapter and the plane mirror converter and adding new mounting and adjusting hardware for the High Stability Adapter. Note the location of the plane mirror converter and high stability adapter with respect to the graphics on the label.

The new mounting and adjusting hardware is contained in a bag shipped with the Agilent 10706B interferometer.

1 Using the hex key provided, install the four 2-56 × 3/16-inch long screws into the holes on the flange of the High Stability Adapter housing. Be sure that they do not protrude through the flange.

2 Equip both 4-40 × 1/2-inch long mounting screws with a compression spring and use them to mount the High Stability Adapter in place of the plane mirror converter as shown in Figure 135.

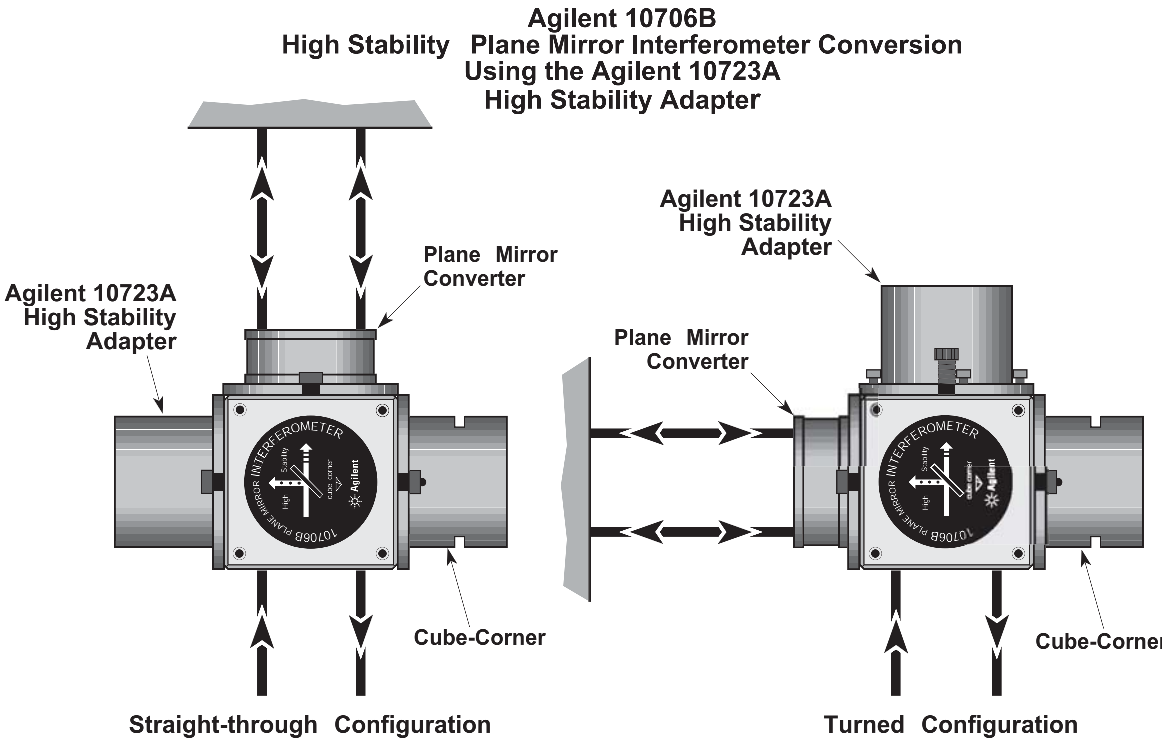


Figure 135 Agilent 10706B Interferometer — configurations

3 Tighten both mounting screws until the head of each just begins to compress the spring. Then tighten each screw two turns to properly compress each spring.

NOTE

Changing to the turned configuration changes the measurement direction sense (see the “Effect of optics on measurement direction sense” section of Chapter 3, “System Design Considerations, “ in Volume I of this manual). If the High Stability Adapter is installed in the wrong location, the interferometer will have worse thermal stability.

Alignment aids

The Agilent 10706B High Stability Plane Mirror Interferometer is supplied with the alignment aids shown in Figure 136.

- Alignment Aid, Agilent Part Number 10706-60001
- Alignment Target, Agilent Part Number 10702-60001
- Alignment Aid, Agilent Part Number 10706-60202

The first two of these alignment aids are the same as those used on the Agilent 10706A Plane Mirror Interferometer. Refer to the “Alignment Aids” for the Agilent 10706A Plane Mirror Interferometer, in Chapter 20, for a further discussion of their use.

Alignment Aid Agilent Part Number 10706-60202 facilitates autoreflection alignment for the high stability adapter to achieve minimal thermal drift. It contains a quarter-wave plate to reflect the reference beam back on itself and return it to the laser head without offset. Figure 137 illustrates how the aid is positioned between the beam splitter and the high stability adapter during alignment.

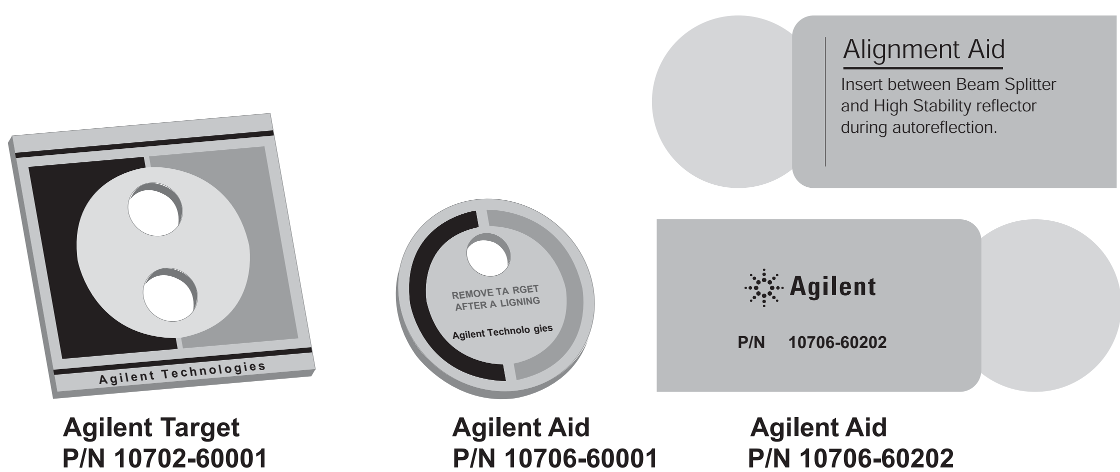


Figure 136 Agilent 10706B Interferometer — alignment aids

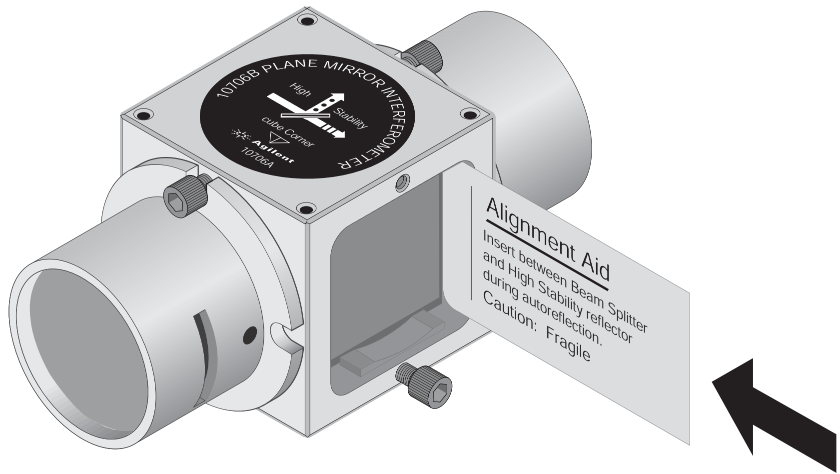


Figure 137 Using the Agilent 10706-60202 Alignment Aid

Alignment Procedures

Two alignment procedures are given for the Agilent 10706B High Stability Plane Mirror Interferometer:

- the straight-through configuration (as shipped) in a single-axis application
- the turned configuration for two-axis X-Y stage applications

Straight-Through Configuration (Signal-Axis Alignment)

This procedure describes the alignment of the Agilent 10706B High Stability Plane Mirror Interferometer used in the straight-through configuration.

Before proceeding, review “Alignment principles” in Chapter 4, “System Installation and Alignment,” in Volume I of this manual.

This procedure minimizes cosine error and the thermal drift coefficient of the Agilent 10706B interferometer, and maximizes signal strength at the receiver. Two separate autoreflection adjustment steps are performed using the two alignment aids.

1 Move the stage to its point furthest from the laser head. Align the laser beam perpendicular to the measurement mirror by autoreflection.

2 Position the Agilent 10706B interferometer in the beam path between the laser head and the measurement mirror.

3 Place the interferometer alignment target (Agilent Part Number 10702-60001) on the laser (input) side of the interferometer. Place the alignment aid (Agilent Part Number 10706-60001) on the outside side of the

interferometer in the correct orientation (the hole allows transmission of the primary measurement beam). Select the small aperture on the front turret of the laser head.

4 Move the interferometer until the beam passes 1) through the center of one hole on the alignment target, 2) through the hole on the alignment aid, and 3) strikes the measurement mirror. Use translucent tape over the target aperture to observe when the beam is centered.

NOTE If the distance between the laser head and the reflector is greater than 0.5 meter (20 inches), the formula given in the “Overlapping Dots Method Summary,” section of Chapter 4 (in Volume I) determines the cosine error based on the offset of the return beam at the laser head. For example, with a distance between the laser head and reflector of 0.5 meter and an offset of the return beam at the small aperture of the laser of 500 microns (0.0202 inch), the cosine error is approximately 0.12 ppm.

5 Pitch and yaw the laser beam until the beam reflected from the measurement mirror returns upon itself, through the interferometer and back to the small aperture of the laser head. Move the laser head or the interferometer to keep the laser beam centered on one hole of the alignment target. Fasten the laser and/or the beam steering optics securely, taking care not to disturb the alignment.

NOTE For high-accuracy alignment or for installations where there is less than 0.5 meter (20 inches) between the laser and mirror, perform steps 6 through 8.

6 Remove the alignment target (Agilent Part Number 10702-60001) and select the large aperture of the laser head. Do not remove the alignment aid (Agilent Part Number 10706-60001) on the output side of the interferometer. Center the output beams on the receiver aperture by moving the receiver. Translucent tape over the receiver aperture will help to observe when the beam is centered.

7 Connect a fast-responding voltmeter (preferably an analog type) to the receiver test point. Pitch and yaw the laser beam until a signal is received. This is indicated by the voltmeter suddenly jumping to a value greater than 0.25 volt. This adjustment is critical and may require great care to achieve the desired result.

8 Pitch and yaw the laser beam to achieve maximum voltmeter reading. Carefully readjust the interferometer until the voltage reading suddenly drops back to about 0.3 volt.

NOTE

The alignment should be adjusted such that the voltage reading from the receiver test point occurs just below the sudden jump up in voltage. If the alignment is fixed to sustain this peaked voltage, system operation will be degraded.

This aligns the laser beam to within ±1.2 arc-minutes to the direction of travel, resulting in a cosine error of approximately 0.05 ppm (0.05 microns per meter of travel or 0.05 microinch per inch).

9 Remove the alignment aid (Agilent Part Number 10706-60001) from the interferometer. Also, remove the plane mirror converter from the interferometer. Switch to the small aperture on the laser head. Block the measurement beam by placing something between the interferometer and the measurement mirror.

10 Insert the Agilent 10706B interferometer alignment aid (Agilent Part Number 10706-60202) between the beam splitter and the high stability adapter as shown in Figure 137. This allows the reference beam to be autoreflected from the high stability adapter back toward the small aperture of the laser head.

11 Observe the reflection of the reference beam back at the laser head. Pitch and yaw the interferometer until this reflection is returned back into the small aperture of the laser head.

12 Fasten the interferometer securely to preserve the pitch and yaw adjustments.

13 Remove the Agilent 10706B interferometer alignment aid (Agilent Part Number 10706-60202) from between the beam splitter and the high stability adapter. Replace the plane mirror converter. Remove the beam block from between the interferometer and measurement mirror.

14 The reference and measurement beams must be centered on the receiver aperture. Use translucent tape over the receiver aperture to observe the beams. Move the receiver side-to-side to center the beams on the receiver aperture.

15 Place the alignment aid (Agilent Part Number 10706-60001) back on the output side of the interferometer and switch to the large aperture on the laser head. Connect a fast-responding voltmeter to the receiver test point. Monitor the voltage reading along the complete travel of the stage. The voltage should not jump up to the previously peaked voltage reading. If the voltage does jump, readjust the laser beam as in step 5 until the voltage reading suddenly drops back down to about 0.3 volt.

16 If readjustment of the laser head or beam steering optics is required in step 15 then return to step 9 and repeat the procedure.

17 Remove the interferometer alignment aid.

18 Rotate the turret on the laser head to the large aperture. Verify that the LED indicator on the receiver is illuminated and the voltage at the receiver test point is between 0.6 and 1.3 volts DC.

Turned Configuration (X-Y Stage Example) Alignment

This procedure describes the alignment of Agilent 10706B interferometers used in an X-Y stage application as shown in Figure 138. Before proceeding, review “Alignment principles” in Chapter 4, “System Installation and Alignment,” in Volume I of this manual.

This procedure minimizes cosine error and the thermal drift coefficient of the Agilent 10706B interferometer, and maximizes the signal at the receiver.

Two separate autoreflection/adjustment steps are performed using the two alignment aids.

NOTE Steps 1 through 17 constitute the Y-axis alignment.

1 Send the beam through the center of the 50% beam splitter. Align the Y-Axis laser beam parallel to the plane of the stage and measurement mirror by pitching and yawing the laser head and moving it side-to-side. This ensures that the interferometer turns the beam 90°. Using an optical square or pentaprism is helpful. Secure the laser head.

X-Y STAGE APPLICATION

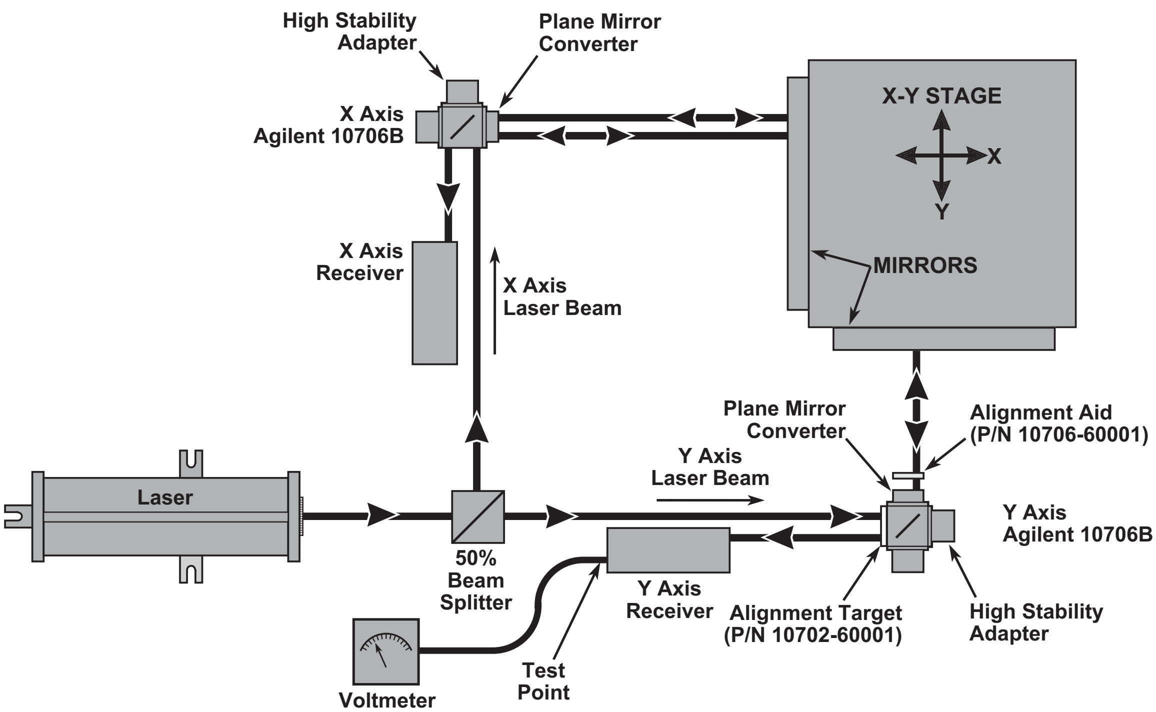


Figure 138 Agilent 10706B High Stability Plane Mirror Interferometer in an X-Y Stage Application

2 Position the Agilent 10706B interferometer in the beam path to turn the beam 90° toward the measurement mirror. Place the alignment target (Agilent Part Number 10702-60001) on the input side of the interferometer. Place the alignment aid (Agilent Part Number 10706-60001) on the output side of the interferometer in the correct orientation (the hole allows transmission of the primary measurement beam). Select the small aperture on the laser head turret.

3 Move the interferometer side-to-side until the beam 1) passes through the center of one hole on the alignment target, 2) through the hole on the alignment aid, and 3) strikes the measurement mirror. Use translucent tape over the target aperture to observe when the beam is centered.

NOTE If the distance between the laser head and the reflector is greater than 0. 5 meter (20 inches), the formula given in the “Overlapping Dots Method Summary,” section of Chapter 4 (in Volume I) determines the cosine error based on the offset of the return beam at the laser head. For example, with a distance between the laser head and reflector of 0.5 meter and an offset of the return beam at the small aperture of the laser of 500 microns (0. 0202 inch), the cosine error is approximately 0.12 ppm.

4 Pitch and yaw the interferometer until the beam reflected from the measurement mirror returns upon itself, through the interferometer and back to the small aperture of the laser head. Once this autoreflection is achieved, secure the interferometer while preserving the alignment.

NOTE For high-accuracy alignment or for installations where there is less then 0.5 meter (20 inches) between the laser and mirror, perform steps 5 through 7.

5 Remove the plane mirror interferometer alignment target and select the large aperture of the laser head. Do not remove the plane mirror interferometer alignment aid on the output side of the plane mirror interferometer. Center the output beams on the receiver aperture by moving the receiver side-to-side. Translucent tape over the receiver aperture will help you observe when the beams are centered.

6 Connect a fast-responding voltmeter (preferably an analog type) to the Y-Axis receiver test point. Pitch and yaw the interferometer until a signal is received. This is indicated by the voltmeter suddenly jumping to a value greater than 0.25 volt. This adjustment is a critical and may require great care to achieve the desired result.

7 Adjust the voltmeter reading (which may be fluctuating) for a maximum by pitching and yawing the interferometer. Carefully readjust the interferometer until the voltage reading suddenly drops back to about 0.3 volt.

NOTE The alignment should be adjusted such that the voltage reading from the receiver test point occurs just below the sudden jump up in voltage. If the alignment is fixed to sustain this peaked voltage, system operation will be degraded.

This aligns the laser beam to within ±1.2 arc-minutes to the direction of travel, resulting in a cosine error of approximately 0.05 ppm (0.05 micron per meter of travel or 0.05 microinch per inch).

8 Fasten the interferometer (Y-Axis) securely, preserving the alignment.

9 Remove the alignment aid (Agilent Part Number 10706-60001) from the interferometer. Also, remove the plane mirror converter from the interferometer. Switch to the small aperture on the laser head. Block the measurement beam by placing something between the Y-Axis interferometer and the measurement mirror.

10 Insert Agilent 10706B interferometer alignment aid (Agilent Part Number 10706-60202) between the beam splitter and the high stability adapter as shown in Figure 137. This allows the reference beam to be autoreflected from the high stability adapter back toward the small aperture of the laser head.

11 Observe the reflection of the reference beam back at the laser head. Adjust two of the four alignment set screws until the beam autoreflects into the small aperture of the laser head. Once autoreflection is achieved, gently snug the two remaining set screws. Be careful to preserve the autoreflection alignment.

12 Remove the Agilent 10706B interferometer alignment aid (Agilent Part Number 10706-60202) between the beam splitter and the high stability adapter. Replace the plane mirror converter (removed in step 9). Remove the beam block from between the interferometer and the measurement mirror.

13 The reference and measurement beams must be centered on the receiver aperture. Use translucent tape over the receiver aperture to observe the beams. Move the receiver side-to-side to center the beams on the receiver aperture.

14 Place the alignment aid (Agilent Part Number 10706-60001) back on the output side of the interferometer and switch to the large aperture on the laser head. Connect a fast-responding voltmeter to the receiver test point. Monitor the voltage reading along the complete travel of the stage. The voltage should not jump up to the previous maximum voltage reading. If the voltage does jump, readjust the interferometer as in step 4 until the voltage reading suddenly drops back to about 0.3 volt.

15 If readjustment of the interferometer is required in step 14, return to step 9 and repeat the procedure from that point.

16 Remove the alignment aid (Agilent Part Number 10706-60001).

17 Rotate the turret on the laser head to the large aperture. Verify that the LED indicator on the receiver is lighted and the voltage at the receiver test point is between 0.6 and 1.3 volts DC.

NOTE

Steps 18 through 34 constitute the X-axis alignment.

18 Align the X-axis laser beam parallel to the plane of the stage and measurement mirror by adjusting the pitch and yaw of the 50% beam splitter (do not adjust the laser head). This ensures that the interferometer turns the beam 90 degrees. Using an optical square or pentaprism is helpful. Secure the 50% beam splitter.

19 Place the Agilent 10706B interferometer in the beam path to turn the beam 90 degrees toward the measurement mirror. Place the alignment target (Agilent Part Number 10702-60001) on the laser (input) side of the interferometer. Place the alignment aid (Agilent Part Number 10706-60001) on the output side of the interferometer, in the correct orientation (the hole allows transmission of the primary measurement beam). Select the small aperture on the front turret of the laser head.

20 Move the interferometer side-to-side until the beam 1) passes through the center of one hole on the alignment target, 2) passes through the hole on the alignment aid (Agilent Part Number 10706-60001), and 3) strikes the measurement mirror. Use translucent tape over the aperture of the alignment target to observe centering of the beam.

NOTE

If the distance between the laser head and the reflector is greater than 0.5 meter (20 inches), the formula given in the "Overlapping Dots Method Summary," section of Chapter 4 (in Volume I) determines the cosine error based on the offset of the return beam at the laser head. For example, with a distance between the laser head and reflector of 0.5 meter and an offset of the return beam at the small aperture of the laser of 500 microns (0.0202 inch), the cosine error is approximately 0.12 pp.

21 Pitch and yaw the interferometer until the beam reflected from the measurement mirror returns upon itself, through the interferometer and back to the small aperture of the laser head. Once autoreflection is achieved, secure the interferometer, preserving the alignment.

NOTE

For high-accuracy alignment or for installation where there is less than 0.5 meter (20 inches) between the laser and mirror, perform steps 22 through 24.

22 Remove the alignment target (Agilent Part Number 10702-60001) and rotate the turret of the laser head to select the large aperture. Do not remove the alignment aid (Agilent Part Number 10706-60001) on the output side of the interferometer. Center the output beams on the receiver aperture by

moving the receiver side-to-side. Translucent tape over the receiver aperture will help you observe when the beam is centered.

23 Connect a fast-responding voltmeter to the receiver test point. Pitch and yaw the plane mirror interferometer until a signal is received at the receiver. (The voltmeter will suddenly jump to some value greater than 0.25 volt.) This adjustment is critical and may require great care to achieve the desired result.

24 Pitch and yaw the interferometer until the voltmeter reading (which may be fluctuating) is maximum. Carefully readjust the interferometer until the voltage reading suddenly drops back down to about 0.3 volt.

NOTE The alignment should be adjusted such that the voltage reading from the receiver test point occurs just below the sudden jump up in voltage. If the alignment is fixed to sustain this peaked voltage, system operation will be degraded.

This aligns the laser beam to within ±1.2 arc-minutes of the direction of travel, resulting in a cosine error of approximately 0.05 ppm (0.05 micron per meter of travel or 0.05 microinch per inch).

25 Fasten the interferometer (X-axis) securely, making sure the alignment is not disturbed.

26 Remove the alignment aid (Agilent Part Number 10706-60001) from the interferometer. Also, remove the plane mirror converter from the interferometer. Switch to the small aperture on the laser head. Block the measurement beam by placing something between the interferometer and the measurement mirror.

27 Insert Agilent 10706B alignment aid (Agilent Part Number 10706-60202) between the beam splitter and the high stability adapter as shown in Figure 137. This allows the reference beam to be autoreflected from the high stability adapter back toward the small aperture of the laser head.

28 Observe the reflection of the reference beam back at the laser head. Adjust two of the four adjustment screws until the beam autoreflects into the small aperture of the laser head. Once autoreflection is achieved, gently snug the two remaining set screws. Be careful to preserve the autoreflection alignment.

29 Remove the Agilent 10706B interferometer alignment aid (P/N 10706-60202) from between the beam splitter and the high stability adapter. Replace the plane mirror converter (removed in step 26 above). Remove the beam block from between the interferometer and the measurement mirror.

30 The reference and measurement beams must be centered on the receiver aperture. Using translucent tape over the receiver aperture to observe the beams, move the receiver side-to-side to center the beams.

31 Place the interferometer alignment aid (P/N 10706-60001) back on the output side of the interferometer and switch to the large aperture on the laser head. Connect a fast-responding voltmeter to the receiver test point. Monitor the voltage reading along the complete travel of the stage. The voltage should not jump up to the previous maximum voltage reading. If the voltage does jump, readjust the interferometer as in step 21 until the voltage reading suddenly drops back to about 0.3 volt.

32 If readjustment of the interferometer is required in step 31, return to step 26 and repeat the procedure from that point.

33 Remove the interferometer alignment aid.

34 Rotate the turret on the laser head to the large aperture. Verify that the LED indicator on the receiver is illuminated and the voltage at the receiver test point is between 0.6 and 1.3 volts DC.

Specifications and Characteristics

Specifications describe the device's warranted performance. Supplemental characteristics (indicated by TYPICAL or NOMINAL) are intended to provide non-warranted performance information useful in applying the device.

Plane mirror systems have a fundamental optical resolution of one quarter wavelength (0.158 micron, 6.23 microinches).

Using electronic resolution extension, the system resolution is increased significantly. Depending on the system, an additional resolution extension factor of 32 (for Agilent 10885A and 10895A) or 256 (for Agilent 10897C and 10898A) is usually available.

Interferometer	Fundamental Optical Resolution	System Resolution 1 (see NOTE)	System Resolution 2 (see NOTE
Agilent 10706B	λ /4 (158.2 nm, 6.2 µin)	λ /128 (5.0 nm, 0.2 µin)	λ /1024 (0.62 nm, 0.024 µin)

NOTE

The system resolution 1 is based on using 32X electronic resolution extension. This is available with the Agilent 10885A and Agilent 10895A electronics.

The system resolution 2 is based on using 256X electronic resolution extension. This is available with the Agilent 10897C and Agilent 10898A electronics.

Agilent 10706B Plane Mirror Interferometer Specifications

Weight: 323 grams (11.4 ounces)

Dimensions: see figure below

Materials Used:

- Housing: Stainless Steel
- Apertures: Plastic (Nylon)
- Spacers: Plastic (Nylon)
- Optics: Optical Grade Glass
- Adhesives: Low Volatility (Vacuum Grade)

Optical Efficiency:

- Typical: 60%
- Worst Case (Calculated): 43%

Thermal Drift Coefficient: (Change of indicated distance per degree C temperature change): 0.04 micron/°C (1.6 µinch/°C) typical

Fundamental Optical Resolution: λ /4

Non-linearity Error: 2.2 nm, peak value

PLANE MIRROR (MEASUREMENT MIRROR) RECOMMENDATIONS

Reflectance: 98% for 633 nanometers at normal incidence (minimum 80%)

Flatness: Depending on the application and accuracy requirements of the application, mirror flatness may range from λ /4 to λ /20; i.e., 0.16 to 0.03 µmeters (6 to 1.2 µinches).

NOTE: Flatness deviations will appear as measurement errors when the mirror is translated across the beam. Mount should be kinematic so as not to bend mirror. If accuracy requirements demand it, mirror flatness might be calibrated (scanned and stored in the system controller) to be used as a correction factor.

Optical Surface Quality: 60 — 40 per MIL-0-13830

Measurement (or Reference) Mirror Pitch/Yaw*:
Depends on distance between interferometer and plane mirror. Typical mirror pitch/yaw angles are:

- ±6 arc-minutes for 152mm (6 inches)
- ±3 arc-minutes for 305 mm (12 inches)
- ±1.5 arc-minutes for 508 mm (20 inches)

*Misalignment of interferometer to measurement mirror will degrade the Thermal Drift Coefficient.

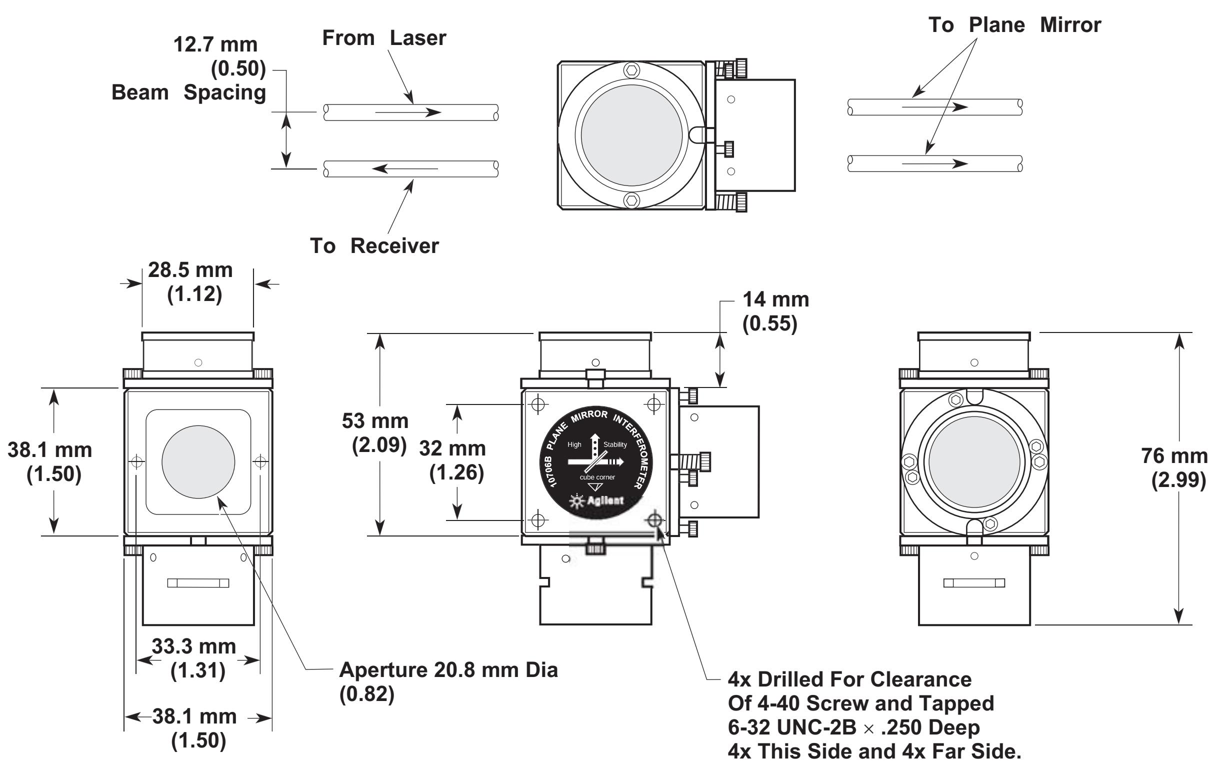


Figure 139 Agilent 10706B Plane Mirror Interferometer — dimensions

22
Agilent 10715A Differential Interferometer

Description

The Agilent 10715A Differential Interferometer (see Figure 140) allows differential measurements to be made between two plane mirrors — the reference plane mirror and the measurement plane mirror. The reference mirror is supplied with the Agilent 10715A. The measurement mirror must be a plane mirror such as the Agilent 10724A Plane Mirror Reflector or other user-supplied plane mirror.

The major benefit of the Agilent 10715A interferometer is that the optical path is common to both the reference and the measurement beams (see Figure 141). This makes the Agilent 10715A extremely tolerant of changes such as thermal expansion or changes in air characteristics. When used in a positioning system, the small reference mirror supplied can be mounted very close to the measurement mirror. The advantages of the common beam path and the small reference mirror combine to significantly reduce deadpath. Deadpath is the optical path length difference between the reference and measurement beams when the stage is at its initial “zero” position. Reducing deadpath results in extremely high stability and resistance to spurious changes in the optical path. Since the measurement beam travels twice between the interferometer and the plane mirror, the resolution of the measurement is twice that of a linear or single-beam interferometer.

A turned configuration (Agilent 10715A-001) is available to turn the beam 90 degrees, thereby eliminating the need for a beam bender.

The orientation of the optics determines which frequency polarization is in the measurement or reference path, thus affecting direction sense.

A differential measurement is one in which both the reference beam and the measurement beam travel to external mirrors outside the interferometer housing. This allows measurement of the relative positions of the two external mirrors, either or both of which may be moving. Viewed another way, this allows measuring the motion of one reflector relative to a reference datum elsewhere in the machine, external to the interferometer itself. This is unlike the typical interferometer configuration because usually the reference beam path length does not change; in differential configurations, it can.

For more information about differential measurements, see Chapter 3, “System Design Considerations,” in Volume I of this manual.

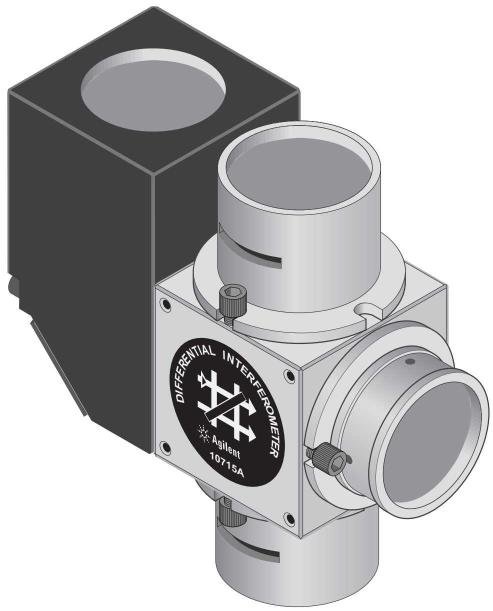


Figure 140 Agilent 10715A Differential Interferometer

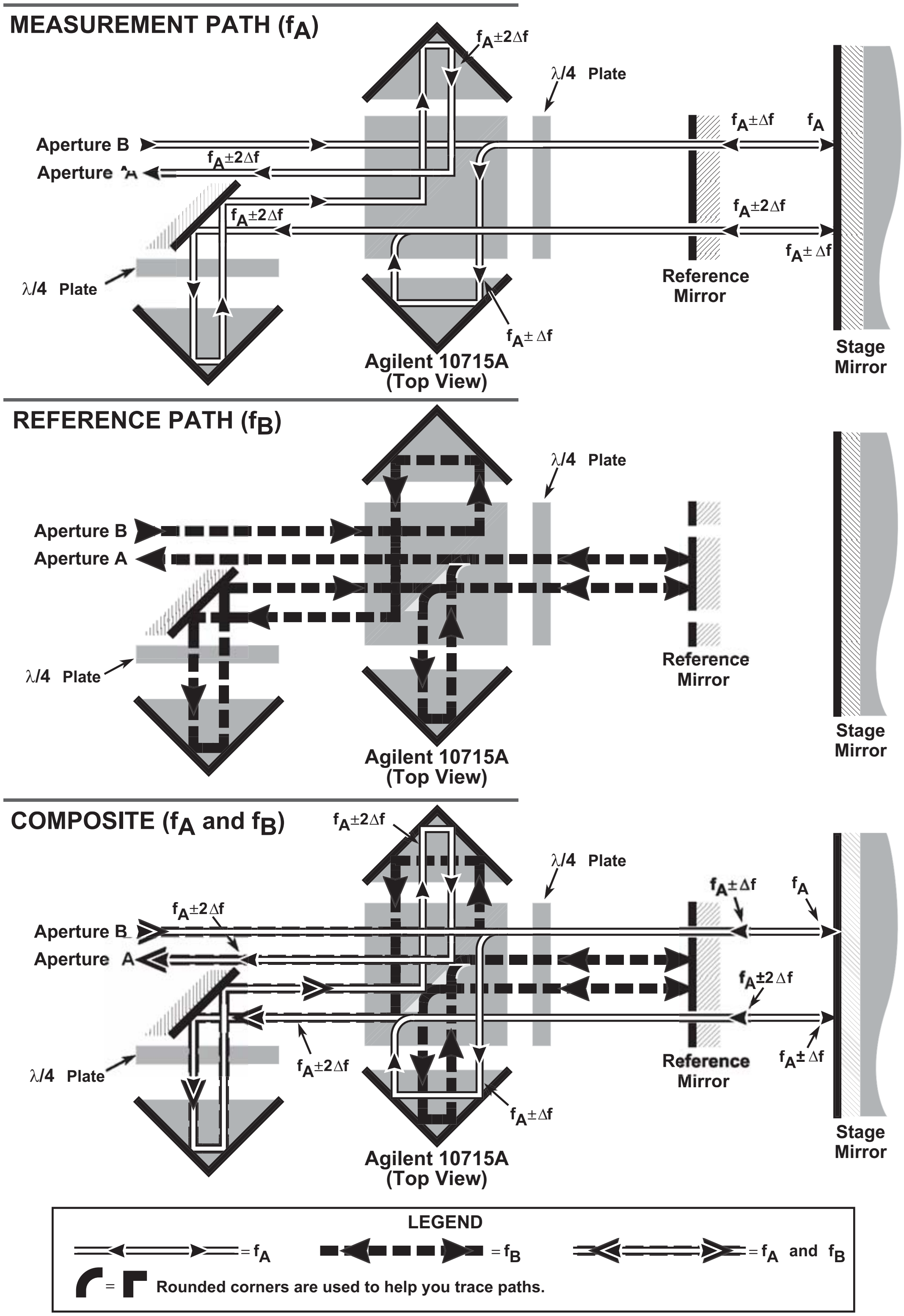


Figure 141 Agilent 10715A Differential Interferometer — laser beam path

Special Considerations (Configuration Effects)

For purposes of convention, aperture B will be considered the input aperture when referring to all configurations. Note that the choice of input aperture is one of the configuration variables that affects the direction sense.

The Agilent 10715A Differential Interferometer is available in two configurations; the Agilent 10715A (see Figure 142) and the Agilent 10715A-001 (see Figure 143). Both have the same direction sense; however, it may change, depending on the mounting and orientation as shown in Table 73.

Configurations with the same direction sense

Standard configuration Agilent 10715A

The Agilent 10715A is assembled and shipped in the “Standard” configuration (see Figure 142).

Turned configuration Agilent 10715A-001

The primary reason for using the Agilent 10715A-001 is to turn the beam. In the “Standard” configuration, the beam is not turned (it passes straight through the interferometer to the measurement reflector).

Agilent 10715A upside down

Mounting the Agilent 10715A in this manner has no effect on the direction sense, assuming the same input aperture is used.

Table 73 shows the direction sense for various optical configurations.

Configurations that change the direction sense

Agilent 10715A Input and Output Apertures

The laser beam may enter either of the two apertures on the Agilent 10715A or Agilent 10715A-001. These apertures are labeled A and B. If aperture A is used as the input, then aperture B is the output aperture and vice-versa. Functionally, it is arbitrary which aperture is the input aperture. However, the choice of A or B does determine which frequency is passed to the measurement mirror and thereby determines the direction sense.

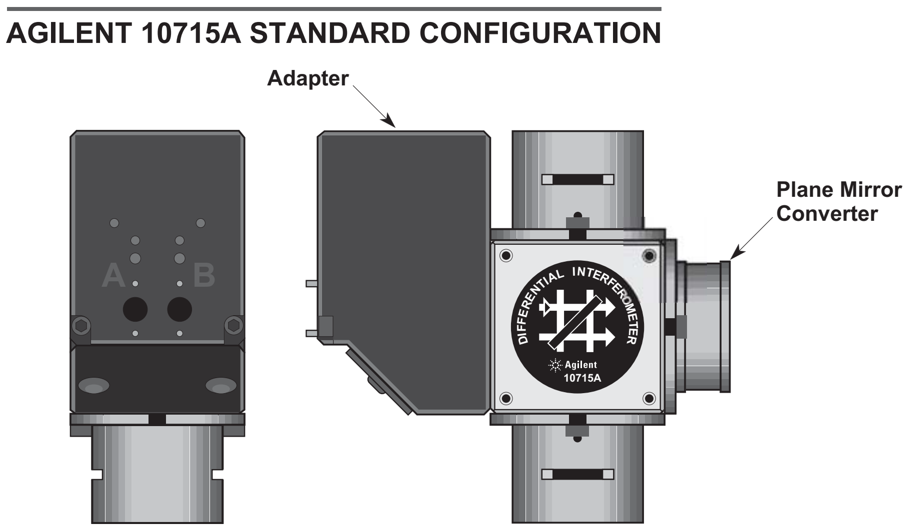


Figure 142 Agilent 10715A Standard Configuration

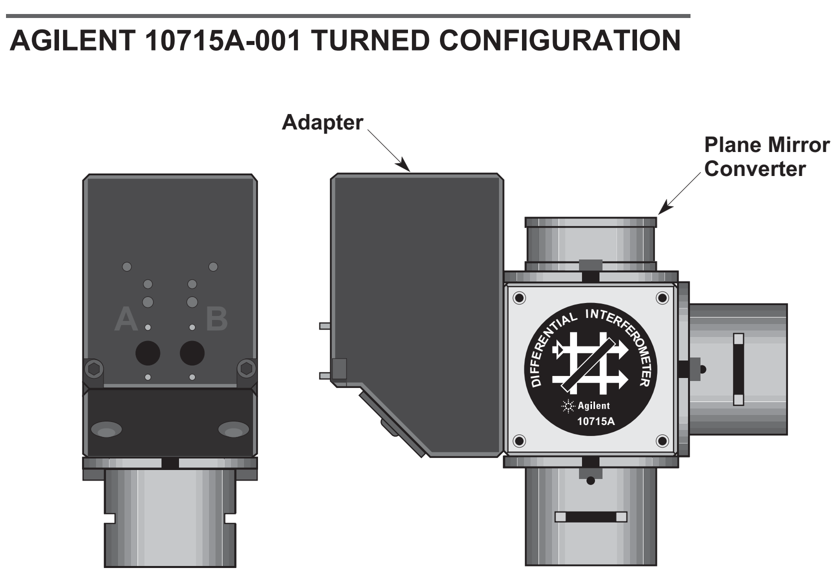


Figure 143 Agilent 10715A-001 Turned Configuration

Agilent 10715A orientation (horizontal or vertical)

The Agilent 10715A may be mounted on a horizontal surface or a vertical surface. The direction sense will be different for each orientation.

If any two of the conditions described above, including the laser head orientation, are changed there is no net change in the direction sense.

Table 73 Agilent 10715A direction sense

<table>
<tr><th>Laser Head</th><th>Laser Head Orientation Horizontal or Rolled 90° About Beam</th><th>Agilent 10715A Input Aperture A or B</th><th>Agilent 10715A Orientation Horizontal or Vertical</th><th>F1 Path</th></tr>
<tr><td rowspan="7">Agilent 5517A/B/C/D
F1 Horizontal
F2 Vertical</td><td rowspan="3">Horizontal</td><td rowspan="2">A</td><td>Horizontal</td><td>Ref</td></tr>
<tr><td>Vertical</td><td>Meas</td></tr>
<tr><td>B</td><td>Horizontal</td><td>Meas</td></tr>
<tr><td rowspan="4">Rotated 90°</td><td rowspan="2">A</td><td>Horizontal</td><td>Meas</td></tr>
<tr><td>Vertical</td><td>Ref</td></tr>
<tr><td rowspan="2">B</td><td>Horizontal</td><td>Ref</td></tr>
<tr><td>Vertical</td><td>Meas</td></tr>
</table>

Mounting

Adjustable mounts

The Agilent 10711A Adjustable Mount provides a convenient means of mounting, aligning, and securely locking the Agilent 10715A interferometer in position. Since the mount allows some tilt and yaw adjustment, the need for custom fixturing is minimized. The mount allows the interferometer to be rotated about its centerline, simplifying installation.

Fasteners

The Agilent 10715A interferometer is supplied with English mounting hardware, which is required to fasten it to its adjustable mount.

Installation and Alignment

The Agilent 10715A Differential Interferometer alignment procedure has more steps than those for other Agilent interferometers because its reference mirror must also be aligned.

Before discussing the alignment procedure for this interferometer, details on beam locations and reference mirror mounting will be covered.

Configurations

Two configurations are available for the Agilent 10715A Differential Interferometer, allowing flexibility in optical layout of a measurement system. They are:

- Standard
- Turned (10715-001)

Figure 144 shows the location of the measurement and reference beams for the standard configuration using input aperture B. The beams are switched if input aperture A is used.

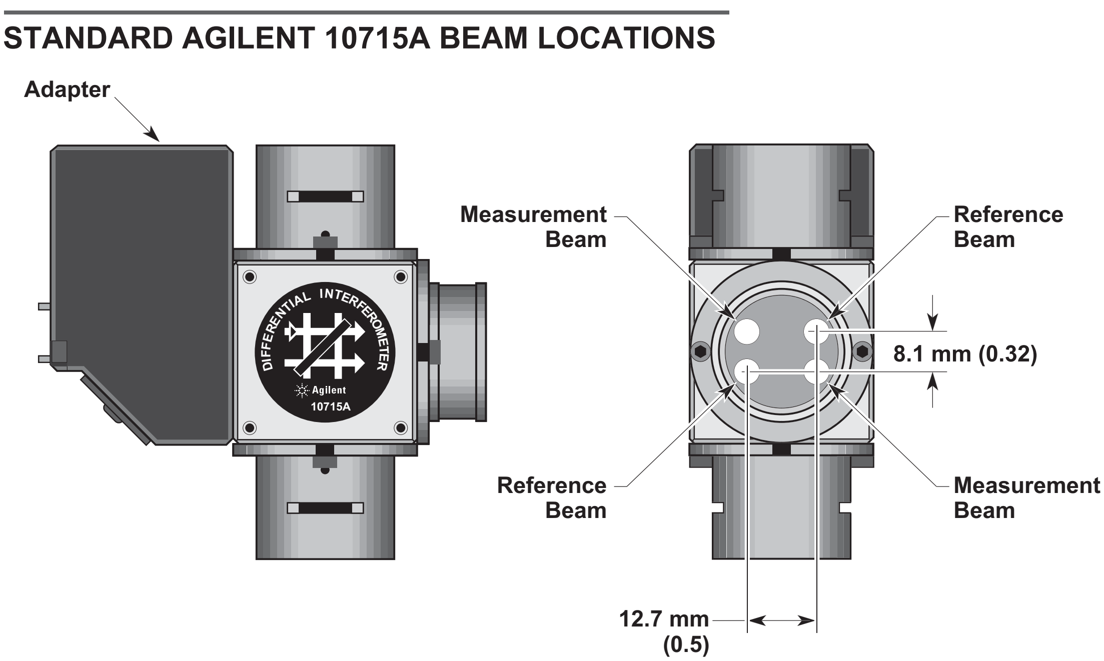


Figure 144 Beam locations for standard Agilent 10715A Differential Interferometer

Figure 145 shows the location of the measurement and reference beams for the turned configuration (Agilent 10715A-001) using input aperture B. The beams are switched if input aperture A is used.

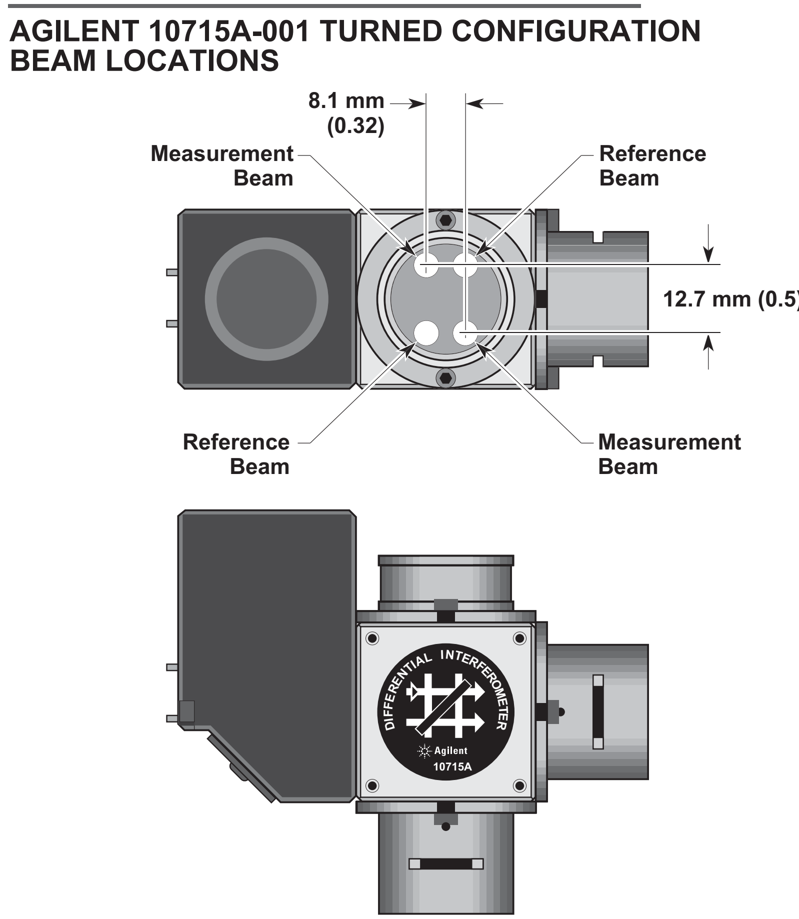


Figure 145 Beam locations for Agilent 10715A-001 Turned Configuration

Reference mirror mounting

The Agilent 10715A interferometer is supplied with a small reference plane mirror (see Figure 145).

Mount the mirror on an adjustable mount so proper alignment can be obtained. When alignment is achieved, rigidly fix the position of the mirror. The recommended method is to use an adhesive to attach the mirror to the mount. The adhesive should not induce stress into the glass during curing. Place the mirror-and-mount assembly as close as possible to the near end of travel of the stage to reduce potential deadpath errors.

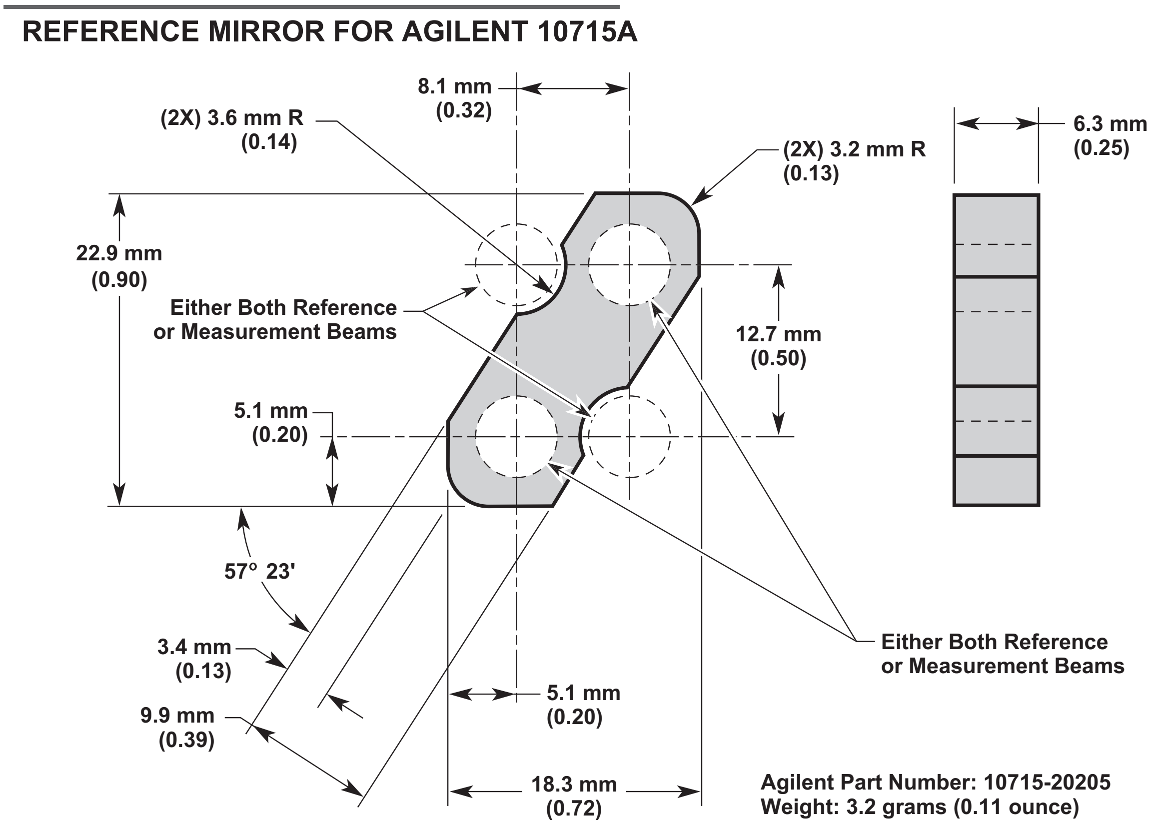


Figure 146 Agilent 10715A Interferometer (reference mirror)

Alignment aid

Alignment Aid (Agilent Part Number 10706-60001) is included with the Agilent 10715A interferometer. This is the same alignment aid used on the Agilent 10706A Plane Mirror Interferometer. For information about use of this alignment aid, see Chapter 20 in this manual, which deals with the Agilent 10706A Plane Mirror Interferometer.

Alignment procedure

This alignment procedure is similar to that for the Agilent 10706A Plane Mirror Interferometer. The main difference is that in this procedure the laser beam must pass through small apertures, which requires fairly precise alignment to avoid clipping part of the beam. It is assumed that the measurement mirror has been aligned perpendicular to the axis of travel.

The alignment procedure below is for the “Standard Configuration”, with the laser beam entering the interferometer in aperture B. The alignment procedure for the “Turned Configuration” is similar, except it is more sensitive to angular alignment of the interferometer.

1 Select the small aperture on the laser head.
2 Roughly align the laser beam for each axis perpendicular to the measurement mirror. This is done by autoreflecting off this mirror and adjusting the laser head or beam bender until the reflected beam is centered in the small aperture on the laser head.
3 Move the interferometer side-to-side so that the laser beam enters the input aperture (aperture B in this example).
4 Place a rectangular gage block over the input aperture so that it reflects the laser beam back toward the laser. See Figure 147.

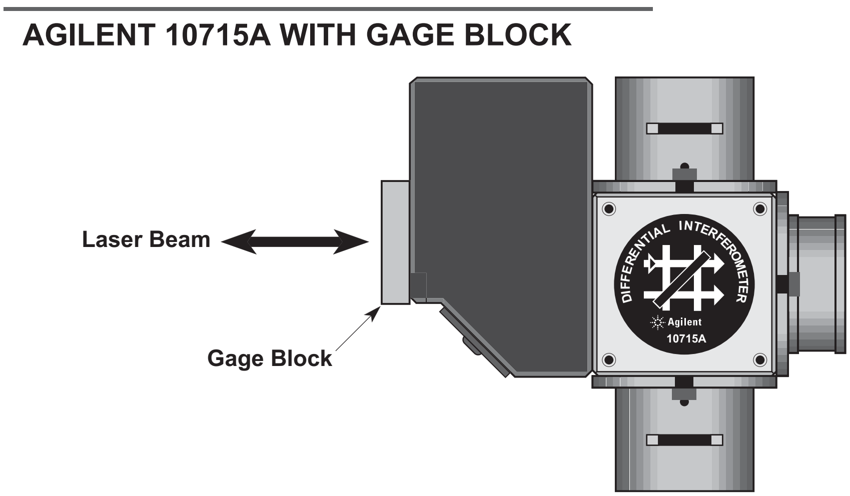


Figure 147 Agilent 10715A with gage block in position

5 Adjust the differential interferometer in pitch and yaw until the laser beam is autoreflected back into the laser head. This insures proper alignment. It may be necessary to move the interferometer again to center the laser beam on the input aperture (aperture B). Use a piece of translucent tape to help observe the beam.
6 Once the autoreflection alignment of the interferometer is complete, remove the gage block and select the large aperture on the laser head. Two parallel unclipped beams should now leave the interferometer. See Figure 148.

NOTE The autoreflection procedure above is used only to reduce clipping, and is not as critical as the autoreflection procedure used to reduce cosine error. As long as the two beams are not clipped, the alignment of the interferometer is adequate.

One of the two beams will be directed to the measurement mirror; the other will be directed to the stationary reference mirror. Which beam goes to which mirror affects only the direction sense (discussed in the “Effect of optics on measurement direction sense” section in Chapter 3, “System Design Considerations,” in Volume I of this manual).

Since it is important that the beam going to the measurement mirror be properly aligned to avoid cosine error, this alignment will be performed first. Alignment is iterative because both the incoming beam and the interferometer require adjustment.

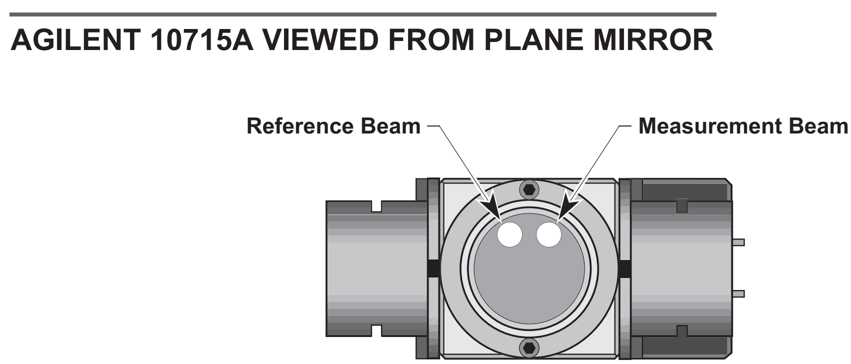


Figure 148 Differential interferometer as viewed from plane mirrors

7 Place the alignment aid over the output aperture (plane mirror converter) of the Differential Interferometer such that the beam going to the measurement mirror (which becomes the measurement beam) passes through the alignment target. See Figure 149.

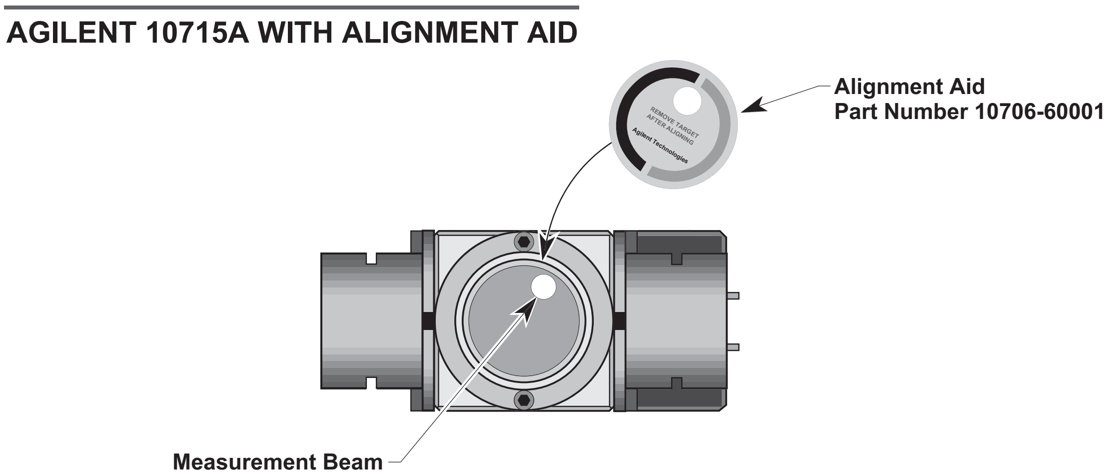


Figure 149 Agilent 10715A with alignment aid attached over measurement beam

8 This beam should clear the reference mirror and strike the measurement mirror. Select the small aperture on the front turret of the laser head. Adjust the laser beam until the beam is autoreflected back through the small aperture of the laser head. This ensures that the beam is perpendicular to the measurement mirror. This step requires pitching and yawing the laser head, beam benders, or beam splitters depending on optical layout. Steps 4 and 5 should be performed after each adjustment to prevent the interferometer from clipping the laser beam.

9 Remove the alignment aid. Laser (measurement) beams should now exit the interferometer aperture in diametrically opposite positions. See Figure 150.

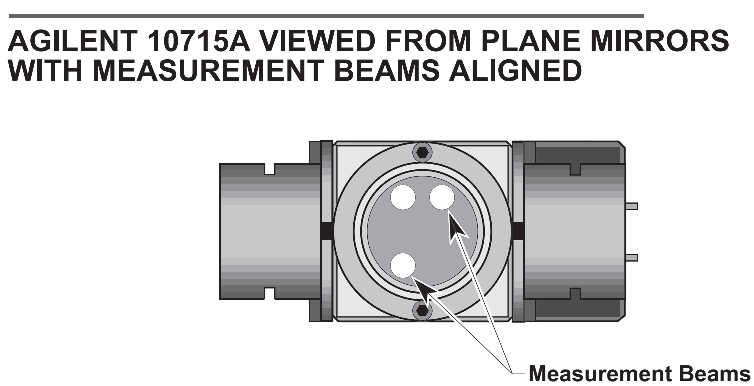


Figure 150 Differential interferometer as viewed from plane mirrors with measurement beams aligned

10 Switch to the large aperture on the laser head.

11 Check to ensure that both measurement beams pass clear of the stationary reference mirror. If necessary, move the reference mirror until both measurement beams pass clear. The return beam should now pass unclipped to the receiver.

12 Replace the alignment aid over the output aperture of the differential interferometer such that the beam going to the reference mirror (which becomes the reference beam) passes through the alignment aid. See Figure 151.

The full reference beam should strike the reference mirror. Select the small aperture on the laser head. If the reference mirror is parallel to the movable mirror, the reference beam will now be reflected back to the small aperture on the laser head. If not, the reference mirror must be adjusted in pitch and yaw until the reference beam is centered on the small aperture.

13 Remove the alignment aid. The measurement beam and the reference beam should now exit the interferometer aperture in diametrically opposite positions. Switch the laser head to its large aperture. See Figure 152.

The measurement beam and the reference beam should pass unclipped to the receiver. Verify this by checking that these beams are centered in the output aperture (aperture A). Use a piece of translucent tape to help observe the laser beam.

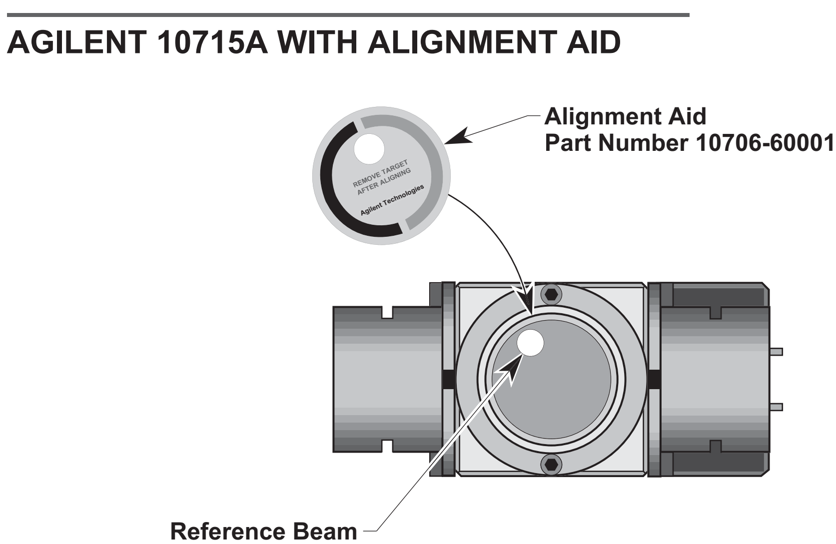


Figure 151 Alignment aid attached over reference beam

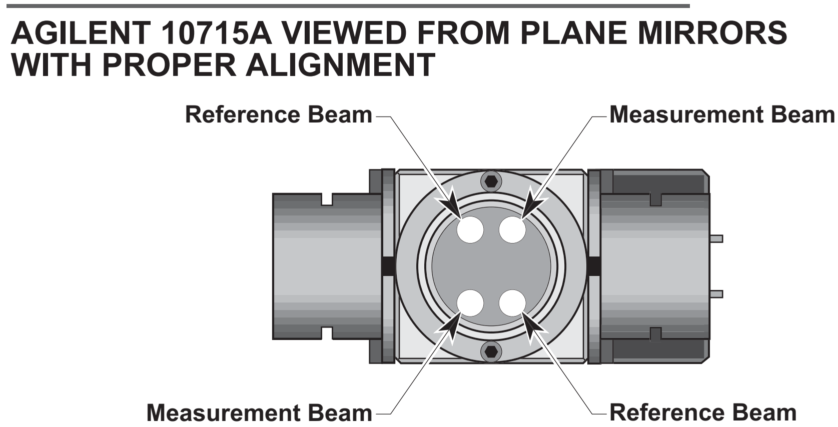


Figure 152 Differential interferometer as viewed from plane mirrors with proper alignment

Specifications and Characteristics

Specifications describe the device's warranted performance. Supplemental characteristics (indicated by TYPICAL or NOMINAL) are intended to provide non-warranted performance information useful in applying the device.

Using electronic resolution extension, the system resolution is increased significantly. Depending on the system, an additional resolution extension factor of 32 (for Agilent 10885A and 10895A) or 256 (for Agilent 10897C and 10898A) is usually available.

Interferometer	Fundamental Optical Resolution	System Resolution 1 (see NOTE)	System Resolution 2 (see NOTE)
Agilent 10715A	λ /4 (158.2 nm, 6.2 µin)	λ /128 (5.0 nm, 0.2 µin)	λ /1024 (0.62 nm, 0.024 µin)

NOTE

The system resolution 1 is based on using 32X electronic resolution extension. This is available with the Agilent 10885A and Agilent 10895A electronics.

The system resolution 2 is based on using 256X electronic resolution extension. This is available with the Agilent 10897C and Agilent 10898A electronics.

Agilent 10715A Differential Interferometer (and 10715A-001 Turned Configuration) Specifications

Weight: 504 grams (1.1 pounds)
Dimensions: see figure below
Materials Used:
- Housing: Stainless Steel and Aluminum
- Optics: Optical Grade Class
- Adhesives: Vacuum Grade

Optical Efficiency: (including a 98% efficient plane mirror reflector and the Reference Mirror)
- Typical: 40%
- Worst Case: 30%

Fundamental Optical Resolution: λ /4
Non-linearity Error: <2.2 nm (0.09 µin)

MEASUREMENT PLANE MIRROR RECOMMENDATIONS
Reflectance: 98% for 633 nanometers at normal incidence
Optical Surface Quality: 60–40 per Mil-0-13830
Flatness: Depending on the application and accuracy requirements of the application, mirror flatness may range from λ /4 to λ /20; i.e., 0.16 to 0.03 µmeters (6 to 1.2 µinches).

NOTE: Flatness deviations will appear as measurement errors when the mirror is translated across the beam. Mount should be kinematic so as not to bend mirror. If accuracy requirements demand it, mirror flatness might be calibrated (scanned and stored in the system controller) to be used as a correction factor.

MEASUREMENT OR REFERENCE MIRROR ALIGNMENT REQUIREMENTS VS DISTANCE:
Maximum Angular Misalignment (pitch and yaw): Depends on distance between interferometer and plane mirror. Typical values are:
- ± 2.5 arc-minutes for 152 mm (6 inches)
- ± 1.3 arc-minutes for 305 mm (12 inches)
- ± 0.7 arc-minute for 508 mm (20 inches)

Thermal Drift: <0.002 micron/°C (0.08 µ/°C) typical
Fundamental Optical Resolution: λ /4
Non-linearity Error: <3.5 nm (0.14 µinch)

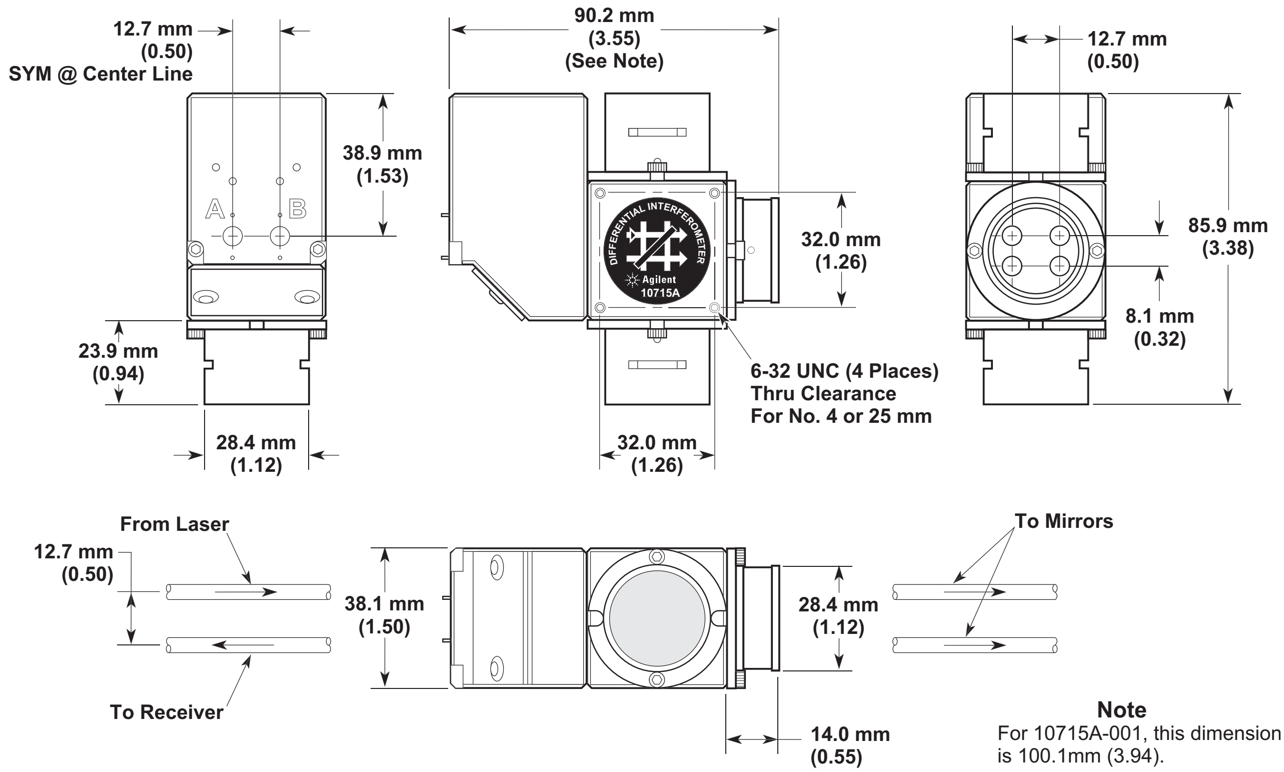


Figure 153 Agilent 10715A Differential Interferometer (and Agilent 10715A-001 Turned Configuration) — dimensions

23
Agilent 10716A High-Resolution Interferometer

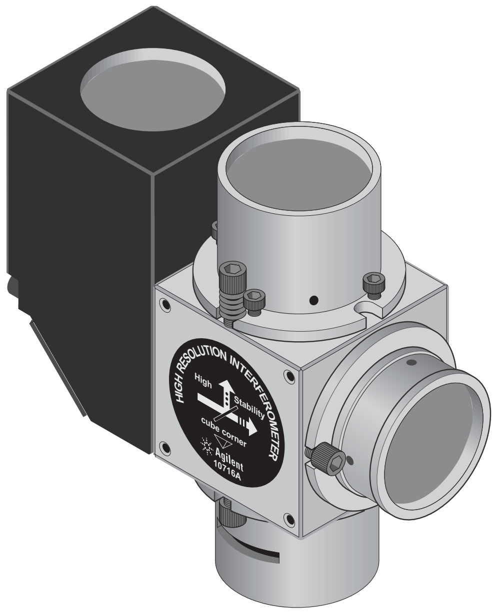
Description

The Agilent 10716A High Resolution Interferometer (see Figure 154) offers twice the resolution of conventional plane mirror interferometers and has the same excellent thermal characteristics as the Agilent 10706B interferometer (typically, only 0.04 micron of drift per degree C). Measurement drift is typically 1/12 of that exhibited by a conventional plane mirror interferometer. These features result in improved accuracy, repeatability, and positioning capability.

Although the Agilent 10716A interferometer is larger than the conventional plane mirror interferometer and the slew rate is halved, the finer resolution of this optic allows laser measurement system measurement resolution of 2.5 nanometers (0.1 microinch) with most Agilent laser electronics.

The Agilent 10716A interferometer can be used in the same applications as other Agilent plane mirror interferometers, but with different alignment techniques. A turned configuration (Agilent 10716A-001) is available to turn the beam 90 degrees, thereby eliminating the need for a beam bender. Like other plane mirror interferometers the Agilent 10716A uses plane mirror reflectors such as the Agilent 10724A Plane Mirror Reflector or a suitable user-supplied plane mirror.

Figure 155 shows the optical schematic of the Agilent 10716A High Resolution interferometer. The unit consists of a cube corner, a plane mirror converter, a retroreflector, a high-stability adapter, and a polarizing beam splitter.



Agilent 10716A
High Resolution Interferometer

Figure 154 Agilent 10716A High Resolution Interferometer

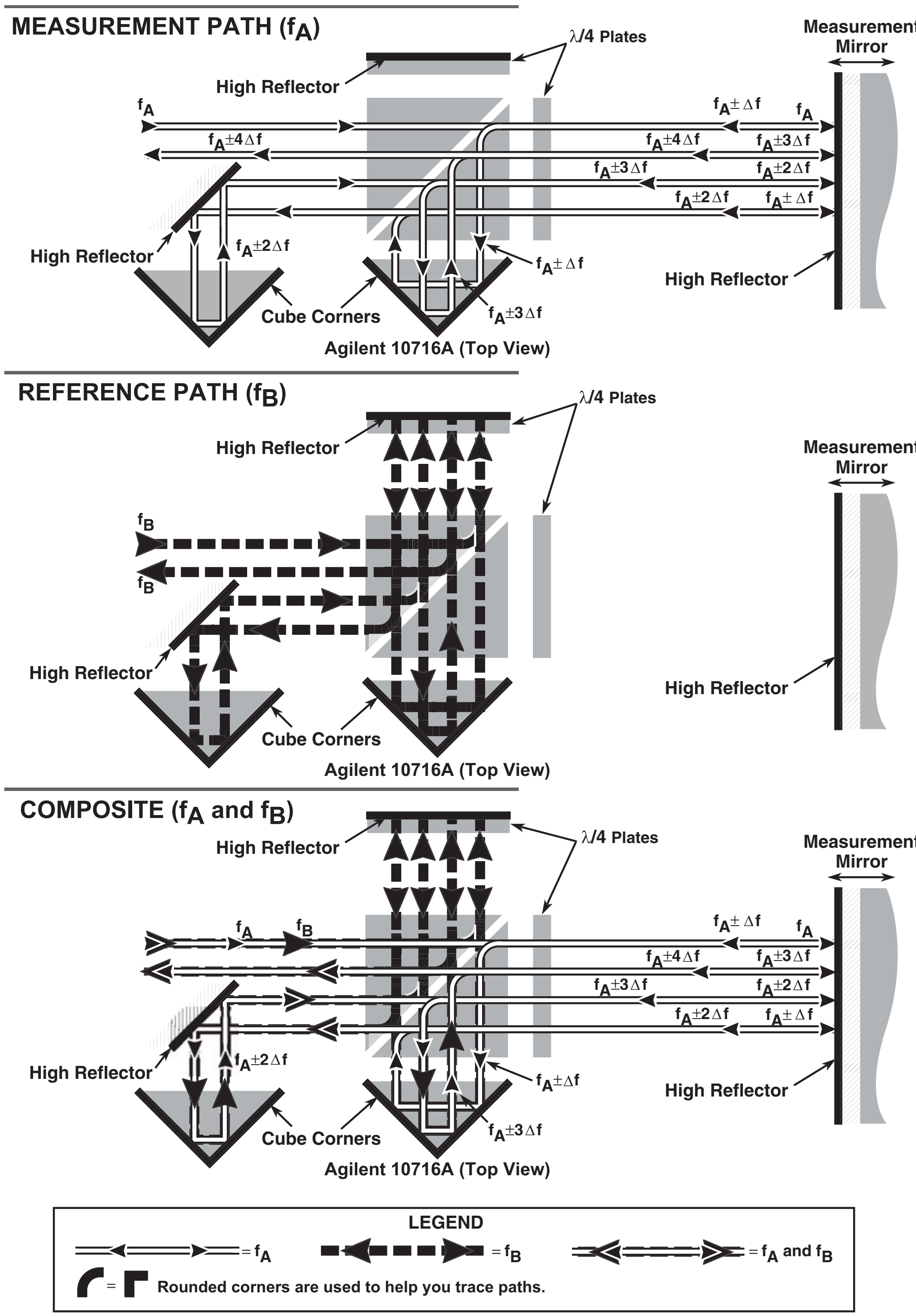


Figure 155 Agilent 10716A High Resolution Interferometer, optical schematic

Special Considerations

Mounting

Adjustable mounts

The Agilent 10711A Adjustable Mount provides a convenient means of mounting, aligning, and securely locking the Agilent 10716A interferometer in position. Since the mount allows some tilt and yaw adjustment, the need for custom fixturing is minimized. The mount allows the interferometer to be rotated about its centerline, simplifying installation.

Fasteners

The Agilent 10716A interferometer is supplied with English mounting hardware, which is required to fasten it to its adjustable mount.

Installation

Pre-installation checklist

In addition to reading chapters 2 through 4, and Chapter 12, “Accuracy and Repeatability,” (in Volume I of this manual), complete the following items before installing a laser positioning system into any application.

- ☐ Complete Beam Path Loss Calculation (see Calculation of signal loss” in Chapter 3, “System Design Considerations,” in Volume I of this manual).
- ☐ You must supply the plane mirror reflectors if the Agilent 10724A Plane Mirror Reflector will not work for your installation. See Chapter 12, “Accuracy and Repeatability,” Chapter 17, “Beam-Directing Optics,” or Chapter 5, “Measurement Optics (General Information),” in Volume I of this manual for mirror specifications.
- ☐ Determine the direction sense for each axis, based on the orientation of the laser head, beam-directing optic, and interferometer. Enter the direction sense for each axis into the measurement system electronics. (See Chapter 16, “Laser Heads,” Chapter 11, “Principles of Operation”, and Chapter 12, “Accuracy and Repeatability,” in Volume I of this manual.
- ☐ Provide for aligning the optics, laser head, and receiver(s) on the machine. (Ideally, you want to be able to translate beam in two directions and rotate beam in two directions for each interferometer input. This typically takes two adjustment optics with proper orientations.)

☐ Be sure to allow for transmitted beam offset of beam splitters (Agilent 10700A and Agilent 10701A) in your design. (See the offset specifications under the "Specifications and Characteristics" section at the end of this chapter.)

Alignment

The objective of these instructions is to align the Agilent 10716A to make measurements with 1) minimal cosine error and thermal drift and 2) maximum signal strength at the Agilent 10780C, Agilent 10780F, Agilent E1708A, or Agilent E1709A receiver.

The procedure below assumes that the plane mirror reflector is the movable optic and has been installed perpendicular to the axis of travel (see the Agilent 10724A installation procedure for details.).

Before proceeding with the alignment procedures, details on interferometer configurations and alignment aids are covered.

Configurations

The two configurations available for the High Resolution Interferometer allow flexibility in optical layout of a measurement system. They are:

- Standard
- Turned (10716-001)

Figures 156 and 157 illustrate the location of the measurement beams for each configuration.

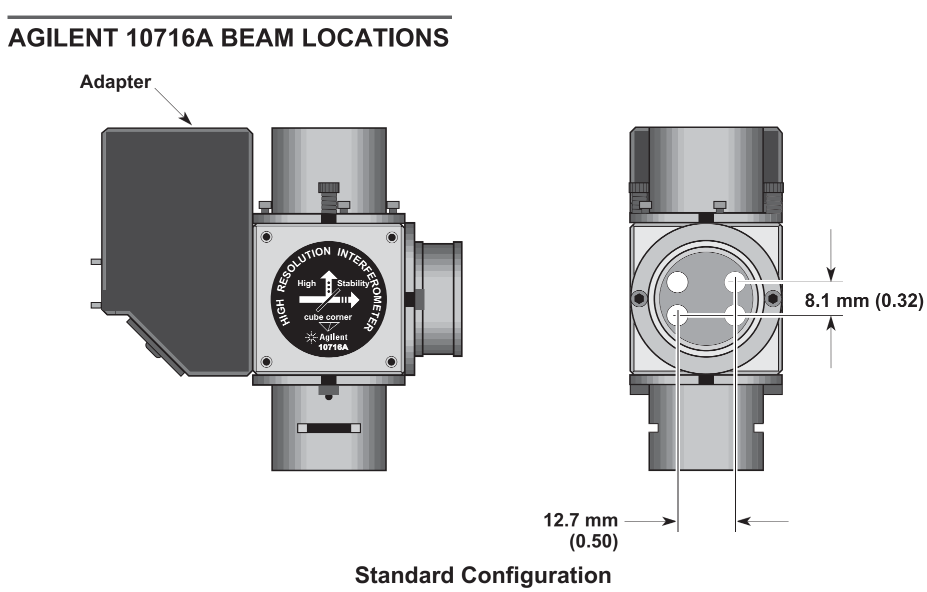


Figure 156 Beam Locations for standard Agilent 10716A Interferometer

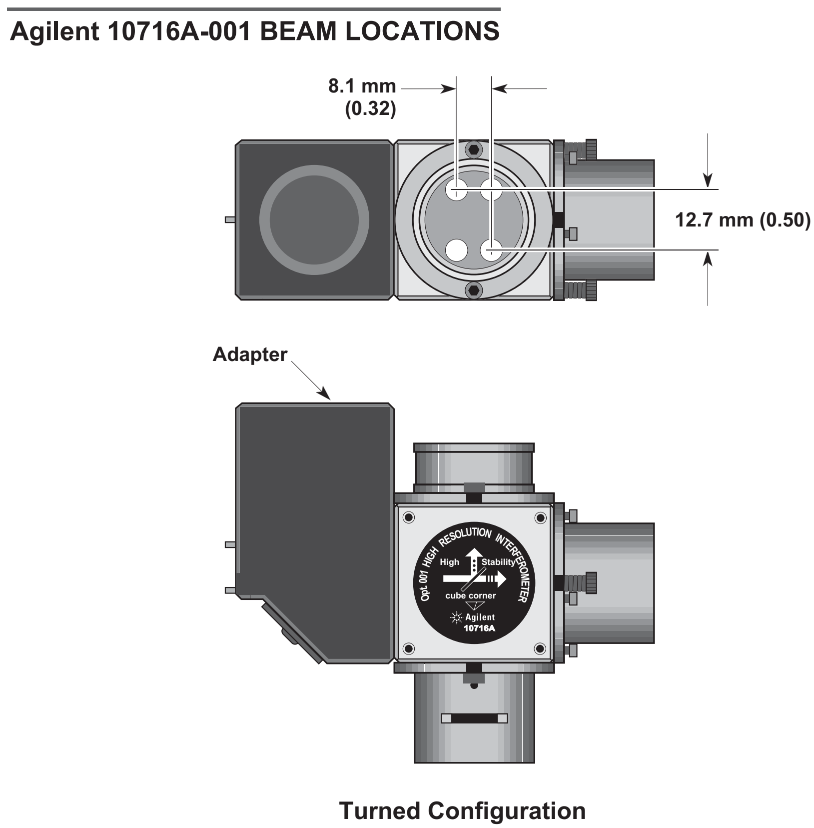


Figure 157 Beam Locations for Agilent 10716A-001 Turned Configuration

Alignment Aids

The Agilent 10716A High Resolution Interferometer is supplied with two of the alignment aids shown in Figure 158.

- Alignment Aid, Agilent Part Number 10706-60001
- Alignment Aid, Agilent Part Number 10706-60202

Alignment Aid Agilent Part Number 10706-60202 eases the autoreflection alignment for the high stability adapter to achieve minimal thermal drift and maximum signal strength. It contains a quarter-wave plate to reflect the reference beam back on itself and return it to the laser without offset. Figure 161 shows how the aid is positioned between the beam splitter and the high stability adapter during alignment.

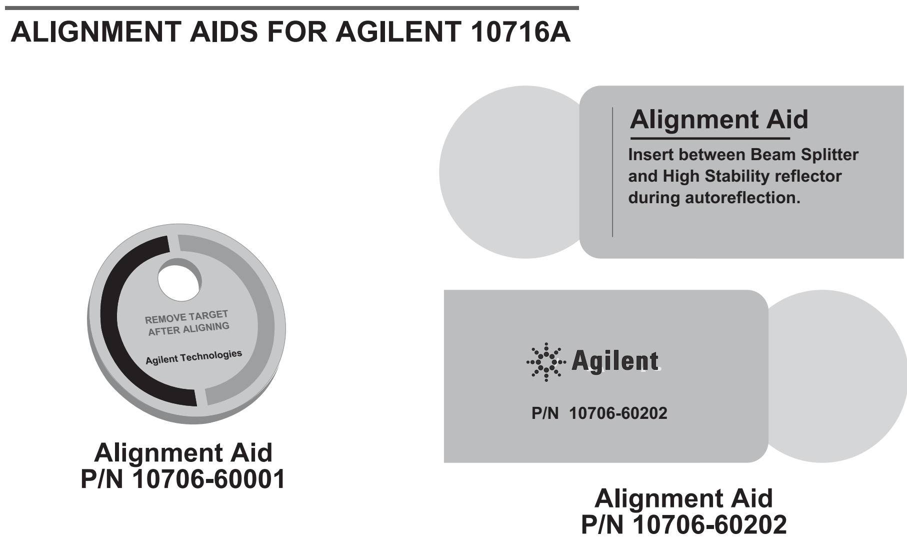


Figure 158 Alignment Aids for the Agilent 10716A Interferometer

Alignment Overview

The alignment procedure is a five-part process.

- Alignment of the laser beam perpendicular to the plane mirror reflector using autoreflection.
- Alignment of the Agilent 10716A Interferometer to the beam, using a reflective gage block and autoreflection.
- Realignment of the laser beam, to correct for slight angular beam deviation caused by the interferometer.
- Alignment of the reference reflector in the interferometer, for minimum thermal drift and maximum signal strength.
- Installation of the Agilent 10780C, Agilent 10780F, Agilent E1708A, or Agilent E1709A receiver to properly receive the reference and measurement beams.

Alignment Procedure

This alignment procedure is for the "Standard Configuration", with the laser beam entering the interferometer in aperture B. The alignment procedure for the "Turned Configuration" is similar, except it is more sensitive to angular alignment of the interferometer.

NOTE **Either aperture A or B of the interferometer may be used as the input aperture. The remaining aperture is the output.**

1 Select the small aperture on the laser head.

2 The laser beam for each axis should be aligned perpendicular to the measurement mirror. This is done by autoreflecting off this mirror and adjusting the laser head or beam bender until the reflected beam is centered in the small aperture on the laser head.

3 Move the interferometer so the laser beam enters the input aperture (aperture B, in this example).

4 Place a rectangular gage block over the input aperture so the laser beam is reflected back toward the laser. See Figure 159.

5 Adjust the interferometer in pitch and yaw until the laser beam is autoreflected back into the laser head, ensuring proper alignment. It may be necessary to move the interferometer again to center the laser beam on the input aperture. Use a piece of translucent tape to help observe the beam.

6 Remove the gage block.

   Note that the autoreflection procedure above is used only to reduce clipping, and is not as critical as the autoreflection procedure used to reduce cosine error. As long as the four beams are not clipped, the alignment of the interferometer is adequate.

   The next steps refine the alignment to reduce cosine error.

7 Place the alignment aid (Agilent Part Number 10706-60001) over the output aperture (plane mirror converter) on the interferometer such that the measurement beam passes through the aperture on the alignment aid. See Figure 160.

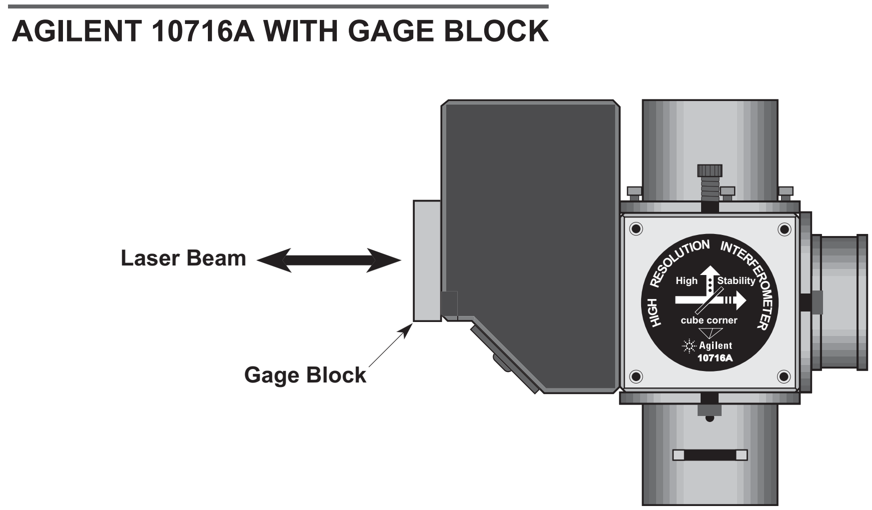


Figure 159 Agilent 10716A with gage block attached

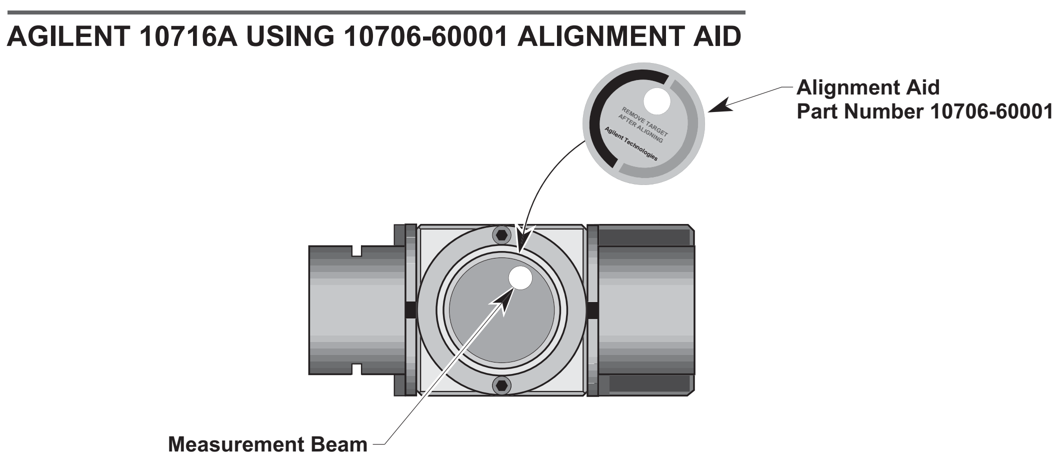


Figure 160 Agilent 10716A with alignment aid attached over measurement beam

8 Select the small aperture on the front turret of the laser head. The return beam from the moving plane mirror may not autoreflect back to the small aperture of the laser head as it did in step 5. This must be corrected. Adjust the laser beam until the laser beam is perpendicular to the measurement mirror. This step requires pitching and yawing the laser head, beam benders, or beam splitters, depending on optical layout.

9 If substantial adjustment of the laser beam was required in step 8, the interferometer will have to be repositioned so that the beam goes through the center of the input aperture. Repeat steps 1 through 5 and secure the interferometer to its mount.

NOTE The Agilent 10716A High Resolution Interferometer is now aligned for minimum cosine error. The final steps (10 through 23) will align the reference reflector for minimum thermal drift coefficient and maximum signal strength.

10 Remove the Plane Mirror Converter assembly (i.e., the quarter-wave plate) from the measurement side of the interferometer by loosening one cap screw and removing the other.

11 Block the measurement beam and select the small aperture on the laser head.

12 Insert the Alignment Aid (Agilent Part Number 10706-60202) between the now-exposed glass beam splitter and the reference reflector (the one with the four adjustment cap screws and two springs). See Figure 161. This will allow the reference beam to autoreflect back toward the small aperture on the laser head.

13 Return light will now be visible from this reflector near the laser output aperture.

14 Now adjust TWO of the small cap screws on the housing so that this return beam autoreflects back into the small output aperture of the laser.

15 GENTLY snug the other two cap screws while observing the return beam on the output aperture. Preserve the beam alignment.

16 Remove the alignment aid (Agilent Part Number 10706-20202) and replace the Plane Mirror Converter.

17 Unblock the measurement beam.

18 Verify autoreflection of the measurement beam by attaching the magnetic alignment aid to the output (measurement) side of the interferometer and observing the autoreflected beam on the laser aperture. Remove the magnetic alignment aid.

19 Verify that you now see four unclipped spots in a rectangular pattern on the face of the measurement plane mirror. (The room lights may have to be dimmed to see these weak spots of scattered light.)

20 Install the Agilent 10780C or Agilent 10780F Receiver so that light from the top aperture (“A” aperture) of the interferometer enters the center of the lens, parallel to the optical axis of the lens.

21 With a piece of translucent tape over the lens, verify that the spots from Reference and Measurement beams overlap adequately.

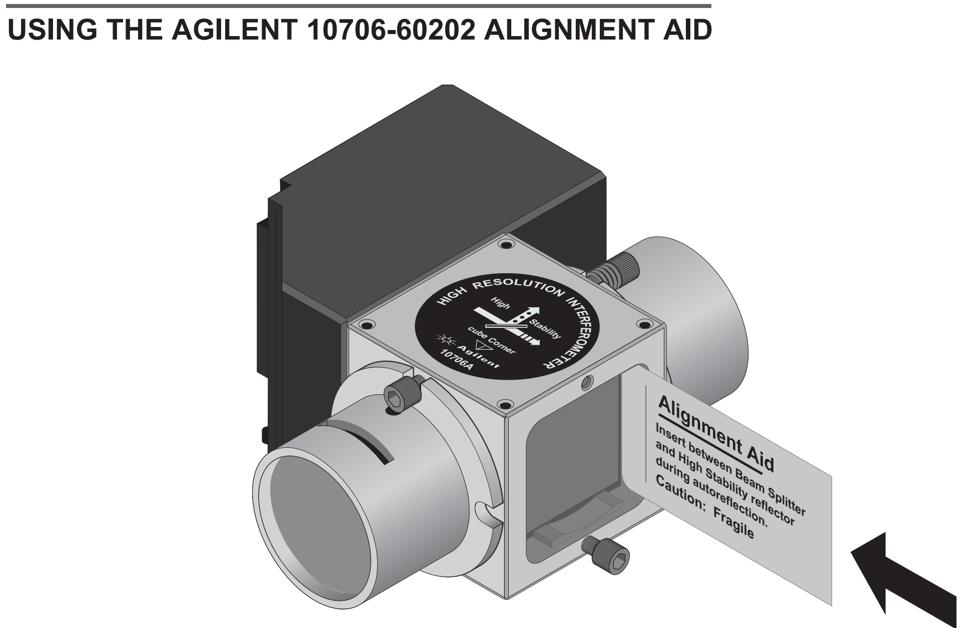


Figure 161 Using the Agilent 10706-60202 Alignment Aid

22 If these spots do not overlap at the receiver, the alignment should be rechecked. It may be necessary to adjust the Reference Reflector adjustment screws to improve overlap.

23 Select the large aperture at the output of the laser head and traverse the full travel at the machine. Verify that the LED indicator on the receiver is lighted through the full travel and the voltage measured at the receiver test point is between 0.6 and 1.3 Vdc.

Specifications and Characteristics

Specifications describe the device's warranted performance. Supplemental characteristics (indicated by TYPICAL or NOMINAL) are intended to provide non-warranted performance information useful in applying the device.

Using electronic resolution extension, the system resolution is increased significantly. Depending on the system, an additional resolution extension factor of 32 (for Agilent 10885A and 10895A) or 256 (for Agilent 10897C and 10898A) is usually available.

Interferometer	Fundamental Optical Resolution	System Resolution 1 (see NOTE)	System Resolution 2 (see NOTE)
Agilent 10716A	λ /8 (79.1 nm, 3.1 µin)	λ /256 (2.5 nm, 0.1 µin)	λ /2048 (0.31 nm, 0.012 µin)

NOTE

The system resolution 1 is based on using 32X electronic resolution extension. This is available with the Agilent 10885A and Agilent 10895A electronics.

The system resolution 2 is based on using 256X electronic resolution extension. This is available with the Agilent 10897C and Agilent 10898A electronics.

Agilent 10716A High Resolution Interferometer (and 10716A-001 Turned Configuration) Specifications

Weight: 502 grams (1.11 pounds)

Dimensions: see figure below

Materials Used:

- Housing: 416 Stainless Steel and 6061 Aluminum
- Spacers: Nylon
- Optics: Optical Grade Glass
- Adhesives: Low Volatility (Vacuum Grade)

Optical Efficiency: (including a 98% efficient plane mirror reflector and the Reference Mirror)

- Typical: 30%
- Worst Case: 25%

Thermal Drift Error:

(Change of indicated distance per degree C temperature change): 0.05 micron/°C (1.6 µinch/°C) typical

Fundamental Optical Resolution: λ /8

Non-linearity Error: 2 nm, peak value

Maximum Angular Beam Deviation: 30 minutes of arc

Maximum Mirror Pitch/Yaw Tolerance:*

Depends on distance between mirror and interferometer.

Typical values are:

- 6 minutes for 152 mm (6 inches)
- 3 minutes for 305 mm (12 inches)
- 2 minutes for 508 mm (20 inches)

MEASUREMENT MIRROR RECOMMENDATIONS

Reflectance: 98% for 633 nanometers at normal incidence

Flatness: Depending on the application and accuracy requirements of the application, mirror flatness may range from λ /4 to λ / 20; i.e., 0.16 to 0.03 µmeters (6 to 1.2 µinches).

Optical Surface Quality: 60 - 40 per Mil-0-13830

NOTE: Flatness deviations will appear as measurement errors when the mirror is translated across the beam. Mount should be kinematic so as not to bend mirror. If accuracy requirements demand it, mirror flatness might be calibrated (scanned and stored in the system controller) to be used as a correction factor.

***Misalignment of interferometer to measurement mirror will degrade the Thermal Drift Coefficient.

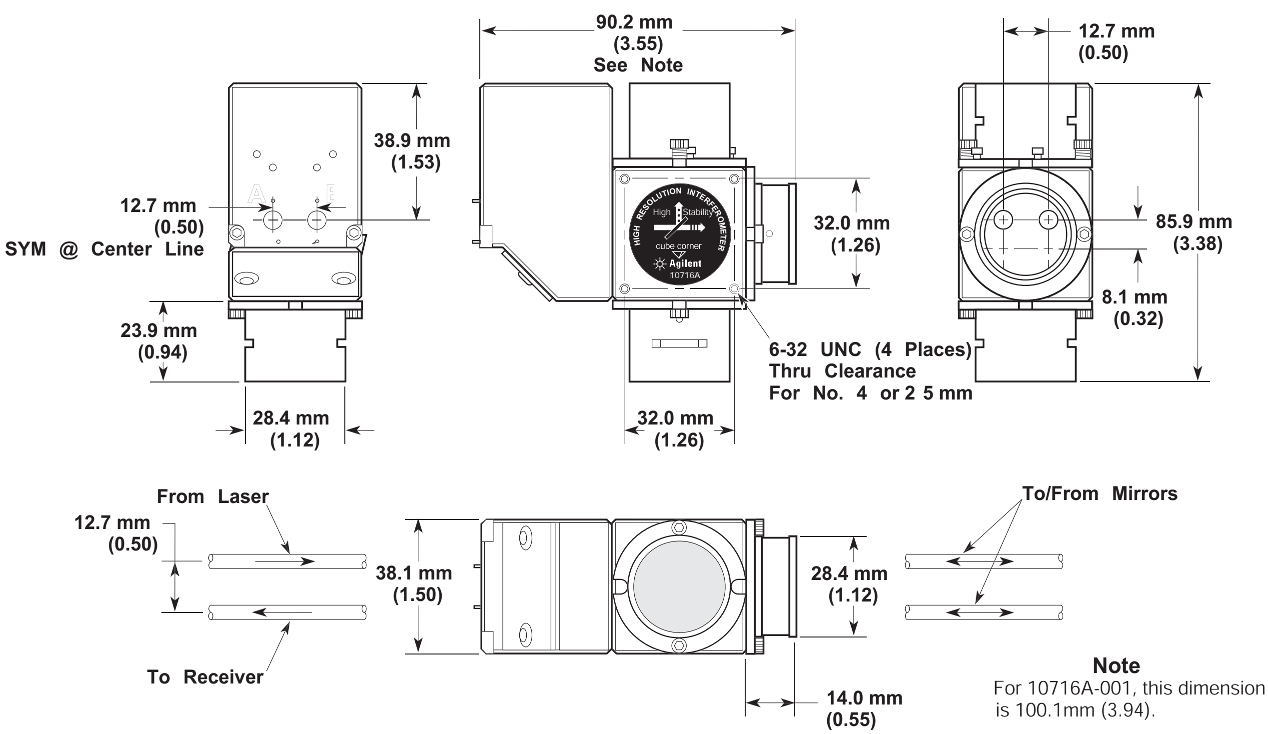


Figure 162 Agilent 10716A High Resolution Interferometer (and Agilent 10716A-001 Turned Configuration)

24
Agilent 10717A Wavelength Tracker

Description

The Agilent 10717A Wavelength Tracker (see Figure 163) uses one axis of a laser measurement system to report wavelength-of-light changes, not changes in position (displacement). The Agilent 10717A Wavelength Tracker's output can be used to correct displacement values reported via other measurement axes in the system. Since the wavelength of the laser light is the length standard used in Agilent laser measurement systems, being able to track these changes helps to make more-accurate measurements.

The Agilent 10717A Wavelength Tracker consists of an optical reference cavity (called an etalon) and an Agilent 10715A Differential Interferometer. Both components are mounted on a common metal baseplate and prealigned at the factory. Built-in baseplate adjustments simplify installation and alignment to the laser system.

Figure 164 shows the optical schematic for the Agilent 10717A Wavelength Tracker.

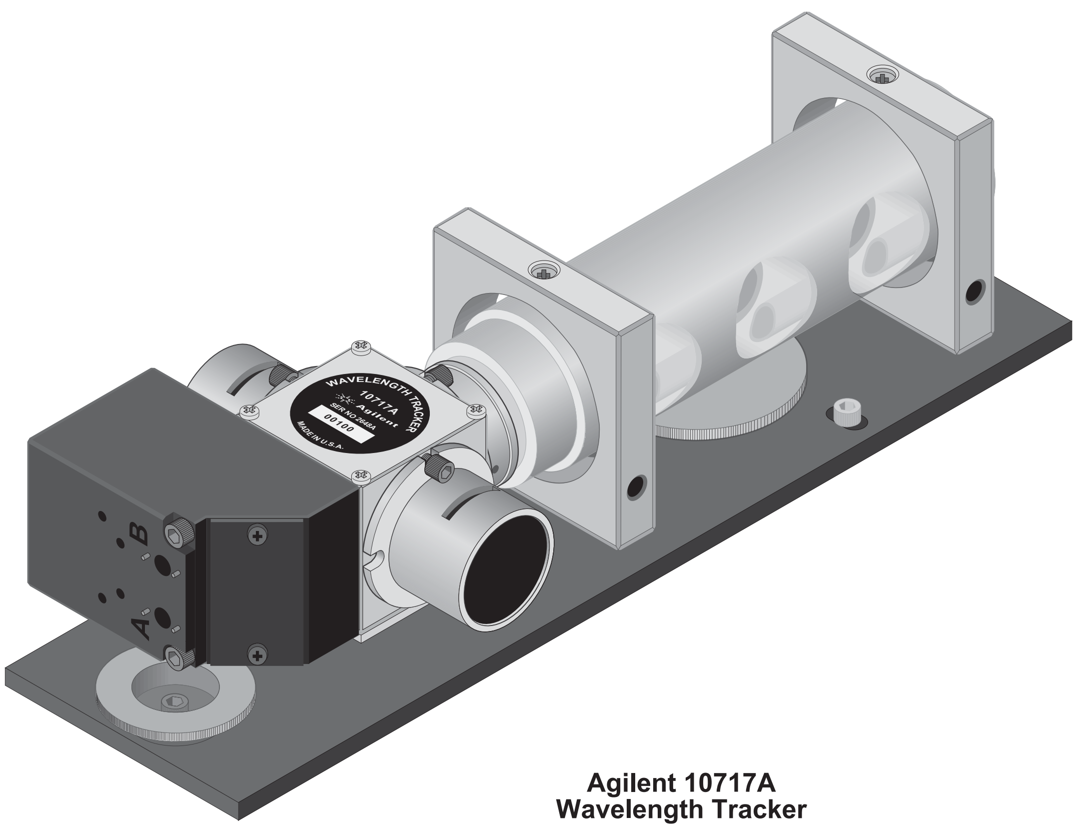


Figure 163 Agilent 10717A Wavelength Tracker

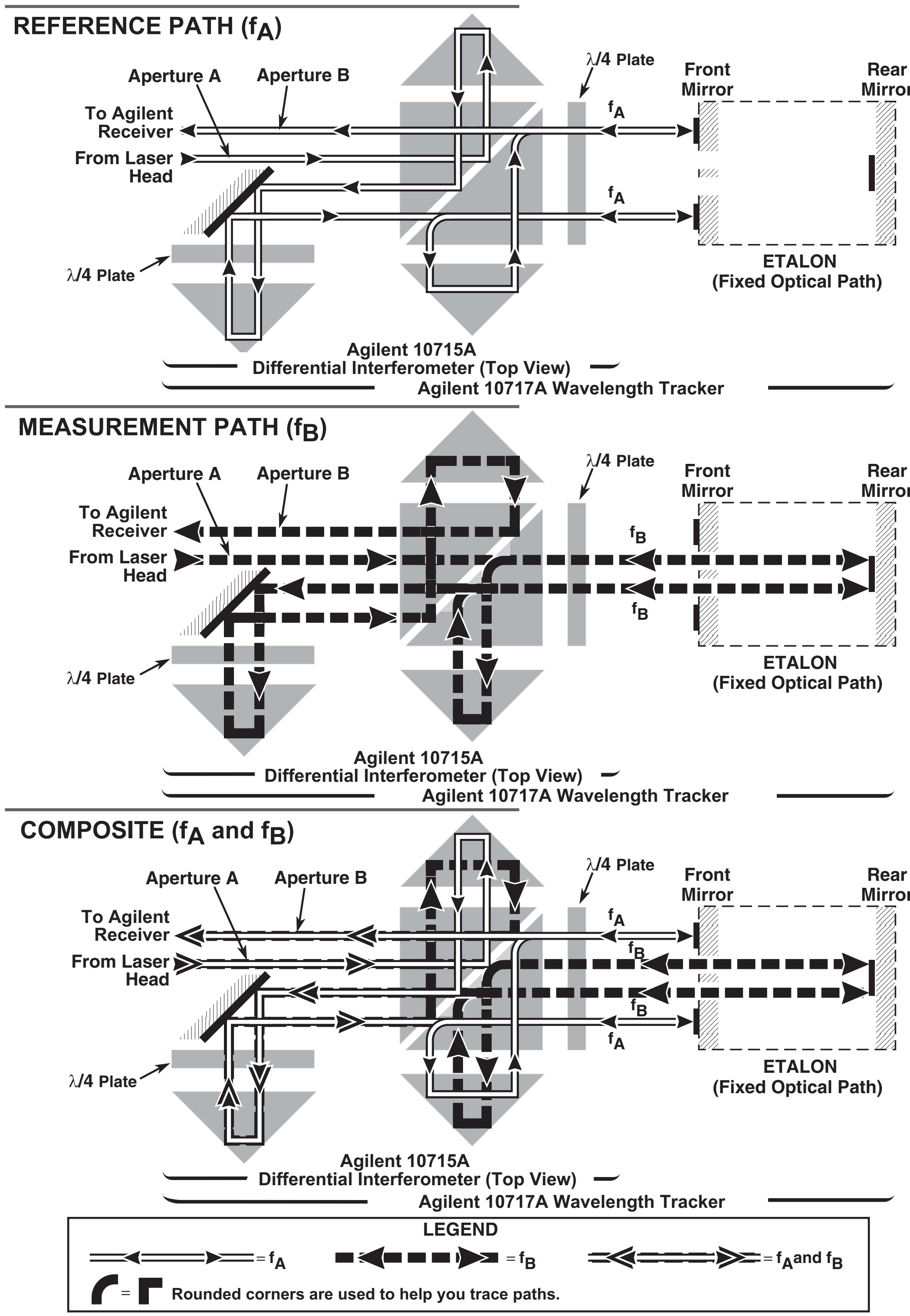


Figure 164 Agilent 10717A Wavelength Tracker laser beam path

The Agilent 10717A Wavelength Tracker provides a higher degree of accuracy than environmental sensors such as the Agilent 10751C or Agilent 10751D Air Sensor, thereby improving the laser system measurement performance. For a more detailed comparison of compensation methods, see “WOL Compensation Method Comparison” in Chapter 12, “Accuracy and Repeatability,” in Volume I of this manual.

The Agilent 10717A Wavelength Tracker’s output must be directed to an Agilent 10780C, Agilent 10780F, Agilent E1708A, or Agilent E1709A receiver where a measurement signal is generated. The laser measurement system electronics use this signal and the laser head’s reference signal to monitor changes in the wavelength of light. For maximum accuracy, the etalon’s length (the number written on the end of the etalon) must be used in the electronics.

Operation is straightforward. The etalon, consisting of two mirrors separated by a thermally stable spacer, presents a fixed distance to the differential interferometer. The interferometer monitors the optical path length between these two mirrors. Any change in the wavelength-of-light (that is, changes in the air density or index of refraction within the etalon cavity) causes an optical path length change, which is detected as a phase shift in the measurement frequency. The Agilent compensation electronics uses this phase information to update the compensation number for use by the rest of the system.

Maintaining the ± 0.20 ppm accuracy typical of this compensation technique requires that air within the etalon’s cavity have the same temperature, pressure, and humidity as the air in the measurement paths. To accomplish this, the Agilent 10717A Wavelength Tracker should be mounted as close to the measurement area as possible.

Figure 165 shows an X-Y stage application using a Wavelength Tracking Compensation system. The components that comprise the Wavelength Tracking Compensation system are:

- Agilent 10717A Wavelength Tracker
- Beam Bender or Beam Splitter
- Agilent 10710B Adjustable Mounts (for mounting beam bender or beam splitter)
- Agilent 10780C or Agilent 10780F receiver
- Receiver Cable (the cable used depends on the measurement system electronics used, see Chapter 36, “Accessories,” in this manual for a listing and description of the cables available.)
- Automatic Compensation Board for the system electronics you are using. (Recommended; see “Automatic Compensation” paragraphs in your electronics documentation for installation procedures.) Alternately, an axis board can also be used to monitor the wavelength tracker’s output.

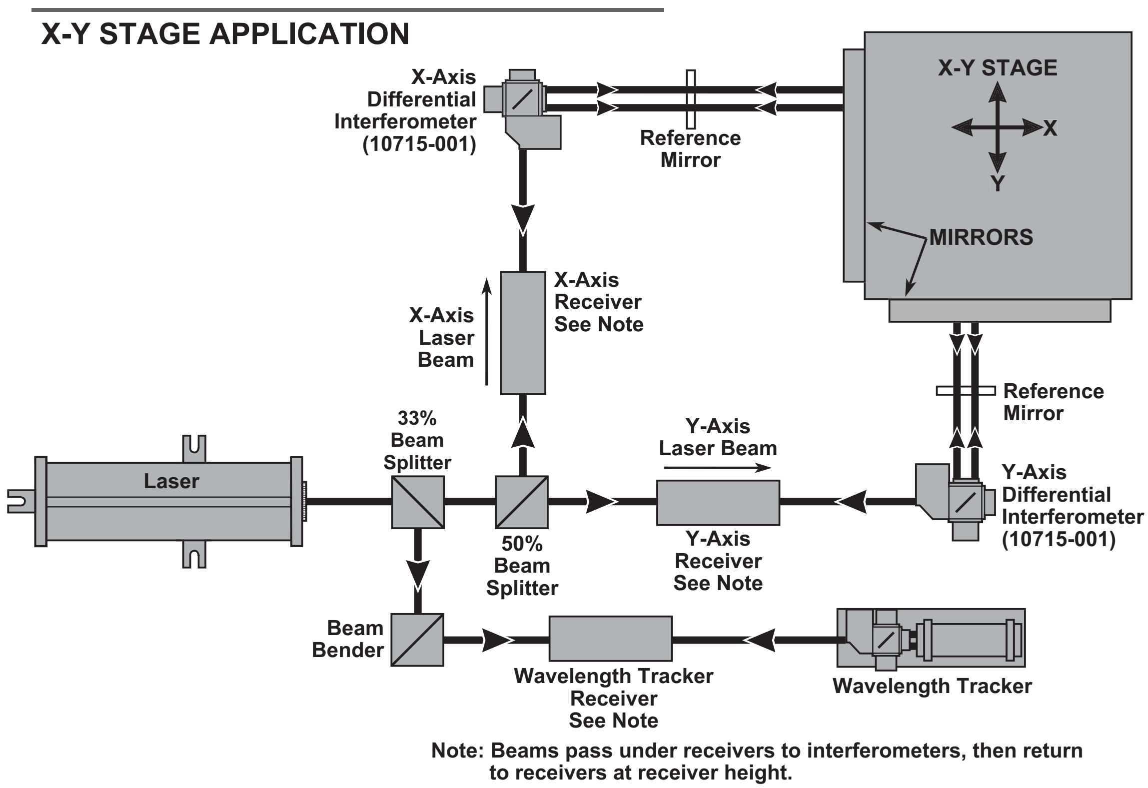


Figure 165 Two-axis differential interferometer with wavelength tracker

Special Considerations

The orientation of the laser head with respect to the Agilent 10717A Wavelength Tracker, and the selection of the input aperture on the wavelength tracker's differential interferometer, affect the direction sense of the compensation output. The correct direction sense of the wavelength tracker signal occurs when the compensation number gets larger as the wavelength-of-light increases. Refer to Chapter 12, "Accuracy and Repeatability," in Volume I of this manual for a discussion on atmospheric compensation.

The direction sense of the wavelength tracker signal may be changed on the Agilent 10896A VME Compensation Board by swapping the Ref and Meas input connections so that the Ref signal is connected to the Meas input. Refer to the board's user's manual for details. Table 74 gives the correct Meas signal connection for various system configurations.

For a quick "reality" check, write a short program to initialize and display the WTI compensation number, and then monitor this value as the air is warmed slightly. The compensation number should go up.

Table 74 Agilent 10717A direction sense

Laser Head	Laser Head Orientation Horizontal or Rolled 90° About Beam	Agilent 10717A Input Aperture A or B	Agilent 10717A Orientation Horizontal or Rotated 90° About Etalon Axis	Meas Signal Connected To
Agilent 5517A/B/BL/C/DL/FL F1 Horizontal F2 Vertical	Horizontal	A	Horizontal	Ref Input
			Rotated 90°	Meas Input
		B	Horizontal (typical)	Meas Input
			Rotated 90°	Ref Input
	Rotated 90°	A	Horizontal	Meas Input
			Rotated 90°	Ref Input
		B	Horizontal	Ref Input
			Rotated 90°	Meas Input

Installation and Alignment

Pre-installation checklist

In addition to reading chapters 2 through 4, and Chapter 12, "Accuracy and Repeatability," complete the following items before installing a laser positioning system into any application.

- ☐ Complete Beam Path Loss Calculation (see Calculation of signal loss" in Chapter 3, "System Design Considerations," in Volume I of this manual).
- ☐ Provide for aligning the optics, laser head, and receiver(s) on the machine.
- ☐ Be sure to allow for transmitted beam offset of beam splitters (Agilent 10700A and Agilent 10701A) in your design. (See the offset specifications under the "Agilent 10717A Wavelength Tracker Specifications and Characteristics" section at the end of this chapter.)

Alignment aid

To help in aligning the Agilent 10717A Wavelength Tracker, an Alignment Aid (Agilent Part Number 10706-60001) is included. This is the same alignment aid used on the Agilent 10706A Plane Mirror Interferometer and Agilent 10715A Differential Interferometer.

Procedure

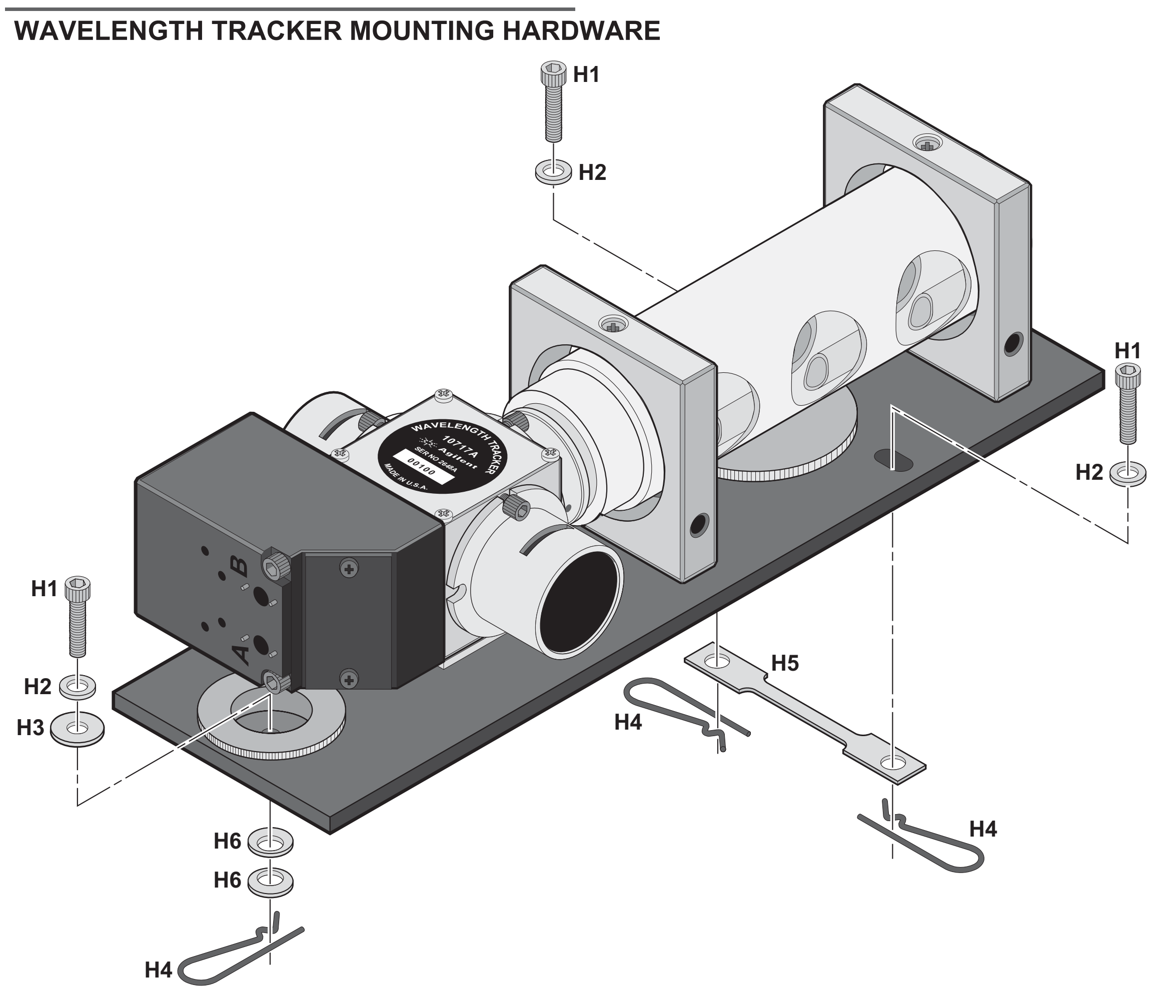
This procedure describes the installation and alignment of the wavelength tracker axis. The two units that require alignment are the Agilent 10717A Wavelength Tracker and the Agilent 10780C or Agilent 10780F Receiver. The wavelength tracker unit itself is prealigned at the factory and requires no internal alignment. The Wavelength Tracking Compensation system should be installed and aligned with the following considerations in mind:

- The wavelength tracker should be installed so that the air it samples is the same air through which the measurement axis beam passes.
- The wavelength tracker should be aligned to obtain maximum laser beam signal at the receiver. (See multiaxis applications information in Chapter 3, "System Design Considerations," in Volume I and elsewhere in this manual.)
- The Agilent 10780C, 10780F, E1708A, or E1709A receiver should be mounted in such a way that its LED indicator and gain adjustment potentiometer are accessible.

- The Agilent 10780C, 10780F, E1708A, or E1709A receiver is properly aligned when: 1) the laser beam is centered on its input aperture, 2) the LED indicator on top is lighted, and 3) the voltage at the its test point is greater than +0.7 Vdc. A receiver alignment procedure is provided in Chapter 35, “Receivers,” in Volume II of this manual.
- No more than six measurement axes are installed in addition to the wavelength tracker.

Alignment starts at the laser head and moves out one component at a time (laser head, beam bending and beam-splitting optics, wavelength tracker, and then receiver) until the last component of the Wavelength Tracking Compensation system is aligned and the laser beam is centered on the receiver’s aperture. This alignment procedure has the laser beam entering the Agilent 10717A’s differential interferometer through aperture A.

NOTE Do not remove the red tape and three hitch-pin clips until instructed to do so in this procedure. The “clips” make installation of the wavelength tracker easier. The red tape and clips (see Figure 166, item H4) keep the three mounting screws in place during installation, and allow installation of the unit at any angle without having to physically hold the three mounting screws in place. After installation is complete, the clips are removed by pulling on the red tape. If the red tape and mounting hardware are removed or lost prior to the wavelength tracker’s installation, refer to Figure 166 for an exploded view of the tracker’s hardware and a listing of their respective Agilent part numbers.



Reference Designator	Description	Agilent Part Number
H1	Screw - HD cap 10-32 0.75 in-lg	3030-0182
H2	Washer - spring	3050-1274
H3	Washer - flat 1/4 in. 0.281 in-lg	3050-0583
H4	Hitch-pin clip	1480-0694
H5	Subplate	10717-20209
H6	Washer - 2 part spherical	3050-1272

Figure 166 Wavelength tracker mounting hardware

1 Set the wavelength tracker over the tapped holes on your equipment.

NOTE Do not remove red tape and hitch-pin clips at this time.

2 Engage three to four threads of the three mounting screws (see Figure 166) by rotating each screw three to four revolutions using the hex-ball driver supplied.

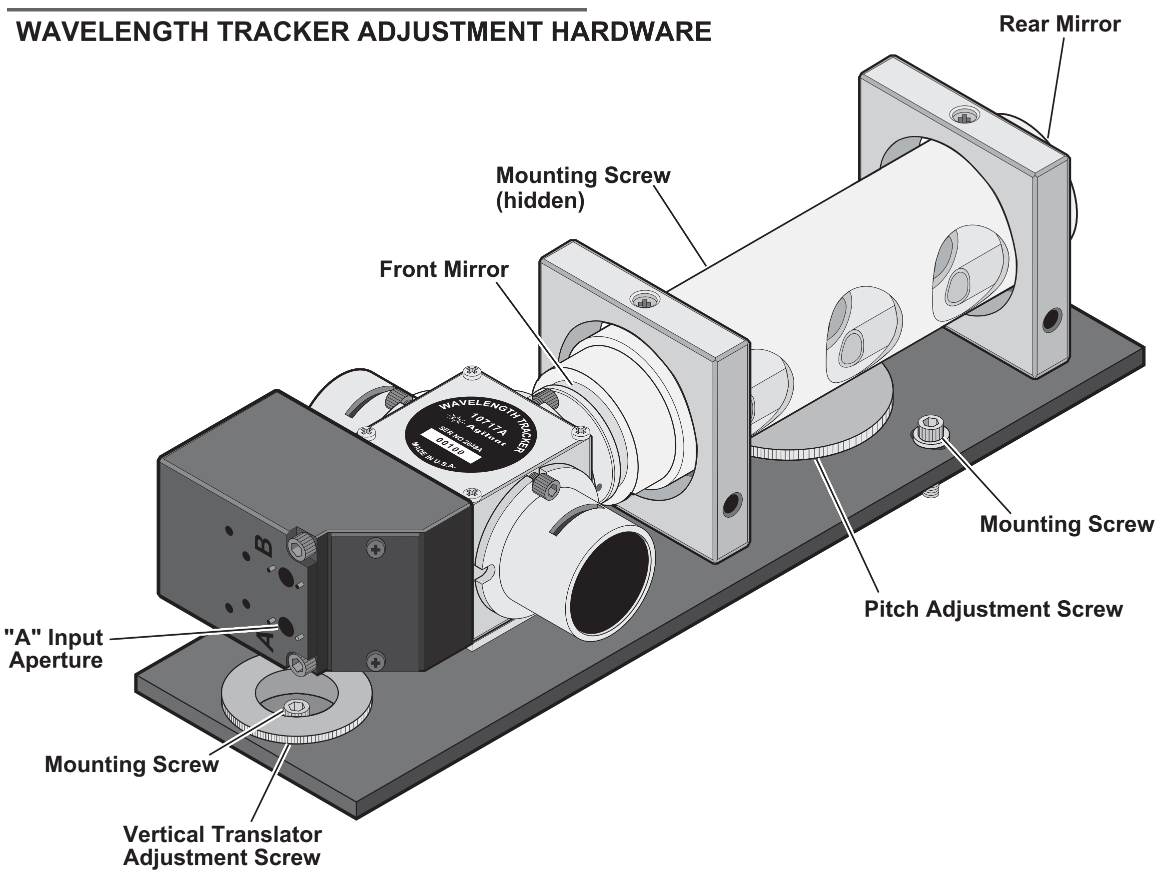


Figure 167 Agilent 10717A Wavelength Tracker adjustment hardware

3 Remove the three hitch-pin clips by pulling on the red tape.

4 Tighten the front mounting screw (Figure 167) until slight resistance is sensed.

5 Place a piece of translucent tape over the differential interferometer's “A” input aperture (see Figure 166). Flatten the tape tightly against the input “A” aperture to produce a high-resolution outline of the input aperture. You should see a well-defined laser pattern on the tape.

6 Rotate the vertical translator adjustment screw (see Figure 167) until the input beam is vertically centered about the input aperture. At the same time, move the tracker horizontally to center the laser beam horizontally.

7 Tighten the front mounting screw (see Figure 167) finger-tight when the laser beam is centered on the input aperture.

8 Remove the translucent tape from the differential interferometer input aperture.

9 Install the quarter-waveplate alignment aid so the primary measurement beam passes through the hole in it (see Figure 168).

NOTE Standard input aperture for the wavelength tracker is "A" (positive sense). If the input beam goes to aperture "B", the direction sense changes (negative sense). See "Special Considerations" section in this chapter and Table 74 for wavelength tracker direction sense change details.

10 Select the small aperture of the laser head.

11 Rotate the pitch adjustment screw (see Figure 167) until the laser beam autoreflected back to the laser head is centered vertically about the output beam. Yaw the baseplate back and forth until the autoreflected beam is concentric with the laser head aperture.

12 Tighten all three mounting screws alternately (see Figure 167) until finger-tight. Now tighten the screws by applying a torque of 0.9 Newton-meter (8 inch-pounds). Maintain proper autoreflection as the screws are tightened. Correct for any change by readjusting the wavelength tracker in pitch and yaw until the laser beam is autoreflected back into the laser head. This insures proper angular alignment.

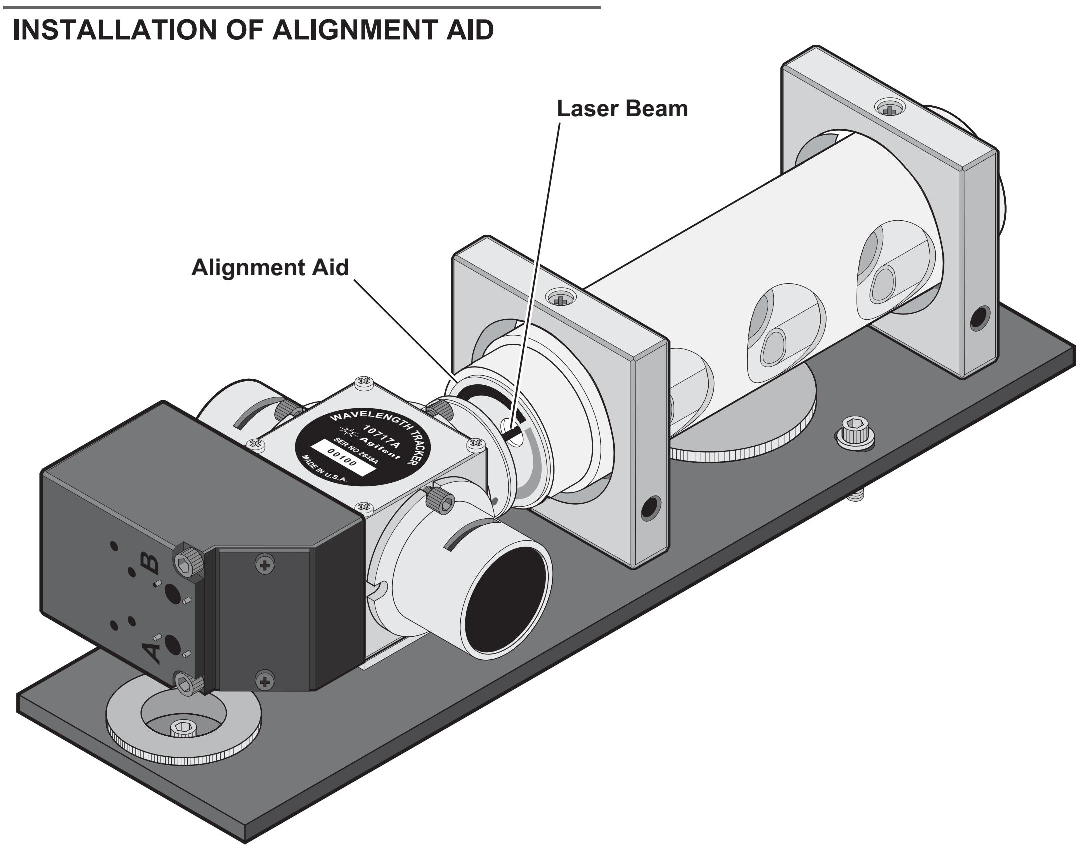


Figure 168 Installation of alignment aid

NOTE Tightening the mounting screws unevenly or exceeding the specified torque specification will disrupt alignment and degrade overall system performance.

13 Remove the alignment aid.

14 Return the laser head turret to its larger aperture. Two parallel unclipped beams should now exit the differential interferometer.

15 Check for a circular, unclipped laser beam. As long as the two beams are not clipped, the wavelength tracker alignment is adequate.

16 Alignment of the receiver is accomplished by moving it (or its sensor head) from side to side, and pitching and yawing it to center the beam on its lens. Coarse beam alignment is performed using the snap-on Alignment Target fixture (Agilent Part Number 10780-40003 or Agilent Part Number 10780-40009) supplied with the receiver (see Chapter 35, “Receivers,” in this manual.) For the wavelength tracker, this target is used only to align the receiver (or its sensor head) to the incident beam.

17 To check the final optical alignment of the Wavelength Tracking Compensation system, place a rectangular gage block over the lens of the receiver (and pressed against the receiver's case, or its sensor head's input face) and autoreflect the beam back toward the differential interferometer of the wavelength tracker. When the receiver (or its sensor head) is mounted properly (which occurs when the beam enters the receiver's or sensor head's input aperture parallel to its housing), the autoreflected beam will be coincident on itself back to the laser head. Refer to the receiver alignment procedures in Chapter 35, "Receivers," in this manual for more receiver alignment information.

After optical alignment of the receiver, the gain of the receiver is adjusted. This procedure ensures that the leakage signal from one of the beams isn't sufficient to turn on the receiver. The following procedure sets the gain just below the optical leakage threshold.

18 Connect a fast-responding voltmeter to the test pin on the receiver.

19 Block one of the two beams incident on the **front** etalon mirror (see Figure 167) with a piece of paper. Be sure to block only one beam at this time. Observe the voltmeter reading. If the reading is greater than +0.1 Vdc, turn the gain adjustment screw counterclockwise until the voltage reads +0.1 Vdc.

20 Block one of the two beams incident on the **rear** etalon mirror (see Figure 167) with a piece of paper. Again, be sure to block only one beam at this time. If the measured voltage is greater than +0.1 Vdc, turn the gain adjustment screw clockwise until the reads +0.1 Vdc.

21 Remove the beam-blocking device. The voltmeter should now read at least +0.7 Vdc. If the measured voltage is below +0.7 Vdc, the wavelength tracker, or the receiver, or both, is not properly aligned. If, after repeating the receiver alignment (steps 16 through 20), the voltage measured at the test point is still below +0.7 Vdc, the entire alignment procedure must be repeated until the misalignment is corrected.

22 Disconnect the voltmeter from the receiver's test point.

All alignment and adjustment procedures are now complete.

NOTE

After the wavelength tracker and receiver have been properly aligned in the measurement system, you should lock the vertical translator adjustment screw (see Figure 167) in place. This will prevent possible cosine error in the wavelength tracker due to thread clearance between the adjustment screw and the baseplate. A suitable low strength, wicking adhesive (Locktite #425) is recommended. In vibration-free environments, this precaution may not be necessary.

Agilent 10717A Wavelength Tracker Specifications and Characteristics

Specifications describe the device's warranted performance.

Supplemental characteristics (indicated by TYPICAL or NOMINAL) are intended to provide non-warranted performance information useful in applying the device.

Dimensions: see figure below

Weight: 1.7 kg (3.7 pounds)

Etalon Length: 127mm (5 inches) nominal

Optical Efficiency:

Typical: 36%
Worst Case: 25%

Angular Adjustment Range (at nominal position):

Pitch: l°

Yaw: l°

Translational Adjustment Range (at nominal position):

Vertical: ± 3 mm (0. 12 inch)

Horizontal: ± 3 mm (0.12 inch)

Mounting:

Three 10-32 UNF2A tapped holes (hardware supplied).

See drawings below

Mounting Screw Torque: 0.9 Newton-meter (8 inch-pounds)

Minimum Mounting Clearance Required:

3 mm (0.12 inch) around perimeter

Calibration: none required

NOTE: If an Agilent Automatic Compensation Board is not used, system measurement repeatability may be calculated as follows:

[(R/127+0.028) ppm +AT(0.06 ppm/° C) +
AP(0.002 ppm/mm Hg)]
where
R = electronics resolution in nm (5 nm for
Agilent Automatic Compensation Boards)

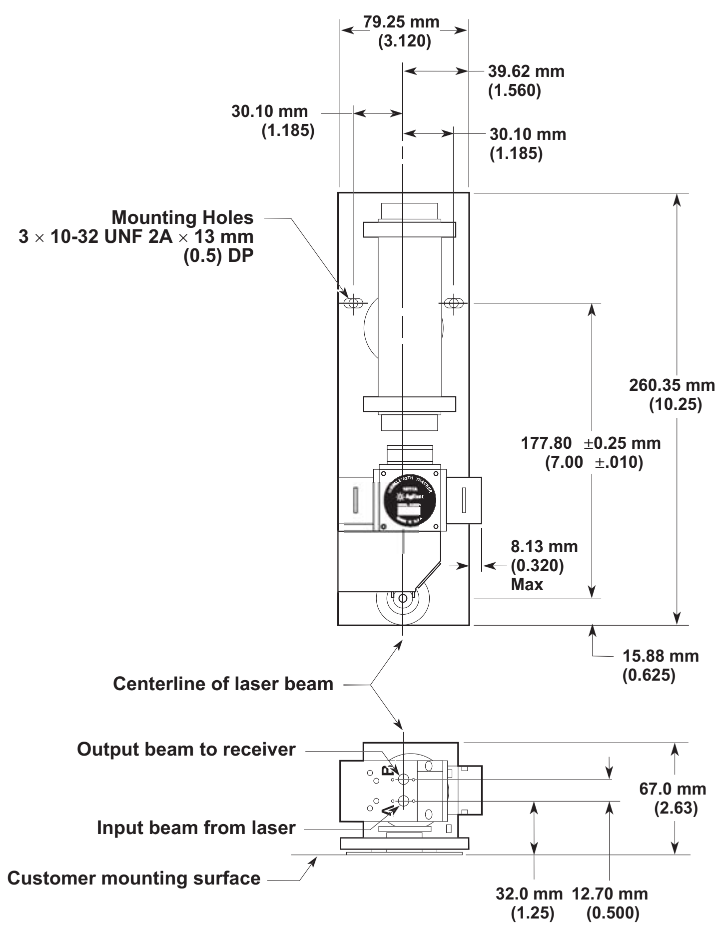


Figure 169 Agilent 10717A Wavelength Tracker — dimensions

25
Agilent 10719A and 10719A-C02 One-Axis Differential Interferometers

Description

General

The Agilent 10719A One-Axis Differential Interferometer (see Figure 170) is a plane mirror type of interferometer that allows differential measurements to be made between a measurement mirror and a reference mirror. Both mirrors are usually provided by the user.

The Agilent 10719A interferometer has the same fundamental optical resolution as the Agilent 10706B High Stability Plane Mirror Interferometer ($\lambda/4$, before electronic resolution extension).

The Agilent 10719A interferometer is designed to use a 3-mm diameter laser beam, available from an Agilent 5517C-003 Laser Head. This beam is smaller than the standard 6 mm beam and allows the measurement plane (centerline of the beams) to be closer to the upper edge of the X-Y stage measurement mirror, thereby reducing Abbé offset.

The measurement and reference beam paths are parallel and are spaced 19.05 mm (0.750 inch) apart.

The Agilent 10719A interferometer is designed primarily for use with the Agilent 10780F Remote Receiver, which can be attached directly to the housing; however, any other Agilent receiver may be used.

The C02 special option, Agilent 10719A-C02, is designed to reduce the thermal drift coefficient.

A metal housing extension is added to the front of the interferometer to protect the optic. This increases the length of the interferometer by 15.5 mm

The thermal drift specification in the Agilent 10719A-C02 is reduced from 150 nm/°C to 50 nm/°C (typical), provided you compensate for the internal air dead path. Internal air dead path for this interferometer is 30.6 mm (1.025 inches). It may be compensated by either of the two methods described in “Operation" on page 528 of this chapter (using 30.6 mm rather than the 19.05 mm for the standard Agilent 10719A interferometer).

Applications

Differential measurements

A differential measurement is one in which both the reference beam and the measurement beam travel to external mirrors outside the interferometer housing. This allows measurement of the relative positions of the two external mirrors, either or both of which may move.

One useful example of a differential measurement in a lithography application is for measuring the motion of the X-Y stage relative to the optical column. The Agilent 10719A One-Axis Differential Interferometer and the Agilent 10721A Two-Axis Differential Interferometer (described in Chapter 26) are ideally suited to this type of measurement, because they provide parallel reference and measurement paths which are offset vertically by 19 mm (0.750 inch). For such an application, a user-supplied reference plane mirror is required in addition to the measurement reflector on the X-Y stage.

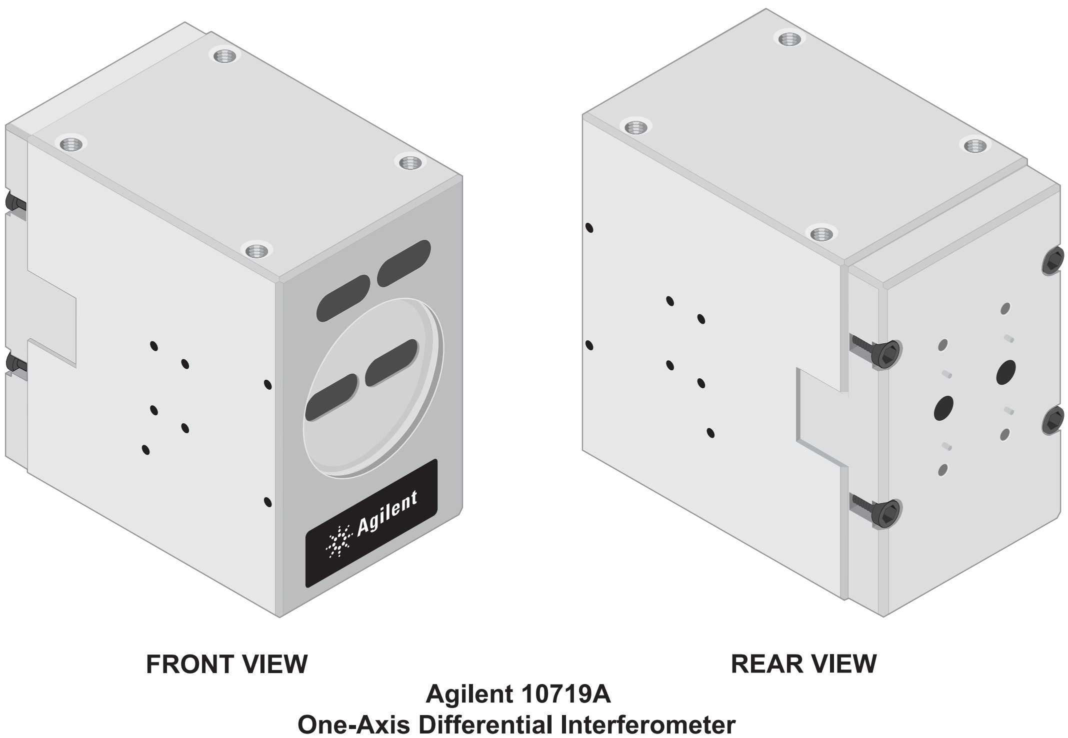


Figure 170 Agilent 10719A One-axis Differential Interferometer

Angular measurements

The Agilent 10719A interferometer can measure angular displacement instead of linear displacement, by directing its reference and measurement beams to the same plane mirror. This creates an optically subtracted angular measurement with a fundamental optical resolution of 1.73 arc-seconds, which can be extended electronically by 32X to give 0.05 arc-second resolution. The concept of optical subtraction and a method to calibrate the angle measurement with high accuracy are described in Chapter 4, “System Installation and Alignment,” in Volume I of this manual.

Both types of measurements using the Agilent 10719A interferometer are illustrated in Figure 171.

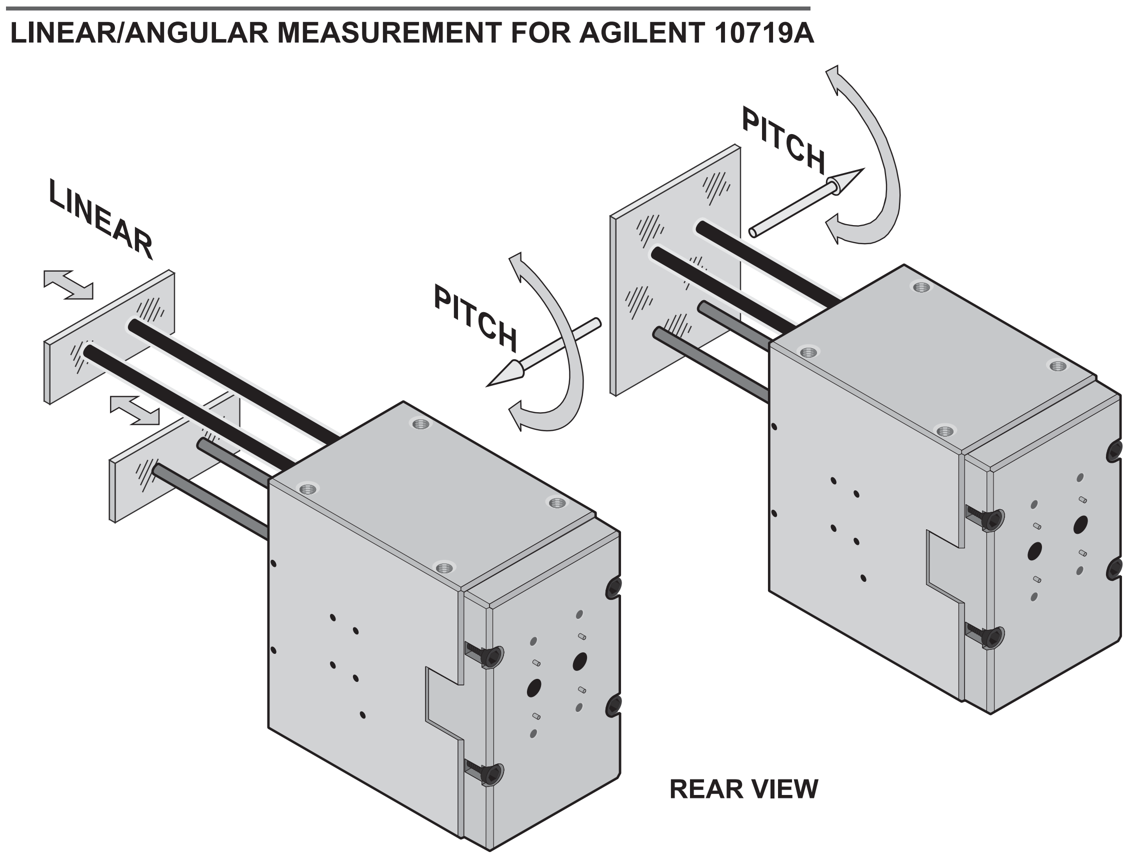


Figure 171 Agilent 10719A Interferometer - Measurements

Multiaxis configurations

The maximum number of independent axes of displacement that can be measured using one laser head depends on: 1) the measurement system electronics, 2) the strength of the beam from the laser head, 3) the sensitivity of the receivers used, 4) linear and angular range to be measured, and 5) the reflectivity and wavefront of the plane mirrors used for the reference and measurement mirrors.

By using the proper combination of beam splitters, beam benders, and interferometers, the measurement axes can be established with a minimum number of components. The following paragraphs provide examples of routing the laser beam for multiaxis measurement configurations.

Agilent 10719A and Agilent 10721A interferometers can be used in combination to create multiaxis stage measurements of one to six axes. Some of these applications are described in the following sections.

Three-Axis System

The three-axis system described here consists of:

- an Agilent 10719A One-Axis Differential Interferometer
- an Agilent 10721A Two-Axis Differential Interferometer

The Agilent 10719A One-Axis Differential Interferometer and the Agilent 10721A Two-Axis Differential Interferometer (described in Chapter 26) are well suited for X-Y stage applications, such as lithography equipment. With these interferometers, the measurement mirror is attached to the X-Y stage, and the reference mirror is attached to the exposure column, allowing positioning of the stage relative to the column itself (see Figure 172).

This configuration also allows yaw measurements of the X-Y stage. The Agilent 10721A interferometer combines the capabilities of two discrete linear interferometers into a single package. It makes two linear measurements with built-in parallelism, spaced 12.7 mm (0.5 inch) apart. The angular measurement can be calculated by taking the arctangent of the difference between these linear measurements divided by their separation:

$$THETA = arc\tan\frac{Y - Y'}{D}$$

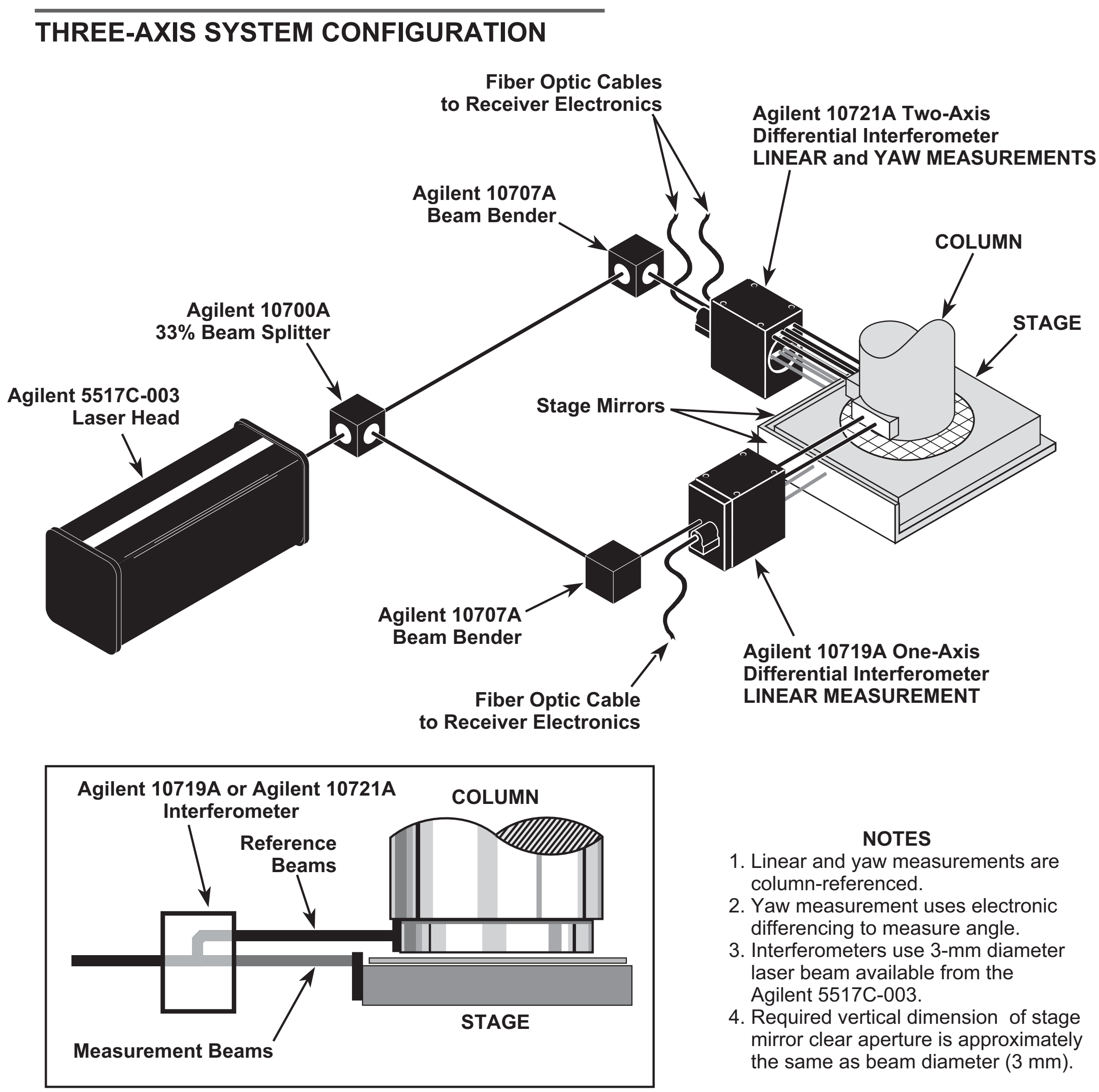


Figure 172 Three axes with Agilent 10719A and Agilent 10721A interferometers

Five-Axis System Using Agilent 10719A and Agilent 10721A Interferometers

The five-axis system described here consists of:

- three Agilent 10719A One-Axis Differential Interferometers
- an Agilent 10721A Two-Axis Differential Interferometer

The Agilent 10719A One-Axis Differential Interferometers and the Agilent 10721A Two-Axis Differential Interferometer may be used in a multiaxis configuration to measure X, Y, Yaw, Pitch, and Roll of an X-Y stage. As in the earlier three-axis system, the first three degrees of motion are column-referenced, and the yaw measurement is electronically subtracted.

Pitch and roll are measured by adding two more Agilent 10719A interferometers to the three-axis setup. Inverting the Agilent 10719A interferometers so the measurement beams and the reference beams both reflect off the stage mirror, creates an optically-subtracted angle measurement. Inverting the Agilent 10719A interferometers instead of just shifting them vertically, keeps the input beams for all interferometers in the same plane, which significantly simplifies installation and alignment. However, this also causes the inverted interferometers to be mounted with a 3.18 mm (0.125 inch) offset relative to the non-inverted ones as described in Figure 173.

Optical schematic

Figure 174 shows the optical schematic of the Agilent 10719A One-Axis Differential Interferometer.

After entering the input aperture, the laser beam is split into its separate components. The measurement beam continues straight through the interferometer to the measurement mirror. The reference path includes two 90-degree bends, causing the reference beam to be parallel to the measurement beam, but offset from it by 19.05 mm (0.750 inch) for the standard10719A or 30.6 mm (1.025 inches) for the 10719A-C02.

To reduce thermal drift errors, the measurement and reference beam paths have the same optical path length in glass. This reduces measurement errors due to temperature changes in the interferometer.

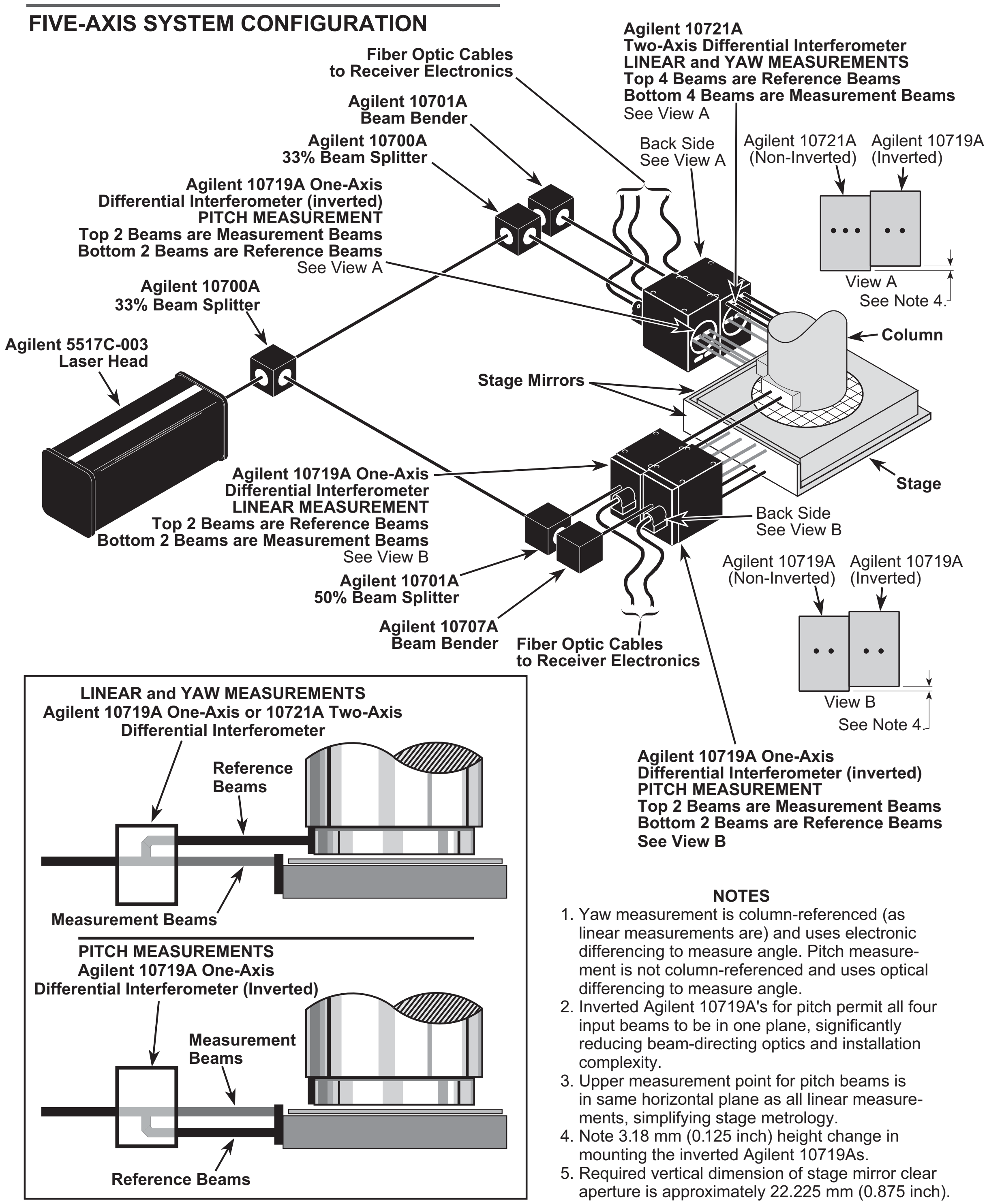


Figure 173 Five-axis system with Agilent 10719A and Agilent 10721A interferometers

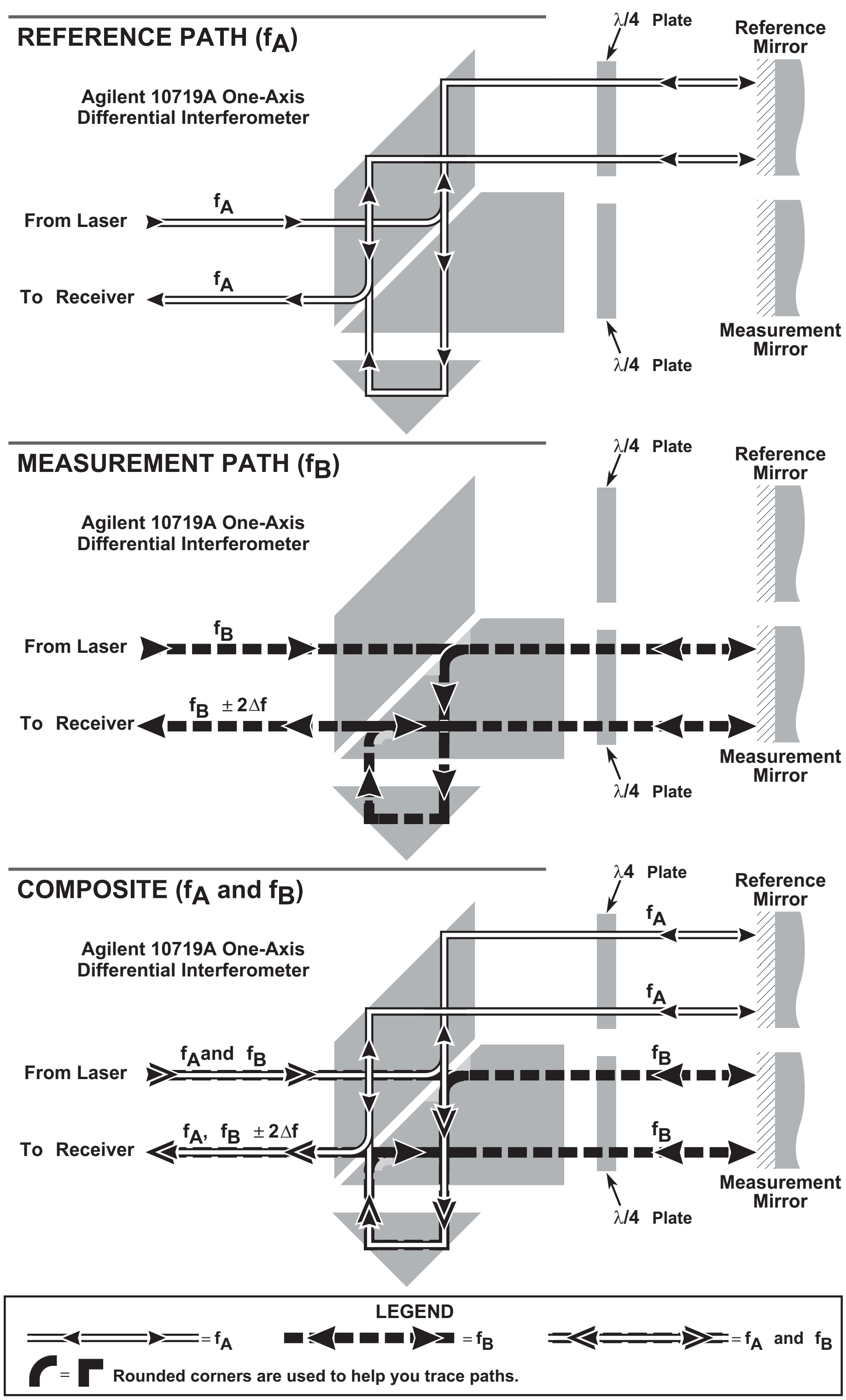


Figure 174 Agilent 10719A One-Axis Differential Interferometer — optical schematic

Special Considerations

Configuration and beam locations

The Agilent 10719A interferometer is designed to be used in a “straight-through” configuration only.

Its input face and measurement face are parallel to each other, on opposite sides of the housing.

The locations of the reference and measurement beams, with inputs and outputs identified, are shown in Figure 175.

The Agilent 10719A interferometer is similar to other plane mirror interferometers except that its reference path is redirected to be parallel to the measurement path outside the interferometer. Thus, the reference path also requires a plane mirror for its reflector.

Beam diameter

The Agilent 10719A interferometer requires the 3 mm diameter beam, available from an Agilent 5517C-003 Laser Head. The smaller diameter beam enables the beam positions on the stage mirror to be closer to the lithographic image plane, reducing Abbé offset errors.

Receiver considerations

The Agilent 10719A interferometer is designed primarily for use with the Agilent 10780F Remote Receiver; however, any other Agilent receiver may be used.

The advantage of using the remote receiver is that the fiber-optic sensor head can be directly attached to the interferometer, eliminating the need for separate mounting brackets.

When laying out an application, be sure to allow enough clearance for the fiber-optic cable without bending it tighter than its minimum bend radius of 35 mm (1.4 inches). Also avoid any kinking where the fiber connects to the sensor head. Kinking or excessive bending of this cable can cause signal attenuation.

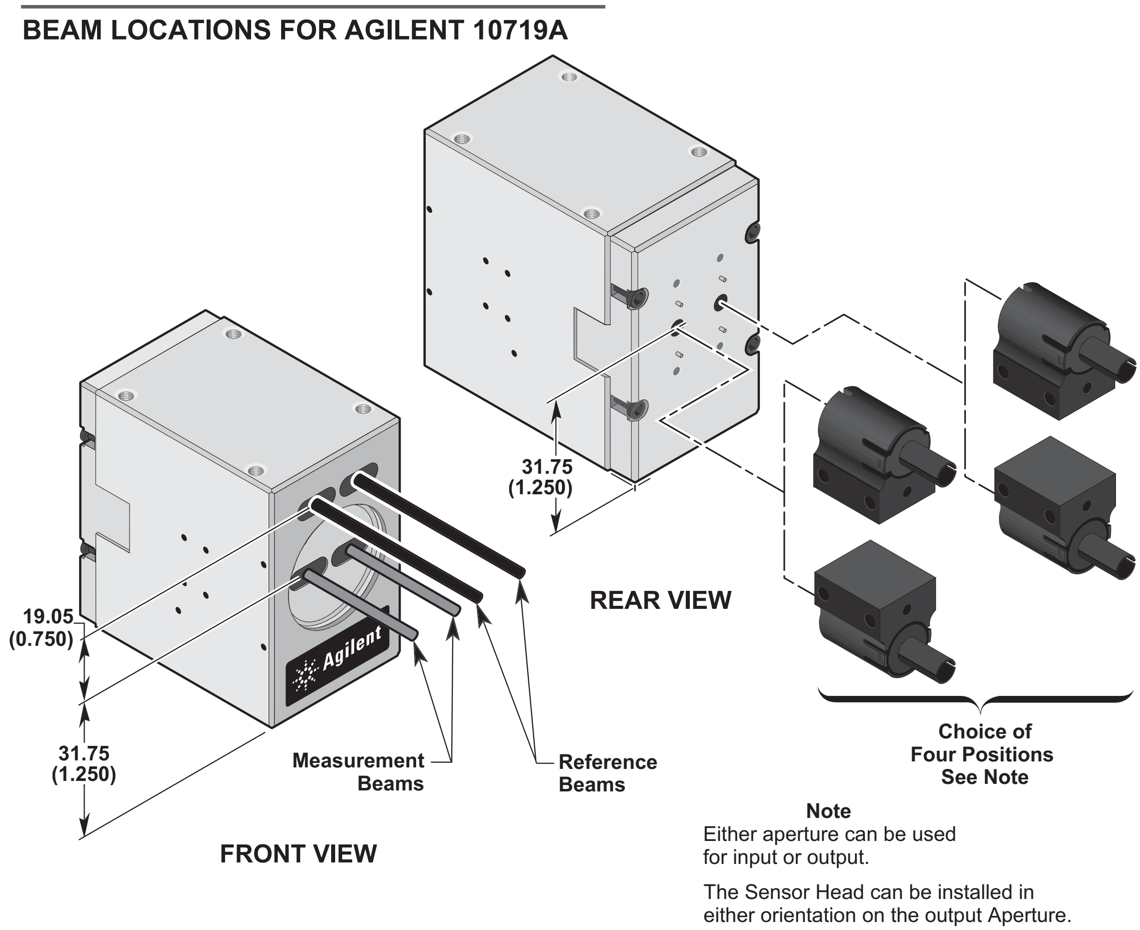


Figure 175 Agilent 10719A Interferometer - Reference and Measurement beams

Mounting pins on the interferometer eliminate the need for any user alignment of the sensor head. The sensor head may be installed on the mounting pins either right-side up or upside-down, whichever is best for your measurement situation.

Use 4-40 × 1-inch screws to fasten the sensor head to the interferometer.

Spacing to beam-directing optic

The recommended minimum spacing between the interferometer and its beam-directing optic is 63.5 mm (2.50 inches). This spacing will provide the minimum clearance for the fiber optic cable when the Agilent 10780F Remote Receiver is used.

Input and output apertures

The Agilent 10719A interferometer has two apertures, which may be used interchangeably as the input or output apertures. Each aperture is equipped with mounting pins for the Agilent 10780F receiver's fiber-optic sensor head; therefore, either aperture can be used for the output beam.

Direction sense

The Agilent 10719A interferometer direction sense depends fundamentally on which laser frequency is in its measurement path. This is affected by the mounting orientations of both the interferometer and the laser head.

In most cases, the Agilent 10719A interferometer will be oriented "upright", that is, with its top and bottom mounting surfaces horizontal. In this orientation, the internal polarizing beam splitter will send the vertical polarization into the measurement beam path and the horizontal polarization into the reference beam path. As mentioned in Chapter 16, "Laser Heads," of this manual, the Agilent 5517C-003 Laser Head produces f_1 (its lower frequency) with horizontal polarization and f_2 (its higher frequency) with vertical polarization.

Thus, an Agilent 5517C-003 with its mounting plane horizontal will direct f_1 into the reference path and f_2 into the measurement path. This configuration will result in the fringe counts DECREASING when the measurement mirror moves AWAY from the interferometer.

The direction sense will change sign for any configuration which rotates either the laser head or the interferometer by 90 degrees. The configuration of the beam-directing optics between the laser head and the interferometer may effectively rotate the laser beam, changing which laser frequency (polarization) is in which interferometer path, and thus the direction sense of the interferometer.

Air Deadpath

The air deadpath is defined as the difference between the reference and measurement air paths when the stage is at its zero position. This difference must be compensated in most applications.

For the Agilent 10719A interferometer, "zero-deadpath" (the condition in which the measurement beam path length and the reference beam path length are equal) does not occur when the reference and measurement mirrors are coplanar.

Because the reference beam travels 19.05 mm (0.750 inch), 30.6 mm (1.025 inches) for option C02, further through air inside the interferometer than the measurement beam does, the zero-deadpath condition for the

Agilent 10719A interferometer occurs when the measurement mirror is 19.05 mm (30.6 mm for option C02) farther from the interferometer housing than the reference mirror is. The consequences of this are discussed in more detail under the “Operation” section, later in this chapter.

Reference and measurement mirror requirements

A key feature of the Agilent 10719A interferometer is its ability to make relative measurements between a measurement plane mirror and a reference plane mirror. Since mirror size requirements depend on the application, both plane mirrors must be supplied by the user. Recommended optical specifications for these reflectors can be found under the “Agilent 10719A and 10719A-C02 One-Axis Differential Interferometer Specifications” section at the end of this chapter.

The mounting system for the mirrors must also be provided by the user. An important consideration in designing the mountings is to provide the means to ensure the mirrors are aligned substantially parallel to each other during system reset (even though they are not, in general, coplanar). Initial parallelism at reset is important for keeping the permitted angle range symmetrical about the initial “zero angle” position. For example, a parallelism error of 10 seconds during reset will effectively reduce the angle range in one direction by 10 seconds and increase it in the other direction by the same amount.

The general solution is to provide a way to adjust at least one, and possibly both, mirrors. As explained below, the alignment procedure requires that the reference and measurement mirrors both be made initially perpendicular to the input laser beam (and of course perpendicular to the axis of stage travel). Thus, with three items to adjust (2 mirrors and 1 input beam), at least two of them should be adjustable. The input beam itself usually allows the first adjustment; so one of the two mirrors must provide the second.

In a typical lithography application, the reference mirror will usually be stationary (that is, mounted to the optical column); hence, it is often the convenient choice for attaching to an adjustable mount.

Whether mounted with adjustment capability or not, the mirrors must be held rigidly and stable after installation. Choose the mounting method with care to avoid the introduction of mounting stresses which deform the surface flatness of the mirrors. Adhesives can be used successfully, but beware of any stresses which may be introduced during curing. The mounting method should also be designed to minimize thermal expansion effects which could displace the mirrors and give “false” displacement or rotation measurements.

Many methods exist for mounting optics with low stress and high thermal stability. For additional information, a useful introductory article is “The Optic As A Free Body”, Photonics Spectra, Aug. 1985, pp. 49-59. Also, textbooks on opto-mechanical design can provide more information.

Mounting

Vibration considerations

Agilent 10719A interferometers are inherently less susceptible to vibration effects than some other interferometers. The stability of these interferometers is due to the fact that both their reference beams and their measurement beams travel to external mirrors. Any motion of the interferometer itself is common to both beams and will not appear as a measurement. Of course, any vibration between the reference and measurement mirrors will constitute real, measurable, displacements.

Interferometer mounting system (user-supplied)

Since the mounting system requirements depend on the application, the mounting system must be designed and provided by the user. Here are some guidelines and recommendations for designing the mounting system.

The Agilent 10719A interferometer is designed for easy mounting and alignment. It may be mounted in any orientation, using the mounting hole patterns on either the top or bottom surface of the housing. The mounting screw thread is English #6-32 UNC.

The Agilent 10719A interferometer is a “referenced” interferometer. This means that the location and orientation of its internal optical components and laser beam paths are related to reference surfaces on its housing. This information is shown in Figure 176 on page 530 (Figure 177 on page 531 provides the information for option C02). This allows the possibility of a mounting scheme which eliminates the need for aligning or adjusting the interferometer.

Designing the mounting system

The first step in designing the mounting system is to choose the nominal position of the interferometer in the application. This is primarily dictated by the desired location of the measurement beams on the measurement mirror.

Next, the mounting system for the interferometer should be designed to restrict each of the six-degrees-of-freedom (three translational, three rotational). The recommended positional tolerances for mounting the interferometer are given below. Consider an ideal case in which the input laser beam is perfectly aligned to its desired axis:

1 There is no recommended tolerance for locating the Agilent 10719A interferometer along the X-axis, since this has no influence on the measurement.

2 The recommended tolerances for locating along the Y-axis and Z-axis are ± 0.15 mm (± 0.006 inch). Positional errors here will displace the effective measurement points on the mirrors by an equal amount. Also, mislocation can offset the beam centering in the input and output apertures.

3 The recommended tolerances for pitch, roll, and yaw of the interferometer are ± 15 arc-minutes each, relative to the input beam. Here again, mislocation chiefly affects beam centering (although gross errors in roll, that is, over ±1 degree, can start to induce non-linearity error due to polarization mixing.)

The primary reason for these tolerances is to control the measurement points on the mirrors and to ensure that the laser beams will reach the receivers properly aligned, with no clipping or signal loss. Small positional errors do not impair the measurement accuracy, provided they are fixed and do not change during the measurement.

With these positional accuracy goals in mind, there are two recommended approaches to designing the mounting system:

- Create an accurate, fixed mounting platform which predetermines the location of each interferometer using reference surfaces, or
- Create an adjustable mount with adjustments to “dial in” the positional accuracy after each interferometer is installed.

Fixed Mounting Platform If you use the first approach, the best design for a mounting platform is to make it kinematic. Kinematic means that all six-degrees-of-freedom are singly and unambiguously restricted. It is best to use a locating plane, a locating line, and a locating point. The locating plane will be the surface to which the top or the bottom of the interferometer is bolted (primary datum). The locating line should be a 2-point contact (or rail) which aligns the front face of the interferometer (secondary datum). The locating point should be a 1-point contact (or pad) which constrains side-to-side translations of the interferometer (tertiary datum). To install the interferometer, it should be firmly pressed against its locating datums while the mounting screws are torqued down. If the platform is made with the above-mentioned accuracy, this mounting method can completely eliminate the need to adjust or align the interferometers during installation. Then only the laser beam itself will need to be aligned to its proper position.

Adjustable Mount The “adjustable mount” approach is recommended when the mechanical tolerances within the application do not permit the use of a predetermined (non-adjustable) platform. Coarse adjustments may be provided in a variety of ways, such as using slotted holes for the mounting screws. For fine adjustments, micro-positioning stages are available from a variety of vendors. When using adjustable mounts, ensure that the adjustment capability does not introduce creep or instability into the mounting system.

In some applications, a combined approach may be best. For example, perhaps a platform having an accurate, fixed height can be used in conjunction with an adjustment for yaw and side-to-side translation.

Whatever approach is used, the Agilent 10719A interferometer should always be held rigidly and stably once it has been installed.

Installation

Pre-installation checklist

In addition to reading chapters 2 through 4, and Chapter 12, “Accuracy and Repeatability,” complete the following items before installing a laser positioning system into any application.

- ☐ Complete Beam Path Loss Calculation (see Calculation of signal loss” in Chapter 3, “System Design Considerations,” in Volume I of this manual).
- ☐ Supply plane mirror reflectors. See Chapter 12, “Accuracy and Repeatability,” or “Agilent 10719A and 10719A-C02 One-Axis Differential Interferometer Specifications” section at the end of this chapter for mirror specifications.
- ☐ Determine the direction sense for each axis, based on the orientation of the laser head, beam-directing optic, and interferometer. Enter the direction sense for each axis into the measurement system electronics. (See Chapter 16, “Laser Heads, Chapter 11, “Principles of Operation,” and Chapter 12, “Accuracy and Repeatability,” in this manual.)
- ☐ Supply suitable mounting means for all components of the laser measurement system, based on the recommendations given earlier in this chapter and elsewhere in this manual.
- ☐ Provide for aligning the optics, laser head, and receiver(s) on the machine.
- ☐ Be sure to allow for transmitted beam offset of beam splitters (e.g., Agilent 10700A and Agilent 10701A) in your design.

Receivers

1. Agilent 10780F, E1708A, or E1709A receiver’s fiber optic sensor heads may be mounted directly to the Agilent 10719A interferometer’s output aperture. Alignment pins are provided for easy installation and alignment. This eliminates the need for any other user-supplied mount for the sensor head.
2. Maintain a bend radius not less than 35 mm (1.4 inches) to prevent signal attenuation in the Agilent 10780F receiver’s fiber optic cable.

Alignment

Alignment aid

To help in aligning the Agilent 10719A interferometer, an alignment aid (Agilent Part Number 10706-60202) is included with the interferometer.

Alignment procedure

The objectives of the alignment procedure are:

1. to locate the measurement point accurately on the measurement mirror,
2. to minimize cosine error,
3. to maximize signal strength at the receiver, and
4. to ensure a symmetrical range of stage tilt about the “zero angle” point.

To accomplish these goals:

1. the measurement mirror must be aligned perpendicular to its axis of linear motion, and
2. the reference mirror must be aligned parallel to the measurement mirror, before proceeding with the steps below.

NOTE When using the Agilent 10719A interferometer for angle measurements, comments in the procedure below regarding reference mirror alignment may be disregarded since they are inherently satisfied by the use of a single mirror for these measurements.

For a system having more than one measurement axis, choose a practical sequence in which to align the axes before beginning the interferometer alignment. Be aware that the laser head and certain beam-directing optics may be adjusted for the first axis, but then must not be readjusted while aligning any other axis. (In fact, the convenience of being able to make independent adjustments may suggest the use of additional beam-directing optics in certain cases.)

1 Begin by installing the laser head and the optics in their desired locations and roughly aligning the laser beam so it is centered on the input aperture of each interferometer. Do not install the receivers yet.

2 If the interferometers are mounted on adjustable mounts, instead of fixed platforms which predetermine their locations, position them to within the translational and rotational tolerances described in "Mounting" section, above. This determines the locations of the measurement points on the mirrors.

3 With the interferometers and mirrors properly positioned, finish the alignment by adjusting the input laser beam's angle and position for each interferometer individually:

   a First, adjust the angle of the input beam using the autoreflection technique.

   1 Start by selecting the small aperture on the front turret of the laser head.

   2 Insert the alignment aid (Agilent Part Number 10706-60202) into the measurement beam between the interferometer and the measurement mirror. (This may be held in position temporarily by affixing a piece of tape to its yellow label.) This will cause the beam reflecting off the mirror to reflect back out through the input aperture toward the laser head.

   3 Angularly adjust the input beam using the beam-directing optics or the laser head or both until the reflected beam re-enters the small aperture of the laser head.

NOTE Careful, accurate autoreflection at this step is essential to minimizing cosine errors, assuming the mirror is perpendicular to the linear axis of travel.

NOTE For higher accuracy alignment, see the "Autoreflection" information in Chapter 4, "System Installation and Alignment," in Volume I of this manual for additional methods to optimize the autoreflection alignment.

   b Second, adjust the centering of the input beam on the input aperture by visual alignment.

   1 Start by switching back to the large aperture on the turret of the laser head (because the small aperture is only roughly aligned to the beam center).

   2 Place a piece of translucent tape across the input aperture of the interferometer to make the input beam easily visible.

NOTE Be careful not to stick the tape to any glass surface.

3 Translate the beam-directing optics or the laser head or both to center the input beam on the aperture. Do not disturb the angular alignments already made. With care, you can center the beam visually to within ±0.15 mm (±0.006 inch) of its ideal position.

c Go back to steps 3.a and 3.b and alternately recheck and readjust the input beam angle and centering until both are simultaneously optimized. Then remove the tape from the input aperture and remove the alignment aid.

d As a further alignment check, place a piece of translucent tape across the output aperture(s) to make the output beam(s) easily visible. Each output beam should now be approximately centered in its aperture without clipping.

NOTE Any clipping observed here indicates a centering problem at the input aperture or an autoreflection problem.

e Clamp down the laser and the beam directing optics without changing their alignment.

4 At this point, the reference beam has also been automatically aligned, assuming the reference mirror is parallel to the measurement mirror. If any parallelism error exists, the beam overlap in the output aperture(s) will be degraded, which may be visible. You can check beam overlap qualitatively by alternately blocking the reference and measurement beams and observing their respective positions on the tape across the output aperture(s). Remove the tape when done.

NOTE If a beam overlap problem exists, recheck the parallelism of the reference mirror, relative to the measurement mirror. Adjust as needed.

5 Attach the Agilent 10780F receiver's fiber-optic sensor heads, using 4-40 screws. Avoid kinking or excessive bending of the cable as explained under the "Receivers" subsection, earlier in this chapter.

6 Repeat the above steps for all other interferometers in the application, being careful to adjust only beam-directing optics which do not disturb the alignments already completed.

Operation

Reset considerations

If the reflectors you use with the interferometer are not at their zero deadpath positions when you reset the system, you should enter a zero-deadpath compensation value, as described in the "Air Deadpath compensation considerations," below.

Air Deadpath compensation considerations

Proper use of deadpath compensation is essential to achieving maximum accuracy.

"Air deadpath" is defined as the difference in the air path length between the reference and measurement arms of the interferometer when the stage is at its "zero" or "home" position. If air deadpath exists and is not compensated, your "zero point" or home position will appear to move around as the air temperature, pressure, and humidity change.

"Zero-deadpath" is the condition in which the measurement beam path length and the reference beam path length are equal. For the Agilent 10719A interferometer, this does NOT occur when the measurement and reference mirrors are coplanar, as a cursory look might imply. Because the reference beam travels an additional 19.05 mm (0.750 inch) for the standard10719A or 30.6 mm (1.025 inches) for the 10719A-C02 through air inside the interferometer housing, the zero-deadpath condition occurs when the measurement mirror is 19.05 mm (30.6 mm for option C02) farther from the interferometer housing than the reference mirror.

Deadpath compensation for the Agilent 10719A interferometer can be performed in one of two ways:

- move the measurement mirror to the zero-air deadpath position before each system reset, or
- use a deadpath compensation number in software. If you use this method, be aware that the compensation number can be either positive or negative, depending on the relative position of the mirrors at reset. Be sure to use the correct sign for your application.

When the Agilent 10719A interferometer is used in its angle-measuring configuration, you must use the second (software) method, since the measurement and reference path lengths are inherently unequal by 19.05 mm (0.750 inch).

Agilent 10719A and 10719A-C02 One-Axis Differential Interferometer Specifications

USE: Single- and multiple-axis applications such as precise positioning of a multiaxis stage, where the stage must be linearly positioned with respect to an external object such as a column or inspection tool. Alternatively, an angle is measured when both reference and measurement beams measure distance to the same mirror. The interferometer can be made vacuum compatible.

SPECIFICATIONS

Operating Temperature: 17 to 23°C

Weight: 300 grams (11 ounces)

Dimensions: see Figure 176 (10719A), Figure 177 (10719-C02)

Materials Used:

Housing: Aluminum

Optics: Optical grade glass

Adhesives: Vacuum grade

Axis: Linear or pitch or roll

Available Beam Size: 3 mm

Thermal Drift Coefficient (Average): 150 nm (5.9 µin.)/°C (for Option C02, 50 nm/°C (typical)

Non-linearity Error: <2.2 nm (0.09 µin)

Resolution:[1]

Optical: λ /4

Linear: 5 nm (using 32 × resolution extension)
0.62 nm (using 256 × resolution extension)

Angular (pitch or roll): 0.7 µrad (0.14 arc-sec)-using X32 electronics
0.1 µrad (0.02 arc-sec)-using X256 electronics

Range:[2]

Linear: 10m (33 ft).

Angular (pitch or roll):

at distance = 150 mm	at distance = 300 mm
± 0.88 mrad (± 3 arc-min)	± 0.44 mrad (± 1.5 arc-min)

[1] Linear and angular resolutions are dependent on the electronics used. Optical resolution is dependent only on the interferometer, and can be used to determine linear and angular resolutions when the electronic resolution extension is known. The linear and angular specifications in this section are for interferometer use with the X32 resolution extension electronics (10885A, 10895A) or X256 resolution extension electronics (10897C, 10898A).

[2] Linear range here is the sum of the ranges for all axes. Angular range is the maximum measurement mirror angle due to all components (i.e., yaw and pitch, or yaw and roll) between the measurement mirror and the interferometer for a 6-axis system. Range will be reduced when the reference mirror is misaligned.

Parallelism (Input to output beams): 0.1 mrad (20 arc-sec).

Optical Efficiency (output beam/input beam):

Average: 60%

Worst Case: 40%

INSTALLATION RECOMMENDATIONS

Installation and alignment: Kinematic installation requires a referenced surface.

Receivers: Agilent 10780F fiber-optic remote receivers or Agilent 10780C receivers.

Receiver Alignment: Self-aligning when mounted to interferometer.

MEASUREMENT AND REFERENCE (Plane) MIRROR RECOMMENDATIONS

Reflectance: 98% at 633 nm, normal incidence.

Flatness: Depending on accuracy requirements of the application, mirror flatness may range from λ /4 to λ /20 (0.16 to 0.03 µmeters, 6 to 1.2 µinches).

Optical Surface Quality: 60—40 per Mil-0-13830.

NOTE: Flatness deviations will appear as measurement errors when the mirror is translated across the beam. Mirror mount should be kinematic so as not to bend mirror. If accuracy requirements demand it, mirror flatness might be calibrated (scanned and stored in the system controller) to be used as a correction factor.

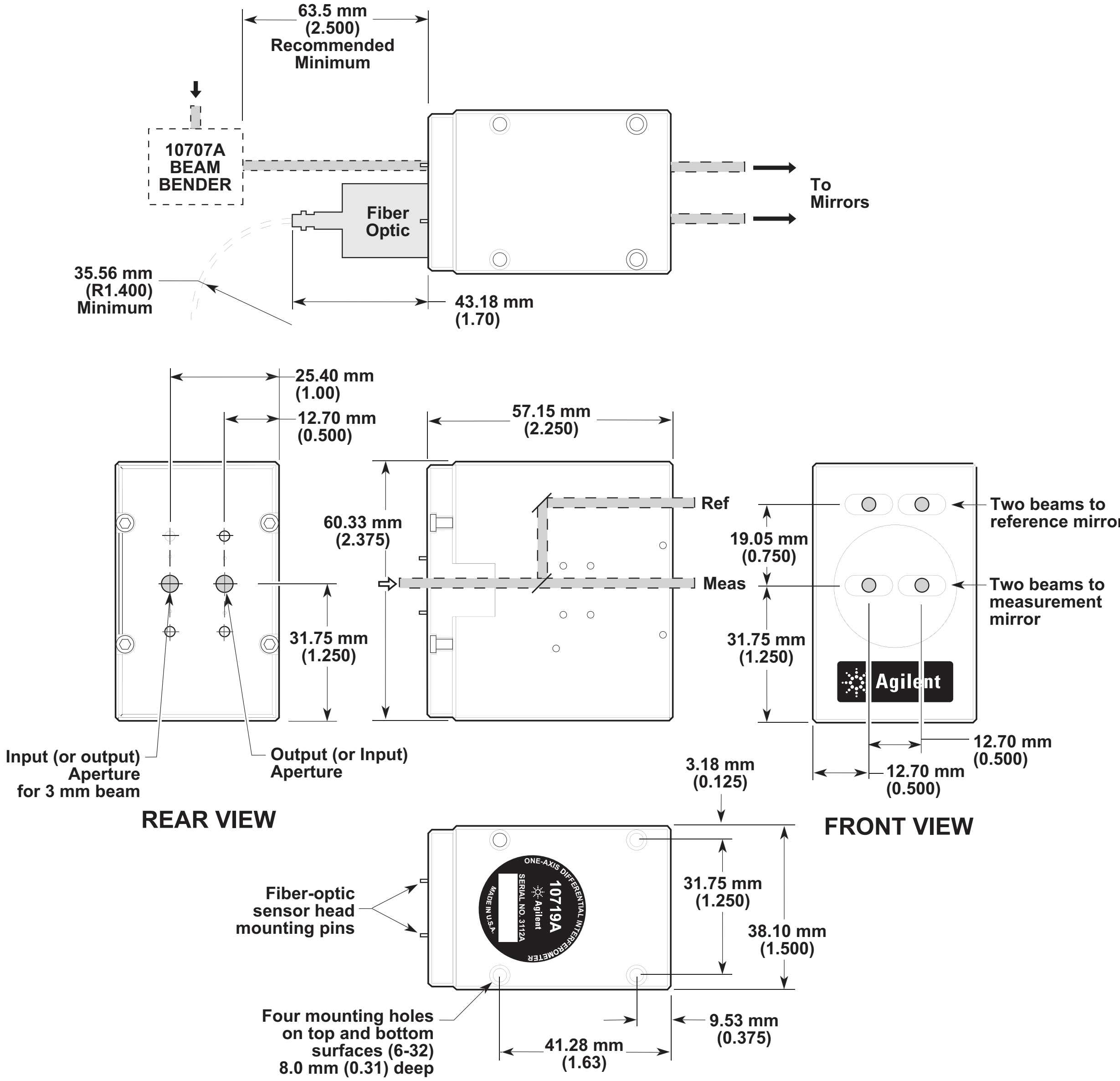


Figure 176 Agilent 10719A One-Axis Differential Interferometer — dimensions

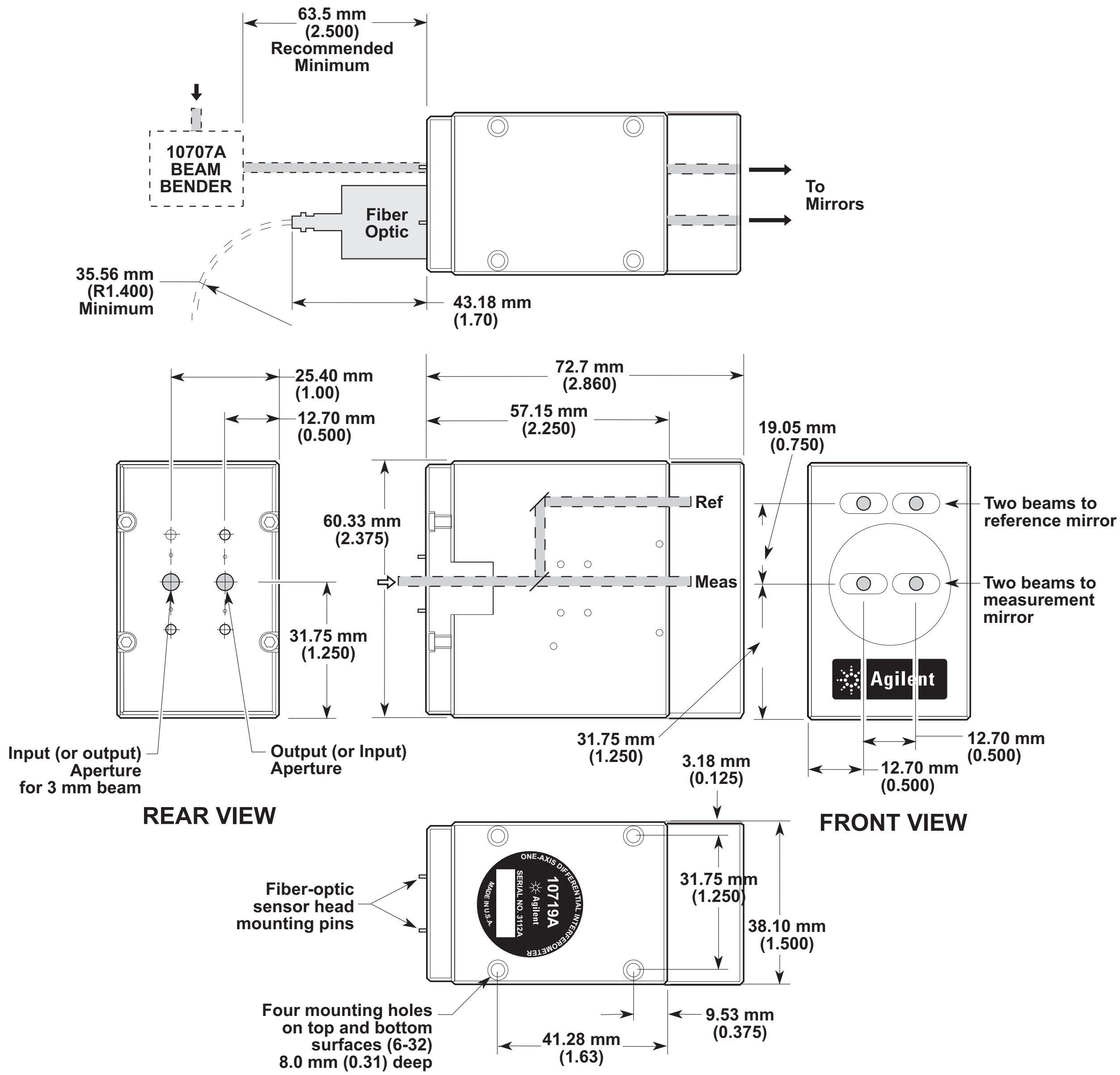


Figure 177 Agilent 10719A-C02 One-Axis Differential Interferometer — dimensions

26
Agilent 10721A and 10721A-C01 Two-Axis Differential Interferometers

Description

General

The Agilent 10721A Two-Axis Differential Interferometer (see Figure 178) is a plane mirror type of interferometer, similar to the Agilent 10719A One-Axis Differential Interferometer (described in Chapter 25) except that it provides an additional measurement axis.

The Agilent 10721A Two-Axis Differential Interferometer is intended for making differential linear and angular measurements, simultaneously, between two separate plane mirrors.

The Agilent 10721A interferometer makes two simultaneous adjacent parallel linear measurements, spaced 12.7 mm (0.500 inch) apart. The parallelism between the two measurements is guaranteed by the internal optics and eliminates the parallelism adjustment required when separate linear interferometers are used for measuring angle. An Agilent 10721A interferometer angle measurement is implemented in software via electronic subtraction. The concept of electronic subtraction and a method to calibrate the angle measurement with high accuracy are described in Chapter 4, “System Installation and Alignment,” in Volume I of this manual.

The Agilent 10721A interferometer is designed to use a 3-mm diameter laser beam, available from an Agilent 5517C-003 Laser Head. This beam is smaller than the standard 6 mm beam and allows the measurement plane (center of the beam) to be closer to the upper edge of the X-Y stage measurement mirror, thereby reducing Abbé errors.

The Agilent 10721A interferometer’s basic optical resolution is the same as that of the Agilent 10719A and Agilent 10706B interferometers.

The Agilent 10721A interferometer’s basic angular resolution is 2.56 arc-seconds, which can be extended electronically by 32X to give 0.08 arc-second resolution.

The Agilent 10721A interferometer is designed primarily for use with the Agilent 10780F Remote Receiver, which can be attached directly to the housing; however, any other Agilent receiver may be used.

The C01 special option, Agilent 10721A-C01, is designed to reduce the thermal drift coefficient.

A metal housing extension is added to the front of the interferometer to protect the optic. This increases the length of the interferometer by 15.5 mm

The thermal drift specification in the Agilent 10721A-C01 is reduced from 150 nm/°C to 50 nm/°C (typical), provided you compensate for the internal air dead path. Internal air dead path for this interferometer is 30.6 mm

(1.025 inches). It may be compensated by either of the two methods described in "Operation" on page 550 of this chapter (using 30.6 mm rather than the 19.05 mm for the standard Agilent 10721A interferometer.

Applications

Differential measurements

A differential measurement is one in which both the reference beam and the measurement beam travel to external mirrors outside the interferometer housing. This allows measurement of the relative positions of the two external mirrors, either or both of which may move.

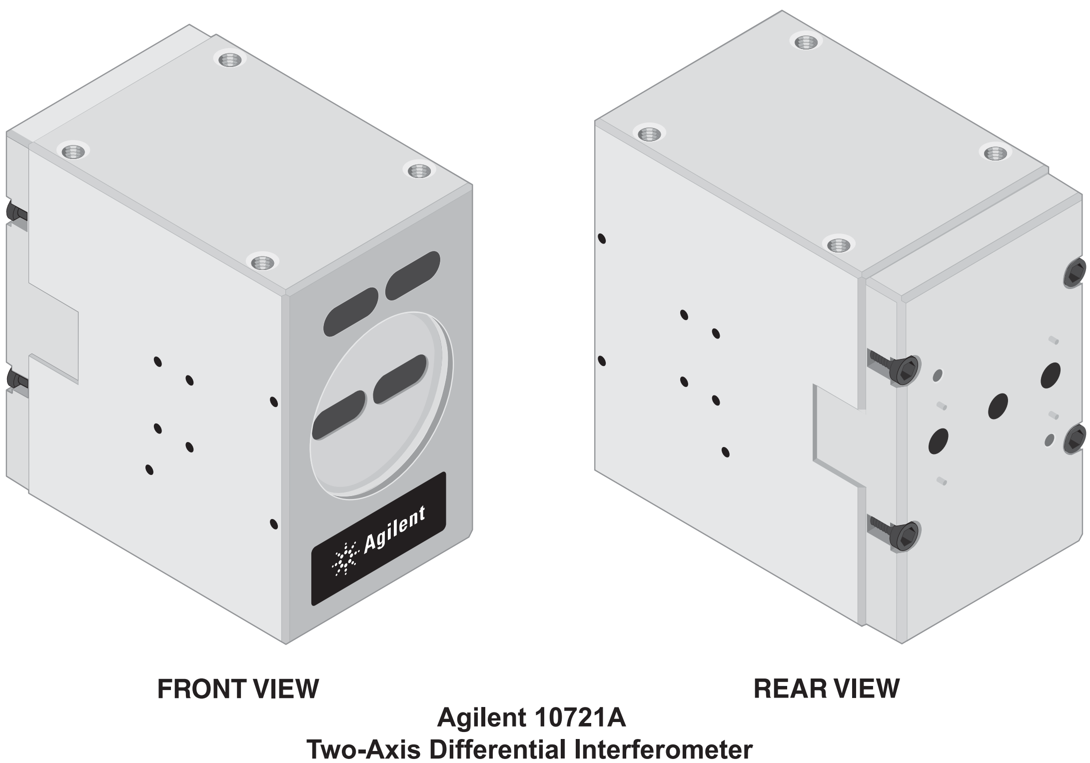


Figure 178 Agilent 10721A Two-Axis Differential Interferometer

One useful example of a differential measurement application is in lithography where the motion of an X-Y stage is measured relative to its related optical column. An example of a laser measurement system for this application, including both Agilent 10721A and Agilent 10719A interferometers, is presented in the Agilent 10719A chapter (Chapter 25) of this manual.

Angular measurements

Because the Agilent 10721A interferometer combines the capabilities of two discrete linear interferometers into a single package, it can be used to make angular measurements. For angular measurements, the Agilent 10721A interferometer makes two linear measurements (Y and Y') with built-in parallelism, spaced 12.7 mm (0.5 inch) apart. The angular measurement is calculated by taking the arctangent of the difference between these linear measurements divided by their separation:

$$THETA = arc\tan\frac{Y - Y'}{D}$$

For more information about angular measurements, see the "Electronic Yaw Calculation Method" and "Optical Yaw Calculation Method" subsections under the "Three-axis measurement system using discrete plane mirror interferometers (X, Y, YAW)" section in Chapter 3, "System Design Considerations," in Volume I of this manual.

Measurements possible using the Agilent 10721A interferometer are illustrated in Figure 179.

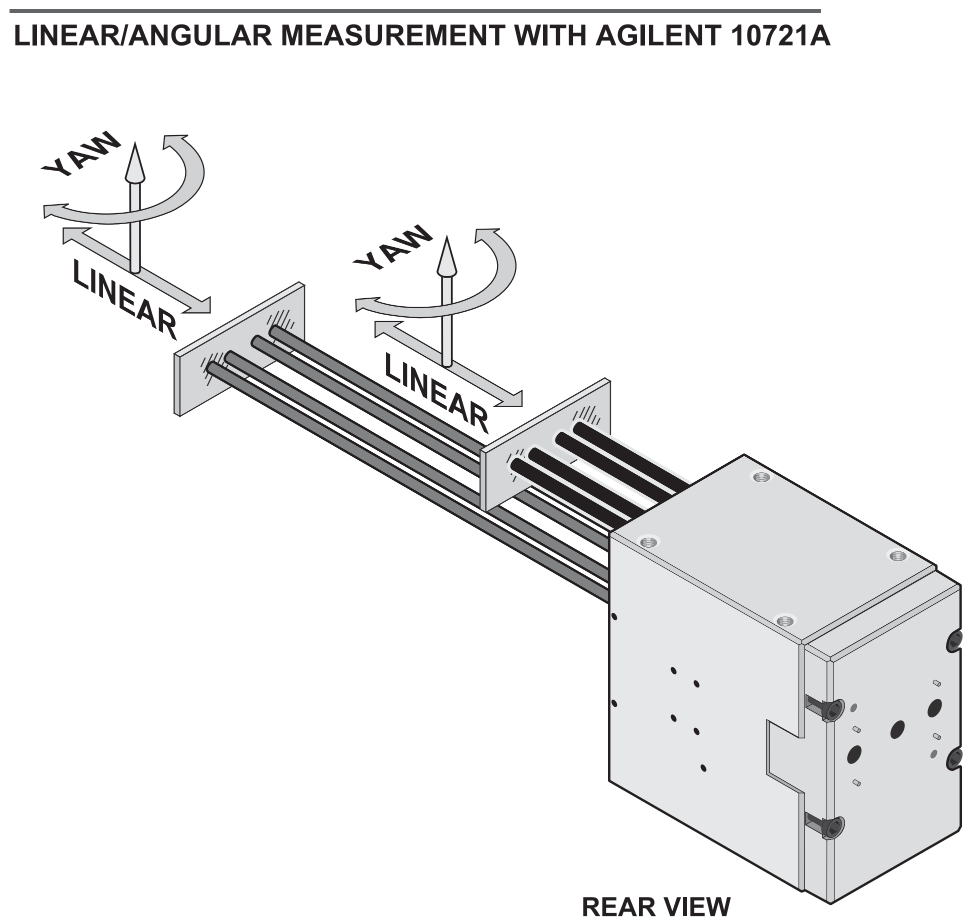


Figure 179 Agilent 10721A Two-Axis Differential Interferometer — measurements

Multiaxis configurations

Refer to the “Multiaxis Configurations” subsection in the Agilent 10719A chapter (Chapter 25) of this manual.

Optical schematic

Figure 180 shows the optical schematic of the Agilent 10721A Two-Axis Differential Interferometer.

After entering the input aperture, the laser beam is split into two parallel beams, 12.7 mm (0.500 inch) apart. Each of these beams is then split into its separate reference and measurement components. Each of the two measurement beams continues straight through the interferometer to its measurement aperture. Each reference path includes two 90-degree bends, causing that reference beam to be parallel to its related measurement beam, but offset from it by 19.05 mm (0.750 inch).

To reduce thermal drift errors, the measurement and related reference beam paths have the same optical path length in glass. This reduces measurement errors due to temperature changes in the interferometer.

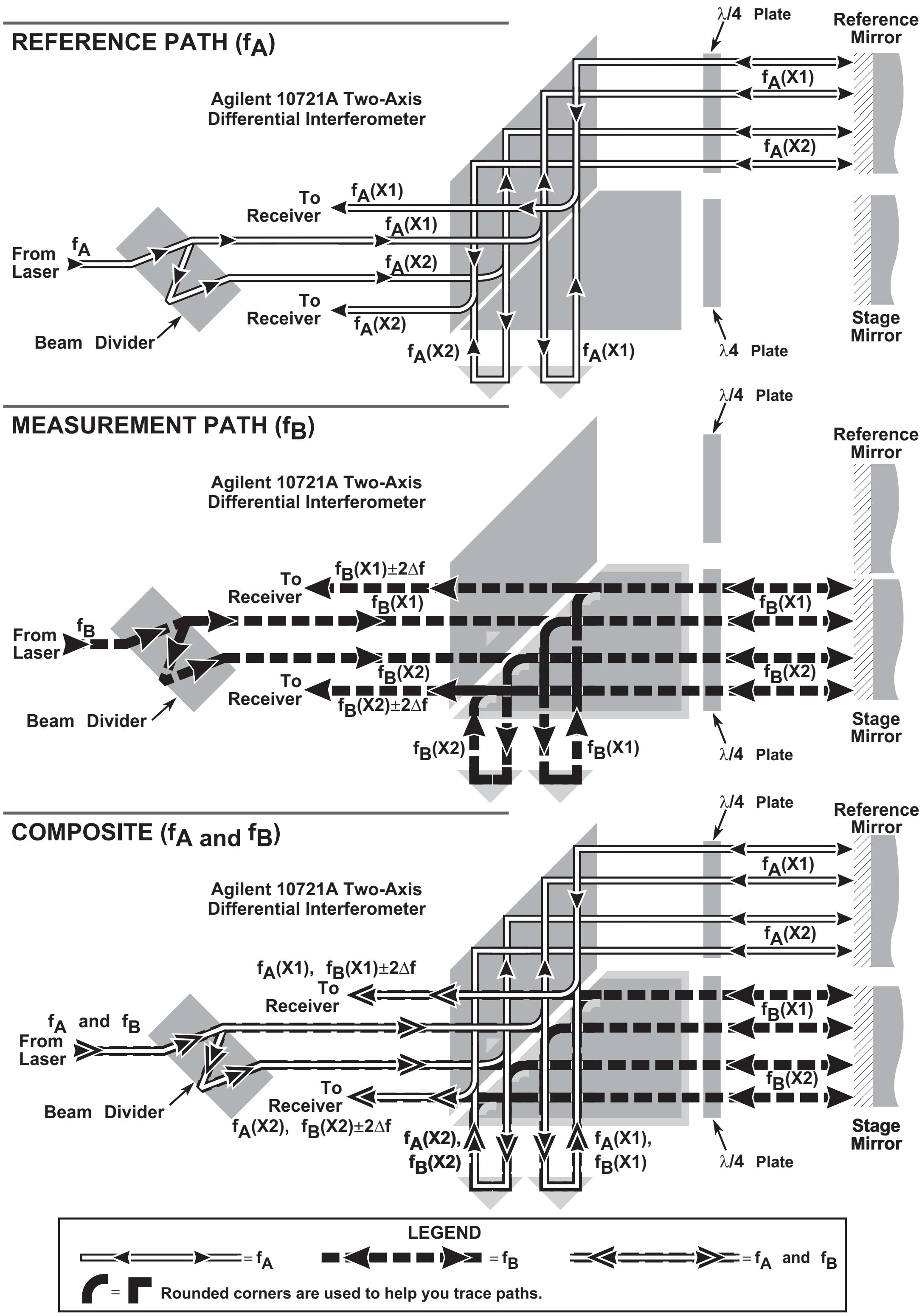


Figure 180 Agilent 10721A Two-Axis Differential Interferometer — laser beam path

Special Considerations

Laser beam power consideration

When you are working with an application that has more than one measurement axis, make sure that you provide enough laser beam power to the Agilent 10721A so it can drive both receivers connected to it. The method for calculating this is described under the “Beam Path Loss Computation” section in Chapter 3, “System Design Considerations,” in Volume I of this manual.

In addition, you should try to balance the available net power (after all losses have been computed), so all receivers in the application will receive nearly equal power. For example, in an application using both an Agilent 10719A interferometer and an Agilent 10721A interferometer, use a 33% beam splitter to send one third of the laser power to the Agilent 10719A interferometer (which has one receiver) and two thirds of the laser power to the Agilent 10721A interferometer (which has two receivers).

Configuration and beam locations

The Agilent 10721A interferometer is designed to be used in a “straight-through” configuration only.

Its input face and measurement face are parallel to each other, on opposite sides of the housing.

The locations of the reference and measurement beams, with inputs and outputs identified, are shown in Figure 181.

The Agilent 10721A interferometer is similar to other plane mirror interferometers except that its reference paths are redirected to be parallel to their related measurement paths outside the interferometer. Thus, each reference path also requires a plane mirror for its reflector.

Beam diameter

The Agilent 10721A interferometer requires the 3 mm diameter beam, available from an Agilent 5517C-003 Laser Head. The smaller diameter beam enables the beam positions on the stage mirror to be closer to the lithographic image plane, reducing Abbé offset errors.

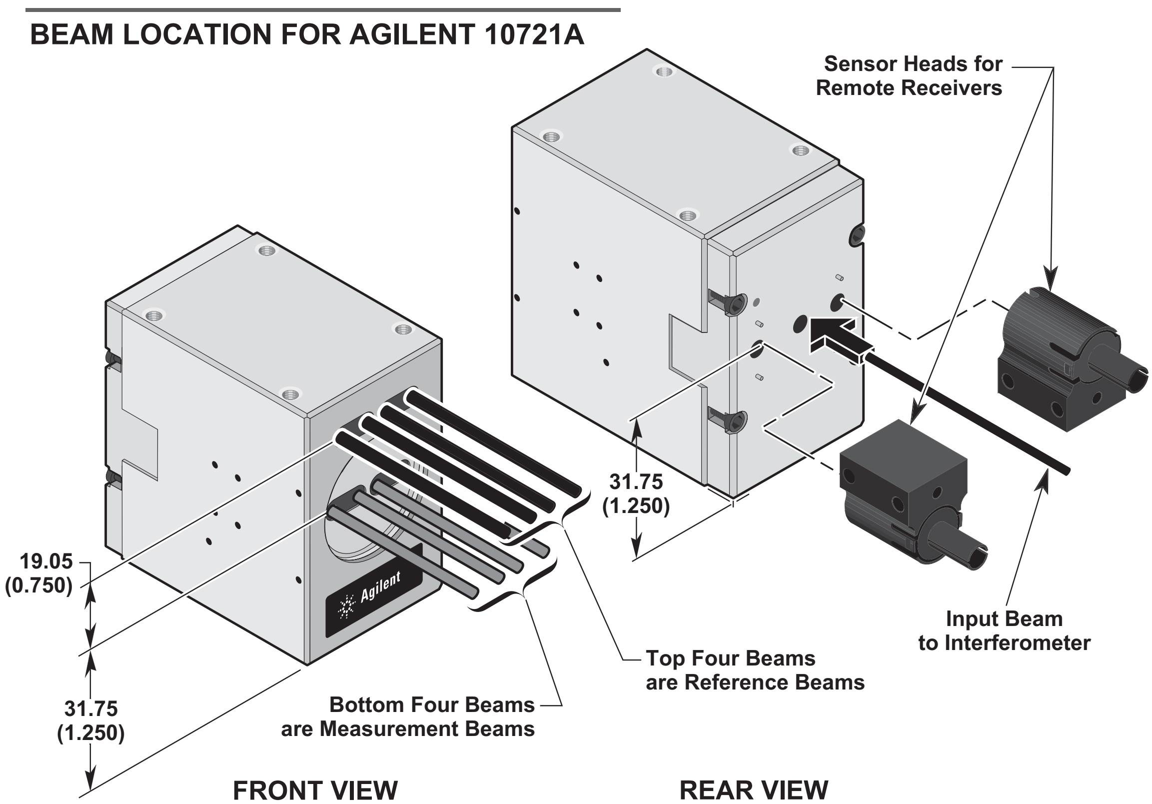


Figure 181 Agilent 10721A Two-Axis Differential Interferometer Reference and Measurement beams

Receiver considerations

The Agilent 10721A interferometer is designed primarily for use with the Agilent 10780F Remote Receiver; however, any other Agilent receiver may be used. One receiver is required for each Agilent 10721A output to be used.

The advantage of using the remote receiver is that the fiber-optic sensor head can be directly attached to the interferometer, eliminating the need for separate mounting brackets.

When laying out an application, be sure to allow enough clearance for the fiber-optic cable without bending it tighter than its minimum bend radius of 35 mm (1.4 inches). Also avoid any kinking where the fiber connects to the sensor head. Kinking or excessive bending of this cable can cause signal attenuation.

Mounting pins on the interferometer eliminate the need for any user alignment of the sensor head. With the Agilent 10721A interferometer, the receiver's sensor head can be oriented only one way at each interferometer output aperture, as determined by the location of the threaded mounting hole.

Use 4-40×1-inch screws to fasten the sensor heads to the interferometer.

Spacing to beam-directing optic

The recommended minimum spacing between the interferometer and its beam-directing optic is 63.5 mm (2.50 inches). This spacing will provide the minimum clearance for the fiber-optic cable when the Agilent 10780F Remote Receiver is used.

Input and output apertures

The Agilent 10721A interferometer has three apertures, which are not interchangeable. The middle aperture must be used for the input beam. The outer two apertures are for the output beams. Both output apertures are equipped with mounting pins for the Agilent 10780F fiber-optic sensor head; therefore, either aperture can be used for the output beam.

Direction sense

The Agilent 10721A interferometer direction sense depends fundamentally on which laser frequency is in its measurement path. This is affected by the mounting orientations of both the interferometer and the laser head.

In most cases, the Agilent 10721A interferometer will be oriented “upright”, that is, with its top and bottom mounting surfaces horizontal. In this orientation, the internal polarizing beam splitter will send the vertical polarization into the measurement beam path and the horizontal polarization into the reference beam path. As mentioned in Chapter 16, “Laser Heads,” of this manual, the Agilent 5517C-003 Laser Head produces f_1 (its lower frequency) with horizontal polarization and f_2 (its higher frequency) with vertical polarization.

Thus, an Agilent 5517C-003 with its mounting plane horizontal will direct f_1 into the reference path and f_2 into the measurement path. This configuration will result in the fringe counts DECREASING when the measurement mirror moves AWAY from the interferometer.

The direction sense will change sign for any configuration which rotates either the laser head or the interferometer by 90 degrees. The configuration of the beam-directing optics between the laser head and the interferometer may effectively rotate the laser beam, changing which laser frequency (polarization) is in which interferometer path, and thus the direction sense of the interferometer.

Air Deadpath

The air deadpath is defined as the difference between the reference and measurement air paths when the stage is at its zero position. This difference must be compensated in most applications.

For the Agilent 10721A interferometer, “zero-deadpath” (the condition in which the measurement beam path length and the reference beam path length are equal) does not occur when the reference and measurement mirrors are coplanar.

Because the reference beam travels 19.05 mm (0.750 inch), 30.6 mm (1.025 inches) for option C01, further through air inside the interferometer than the measurement beam does, the zero-deadpath condition for the Agilent 10721A interferometer occurs when the measurement mirror is 19.05 mm (30.6 mm for option C01) farther from the interferometer housing than the reference mirror is. The consequences of this are discussed in more detail under the “Operation” section, later in this chapter.

Reference and measurement mirror requirements

A key feature of the Agilent 10721A interferometer is its ability to make relative measurements between a measurement plane mirror and a reference plane mirror. Since mirror size requirements depend on the application, both plane mirrors must be supplied by the user. Recommended optical specifications for these reflectors can be found in the “Agilent 10721A and 10721A-C01 Two-Axis Differential Interferometer Specifications” section at the end of this chapter.

You must also provide the mounting system for the mirrors. An important consideration in designing the mountings is to provide the means to ensure that the two mirrors are aligned substantially parallel to each other during system reset (even though they are not, in general, coplanar). Initial parallelism at reset is important for keeping the permitted measurement mirror angle range symmetrical about the initial “zero angle” position. For example, a parallelism error of 10 seconds during reset will effectively reduce the angle range in one direction by 10 seconds and increase it in the other direction by the same amount.

The general solution is to provide a way to adjust at least one, and possibly both, mirrors. As explained below, the alignment procedure requires that the reference and measurement mirrors both be made initially perpendicular to the input laser beam (and of course perpendicular to the axis of travel). Thus, with three items to adjust (two mirrors and one input beam), at least two of them should be adjustable. The input beam itself usually allows the first adjustment; therefore, one of the two mirrors must provide the second.

In a typical lithography application, the reference mirror will usually be stationary (that is, mounted to the optical column), so it is often the convenient choice for attaching to an adjustable mount.

Whether mounted with adjustment capability or not, the mirrors must be held rigidly and stably once they are installed. Choose your mounting method with care, to avoid introducing mounting stresses which deform the mirrors' surface flatness. Adhesives can be used successfully, but beware of any stress which may be introduced during curing. Your mounting method should also minimize thermal expansion effects which could displace the mirrors and give “false” displacement or rotation measurements.

Many methods exist for mounting optics with low stress and high thermal stability. For additional information, a useful introductory article is “The Optic As A Free Body”, Photonics Spectra, Aug. 1985, pp. 49-59. Also, textbooks on opto-mechanical design can provide more information.

Mounting

Vibration isolation

Agilent 10721A interferometers are inherently less susceptible to vibration effects than some other interferometers. The stability of these interferometers is due to the fact that both their reference beams and their measurement beams travel to external mirrors. Any motion of the interferometer itself is common to both beams and will not appear as a measurement. Of course, any vibration between the reference and measurement mirrors will constitute real, measurable, displacements.

Interferometer mounting system (user-supplied)

Since the mounting system requirements depend on the application, the mounting system must be designed and provided by the user. The following paragraphs provide some guidelines and recommendations for designing the mounting system.

The Agilent 10721A interferometer is designed for easy mounting and alignment. It may be mounted in any orientation, using the mounting hole patterns on either the top or bottom surfaces of the housing. The mounting screw thread is English #6-32 UNC.

A key feature of the Agilent 10721A interferometer is that it is designed as a “referenced” interferometer. In other words, the location and orientation of its internal optical components and laser beam paths are related to reference surfaces on its housing. This opens the possibility of a mounting scheme which eliminates the need for aligning or adjusting the interferometer.

Designing the mounting system

The first step in designing the mounting scheme is to determine the nominal position of each interferometer. This is generally dictated by the intended location of the measurement beams on the measurement mirror.

The mounting system for each interferometer should be designed to restrict each of the six-degrees-of-freedom (three translational, three rotational). The recommended positional tolerances for mounting the interferometers are given below. Consider an ideal case in which the input laser beam is perfectly aligned to its desired axis:

1. There is no recommended tolerance for locating the Agilent 10721A interferometer along the X-axis since this has no influence on the measurement.
2. The recommended tolerances for locating the interferometer along the Y-axis and Z-axis are ±0.15 mm (±0.006 inch). Positional errors here will

displace the effective measurement points on the mirrors by an equal amount. Also, mislocation can offset the beam centering in the input and output apertures.

3 The recommended tolerances for pitch, roll, and yaw of the interferometers are ±15 arc-minutes, relative to the input beam. Here again, mislocation chiefly affects beam centering (though gross errors in roll—that is, over ±1 degree—can start to induce non-linearity error due to polarization mixing.)

The primary reason for these tolerances is to control the measurement points on the mirrors and to ensure that the laser beams will reach the receivers properly aligned, with no clipping or signal loss. Small positional errors do not impair the measurement accuracy, provided they are fixed and do not change during the measurement.

With these positional accuracy goals in mind, there are two recommended approaches to designing the mounting system:

- Create an accurate, fixed mounting platform which predetermines the location of each interferometer using reference surfaces; or,
- Create an adjustable mount with adjustments to “dial in” the positional accuracy after each interferometer is installed.

Fixed Mounting Platform If you use the first approach, the best design for a mounting platform is to make it kinematic. Kinematic means that all 6 degrees of freedom are singly and unambiguously restricted. It is best to use a locating plane, a locating line, and a locating point. The locating plane will be the surface to which the top or the bottom of the interferometer is bolted (primary datum). The locating line should be a 2-point contact (or rail) which aligns the front face of the interferometer (secondary datum). The locating point should be a 1-point contact (or pad) which constrains side-to-side translations of the interferometer (tertiary datum). To install the interferometer, it should be firmly pressed against its locating datums while the mounting screws are torqued down. If the platform is made with the above-mentioned accuracy, this mounting method can completely eliminate the need to adjust or align the interferometers during installation. Then only the laser beam itself will need to be aligned to its proper position.

Adjustable Mount The “adjustable mount” approach is recommended when the mechanical tolerances within the application do not permit the use of a pre-determined (non-adjustable) platform. Coarse adjustments may be provided in a variety of ways, such as using slotted holes for the mounting screws. For fine adjustments, micro-positioning stages are available from a variety of vendors. When using adjustable mounts, a key consideration is to ensure that the adjustment capability does not introduce creep or instability into the mounting system.

In some applications, a combined approach may be best. For example, perhaps a platform having an accurate, fixed height can be used in conjunction with an adjustment for yaw and side-to-side translation.

Whatever approach is used, the interferometer should always be held rigidly and stably once installed.

Installation

Pre-installation checklist

In addition to reading chapters 2 through 4, and Chapter 12, “Accuracy and Repeatability,” complete the following items before installing a laser positioning system into any application.

- ☐ Complete Beam Path Loss Calculation (see Calculation of signal loss” in Chapter 3, “System Design Considerations,” in Volume I of this manual).
- ☐ Supply plane mirror reflectors. See Chapter 12, “Accuracy and Repeatability,” or “Agilent 10721A and 10721A-C01 Two-Axis Differential Interferometer Specifications” section at the end of this chapter for mirror specifications.
- ☐ Determine the direction sense for each axis, based on the orientation of the laser head, beam-directing optic, and interferometer. Enter the direction sense for each axis into the measurement system electronics. (See Chapter 16, “Laser Heads, Chapter 11, “Principles of Operation,” and Chapter 12, “Accuracy and Repeatability,” in this manual.)
- ☐ Supply suitable mounting means for all components of the laser measurement system, based on the recommendations given earlier in this chapter and elsewhere in this manual.
- ☐ Provide for aligning the optics, laser head, and receiver(s) on the machine.
- ☐ Be sure to allow for transmitted beam offset of beam splitters (Agilent 10700A and Agilent 10701A) in your design.

Receivers

1 Agilent 10780F, E1708A, or E1709A receiver’s fiber-optic sensor heads may be mounted directly to the Agilent 10721A interferometer’s output aperture. Alignment pins are provided for easy installation and alignment. This eliminates the need for any other user-supplied mount for the sensor head.

2 Maintain a bend radius not less than 35 mm (1.4 inches) to prevent signal attenuation in the Agilent 10780F, E1708A, or E1709A receiver’s fiber-optic cable.

Alignment

Alignment aid

To help in aligning the Agilent 10721A interferometer, an alignment aid (Agilent Part Number 10706-60202) is provided with it.

Alignment procedure

The objectives of the alignment procedure are:

1 to position the measurement point accurately on the measurement mirror,

2 to minimize cosine error,

3 to maximize signal strength at the receiver, and

4 to ensure a symmetrical range of stage tilt about the “zero angle” point.

To accomplish these goals:

1 the measurement mirror must be aligned perpendicular to its axis of linear motion, and

2 the reference mirror must be aligned parallel to the measurement mirror, before the following steps.

NOTE When using the Agilent 10721A interferometer for angle measurements, comments in the procedure below regarding reference mirror alignment may be disregarded since they are inherently satisfied by the use of a single mirror for these measurements.

For a system having more than one measurement axis, choose a practical sequence in which to align the axes before beginning the interferometer alignment. Be aware that the laser head and certain beam-directing optics may be adjusted for the first axis but then will not be permitted to move while aligning subsequent axes. (In fact, the convenience of independent adjustments may suggest the use of additional beam-directing optics in certain cases.)

1 Begin by installing the laser head and the optics in their desired locations and roughly aligning the laser beam so it is centered on the input aperture of each interferometer. Do not install the receivers yet.

2 If the interferometers are mounted on adjustable mounts, instead of fixed platforms which predetermine their locations, position them to within the translational and rotational tolerances described in the previous “Mounting” section. This determines locations of the measurement points on the mirrors.

3 With the interferometers and mirrors properly positioned, finish the alignment by adjusting the input laser beam's angle and position for each interferometer individually:

a Adjust the angle of the input beam first, using the autoreflection technique.

1 Start by selecting the small aperture on the front turret of the laser head.

2 Insert the alignment aid (Agilent Part Number 10706-60202) into the measurement beam between the interferometer and the measurement mirror. (This may be held in position temporarily by affixing a piece of tape to its yellow label.) This will cause the beam reflecting off the mirror to reflect back out through the input aperture toward the laser head.

3 Angularly adjust the input beam using the beam directing optics or the laser head or both until the reflected beam re-enters the small aperture of the laser head.

NOTE Careful, accurate autoreflection at this step is essential to minimizing cosine errors, assuming the mirror is perpendicular to the linear axis of travel.

NOTE For higher accuracy alignment, see the "Autoreflection" information in Chapter 4, "System Installation and Alignment," in Volume I of this manual for additional methods to optimize the autoreflection alignment.

b Adjust the centering of the input beam on the input aperture, by visual alignment.

1 Start by switching back to the large aperture on the turret of the laser head (because the small aperture is only roughly aligned to the beam center).

2 Place a piece of translucent tape across the input aperture of the interferometer to make the input beam easily visible.

NOTE Be careful not to stick the tape to any glass surface.

3 Translate the beam directing optics or the laser head or both to center the input beam on the aperture. Do not disturb the angular alignments already made. With care, you can center the beam visually to within ±0.15 mm (±0.006 inch) of its ideal position.

c Go back to steps 3a and 3b and alternately recheck and readjust the input beam angle and centering until both are simultaneously optimized.

Then remove the tape from the input aperture and remove the alignment aid.

d As a further alignment check, place a piece of translucent tape across the output aperture(s) to make the output beam(s) easily visible. Each output beam should now be approximately centered in its aperture without clipping.

NOTE Any clipping observed here indicates a centering problem at the input aperture or an autoreflection problem.

e Clamp down the laser and the beam directing optics without altering their alignment.

4 At this point, the reference beam has also been automatically aligned, assuming the reference mirror is parallel to the measurement mirror. If any parallelism error exists, then the beam overlap in the output aperture(s) will be degraded, and this may be visible. Beam overlap can be checked qualitatively by alternately blocking the reference and measurement beams and observing their respective positions on the tape across the output aperture(s). Remove tape when done.

NOTE If a beam overlap problem exists, recheck the parallelism of the reference mirror, relative to the measurement mirror. Adjust as needed.

5 Attach the fiber-optic sensor head using a 4-40 screw. Avoid kinking or excessive bending of the fiber cables as explained in the “Receivers" on page 547.

6 Repeat the above steps for all other interferometers in the application, being careful to adjust only beam-directing optics which do not disturb the alignments already completed.

Operation

Reset considerations

If the reflectors you use with the interferometer are not at their zero-deadpath positions when you reset the system, you should enter a zero-deadpath compensation value, as described under “Air Deadpath compensation considerations,” below.

Air Deadpath compensation considerations

Proper use of deadpath compensation is essential to achieving maximum accuracy.

“Air deadpath” is defined as the difference in the air path length between the reference and measurement arms of the interferometer when the stage is at its “zero” or “home” position. If air deadpath exists and is not compensated, your “zero point” or home position will appear to move around as the air temperature, pressure, and humidity change.

“Zero-deadpath” is the condition in which the measurement beam path length and the reference beam path length are equal. For the Agilent 10721A interferometer, this does NOT occur when the measurement and reference mirrors are coplanar, as a cursory look might imply. Because the reference beam travels an additional 19.05 mm (0.750 inch) for the standard10721A or 30.6 mm (1.025 inches) for the 10721A-C01 through air inside the interferometer housing, the zero-deadpath condition occurs when the measurement mirror is 19.05 mm (30.6 mm for option C01) farther from the interferometer housing than the reference mirror.

Deadpath compensation for the Agilent 10721A interferometer can be performed in one of two ways:

- move the measurement mirror to the zero-air deadpath position before each system reset, or
- use a deadpath compensation number in software. If you use this method, be aware that the compensation number can be either positive or negative, depending on the relative position of the mirrors at reset. Be sure to use the correct sign for your application.

When the Agilent 10721A interferometer is used in its angle-measuring configuration, you must use the second (software) method, since the measurement and reference path lengths are inherently unequal by 19.05 mm (0.750 inch).

Agilent 10721A and 10721A-C01 Two-Axis Differential Interferometer Specifications

USE: Multiple-axis applications such as precise positioning of a multiaxis stage, where the stage must be linearly and angularly positioned with respect to an external object such as a column or inspection tool. The interferometer can be made vacuum compatible.

SPECIFICATIONS

Operating Temperature: 17 to 23°C

Weight: 300 grams (11 ounces)

Dimensions: see Figure 182 (10721A), Figure 183 (10721A-C01)

Materials Used:

Housing: Aluminum
Optics: Optical grade glass
Adhesives: Vaccum grade

Axis: Linear and yaw

Available Beam Size: 3 mm

Thermal Drift Coefficient (Average): 150 nm (5.9 µin.)/°C (for Option C01, 50 nm/°C (typical)

Resolution:[1]

Optical: λ /4

Linear: 5 nm (using 32 × resolution extension)
0.62 nm (using 256 × resolution extension)

Angular (pitch or roll)[2]: 0.39 µrad (0.08 arc-sec)-using X32 electronics
0.01 µrad (0.049 arc-sec)-using X256 electronics

Non-linearity Error: < ± 2.2 nm for each axis

Range:[2]

Linear: 10m (33 ft)
Angular (yaw):

at distance = 150 mm	at distance = 300 mm
± 0.88 mrad (± 3 arc-min)	± 0.44 mrad (± 1.5 arc-min)

[1]Linear and angular resolutions are dependent on the electronics used. Optical resolution is dependent only on the interferometer, and can be used to determine linear and angular resolutions when the electronic resolution extension is known. The linear and angular specifications in this section are for interferometer use with the X32 resolution extension electronics (10885A, 10895A) or X256 resolution extension electronics (10897C, 10898A).

[2] Pitch (or roll) measurements are done by having both meas and ref beams reflect off the same mirror, in which case only angular measurements are made, there are no linear displacement values available.

[3] Linear range here is the sum of the ranges for all axes. Angular range is the maximum measurement mirror angle due to all components (i.e. , yaw and pitch, or yaw and roll) between the measurement mirror and the interferometer for a 6-axis system. Range will be reduced when the reference mirror is misaligned.

Parallelism (Input to output beams): <0.1 mrad (20 arc-sec)

Optical Efficiency (output beam/input beam):

Average: 27%

Worst Case: 18%

INSTALLATION RECOMMENDATIONS

Installation and alignment: Kinematic installation requires a referenced surface.

Inter-axis Alignment: All internal optics are reference to mounting surface and have fixed alignment.

Receivers: Agilent 10780F fiber-optic remote receivers or Agilent 10780C receivers.

Receiver Alignment: Self-aligning when mounted to interferometer.

MEASUREMENT AND REFERENCE (PLANE) MIRROR RECOMMENDATIONS

Reflectance: 98% at 633 nm, normal incidence.

Flatness: Depending on accuracy requirements of the application, mirror flatness may range from λ /4 to λ /20 (0.16 to 0.03 µmeters, 6 to 1.2 µinches).

Optical Surface Quality: 60—40 per Mil-0-13830.

NOTE: Flatness deviations will appear as measurement errors when the mirror is translated across the beam. Mirror mount should be kinematic so as not to bend mirror. If accuracy requirements demand it, mirror flatness might be calibrated (scanned and stored in the system controller) to be used as a correction factor.

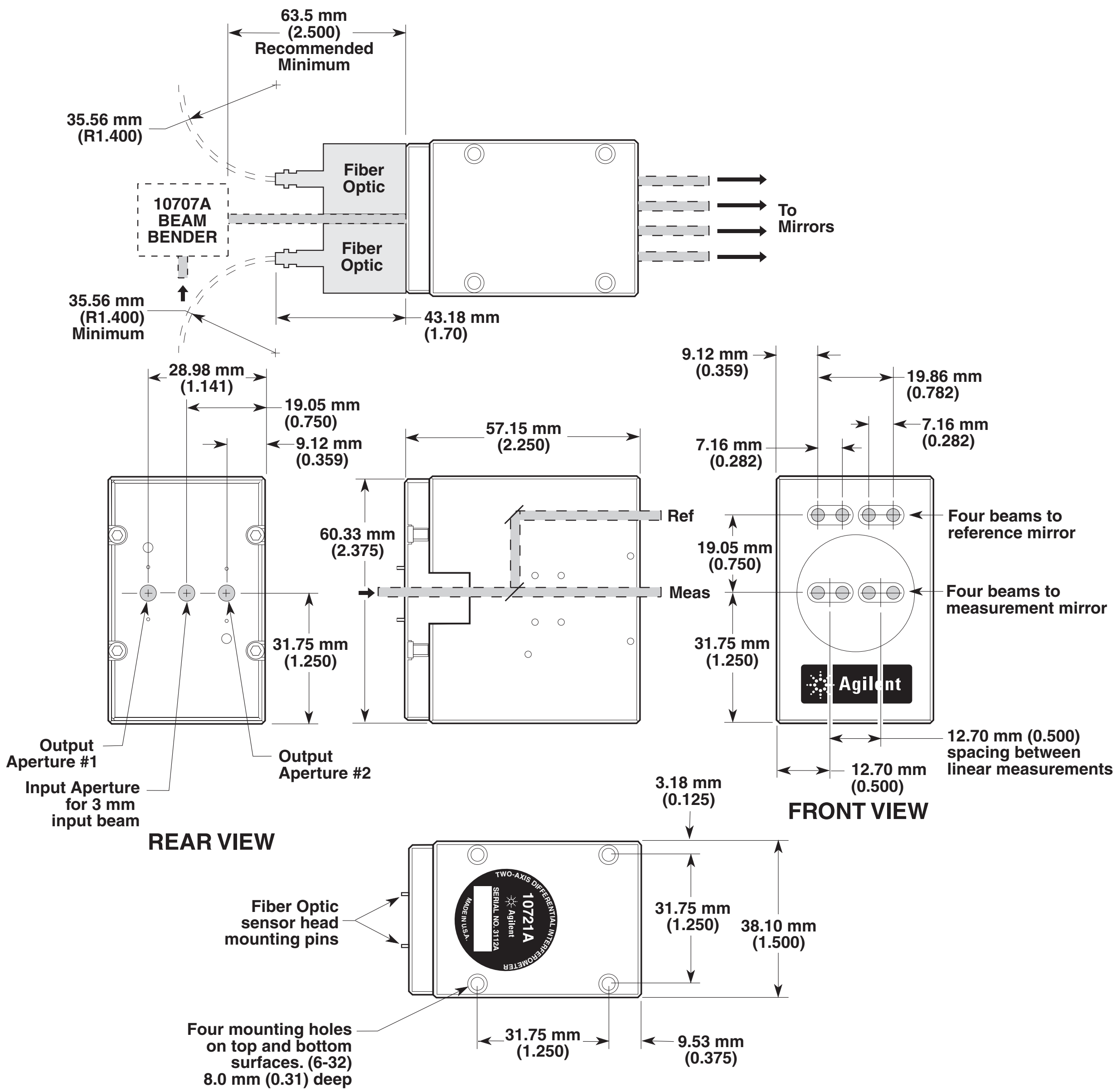


Figure 182 Agilent 10721A Two-Axis Differential Interferometer — dimensions

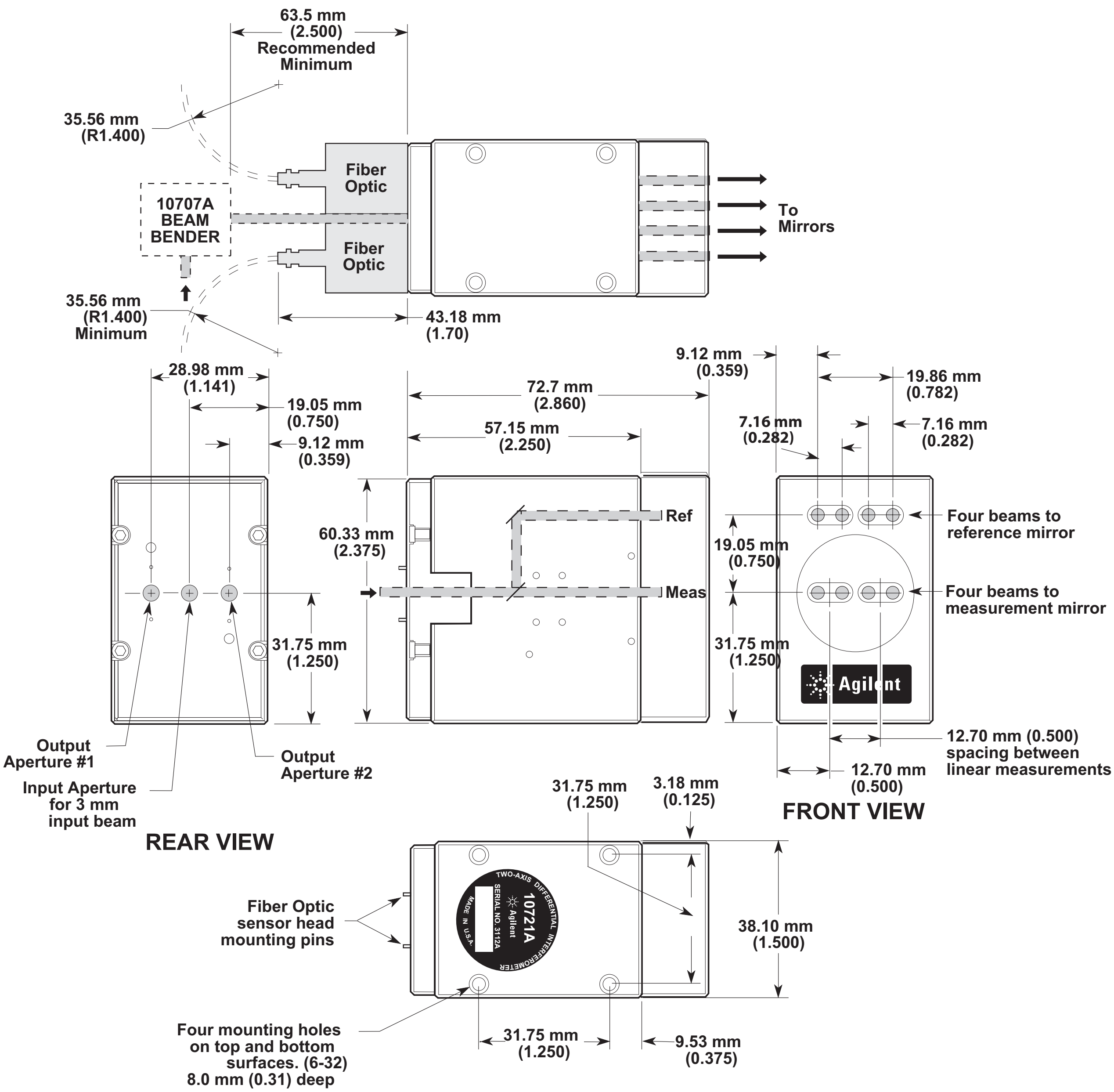


Figure 183 Agilent 10721A-C01 Two-Axis Differential Interferometer — dimensions

27
Agilent 10735A, 10736A, and 10736A-001 Three-Axis Interferometers

Description

The Agilent 10735A and Agilent 10736A Three-Axis interferometers (see figures 184 and 185, respectively) provide three parallel interferometers in a single housing. They allow up to three measurements (displacement, pitch, yaw) to be made on a single axis.

The Agilent 10735A and Agilent 10736A interferometers are identical except for their measurement beam patterns.

The Agilent 10736A-001 interferometer (see Figure 186) is identical to the Agilent 10736A interferometer, except that its Measurement Axis #2 beam paths are bent at right angles away from its other measurement axis paths.

These interferometers are designed to use a 9 mm diameter laser beam, available from an Agilent 5517C-009 Laser Head. Smaller-diameter laser beams can be used, but the usable angle range is reduced. Agilent 10725A 50% Beam Splitters and Agilent 10726A Beam Benders are available for use in delivering the beam from the laser head to the interferometer. Agilent 10780F, E1708A, or E1709A remote receivers are used at the Agilent 10735A's laser output apertures.

The measurement beam parallelism inherent in the design of the Agilent 10735A and Agilent 10736A interferometers ensures that there is essentially no cosine error between their three measurements and also ensures angle accuracy for pitch and yaw measurements. The Agilent 10736A-001 interferometer has the same parallelism characteristic for its two parallel measurement axes.

These interferometers are designed for direct attachment of Agilent 10780F, E1708A, or E1709A remote receiver fiber-optic sensor heads (one per axis). This simplifies user assembly, since no optical alignment of the receiver is required. The three fiber-optic receiver sensor heads are attached directly to apertures on the same face of the interferometer as the input aperture.

The optics of each of these interferometers are factory-aligned to predetermined mounting surfaces on the interferometer's housing. This simplifies user installation and alignment of the interferometer in the measurement system.

These interferometers are of the same type of high-stability plane mirror interferometer design as the Agilent 10706B interferometer.

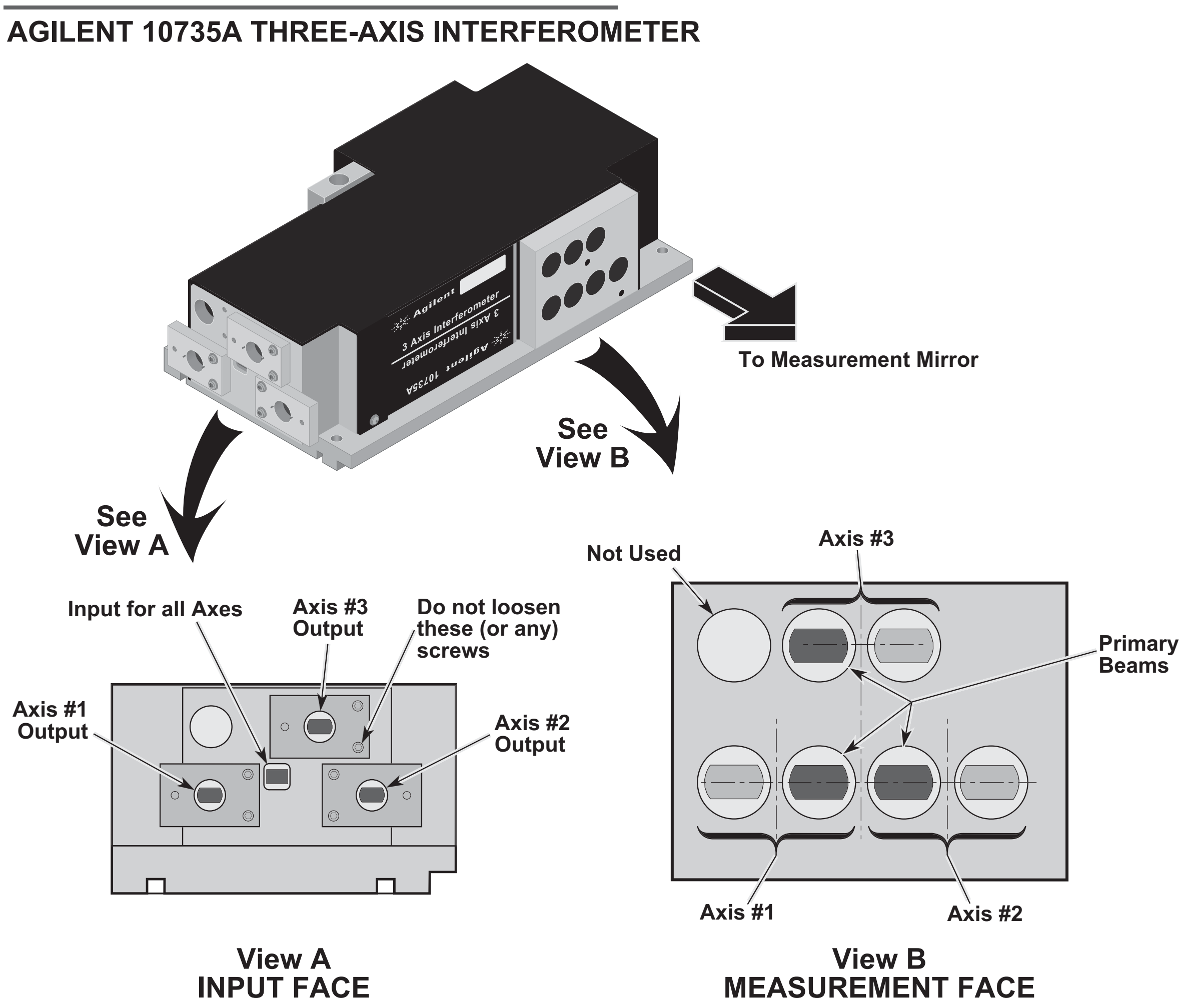


Figure 184 Agilent 10735A Three-Axis Interferometer

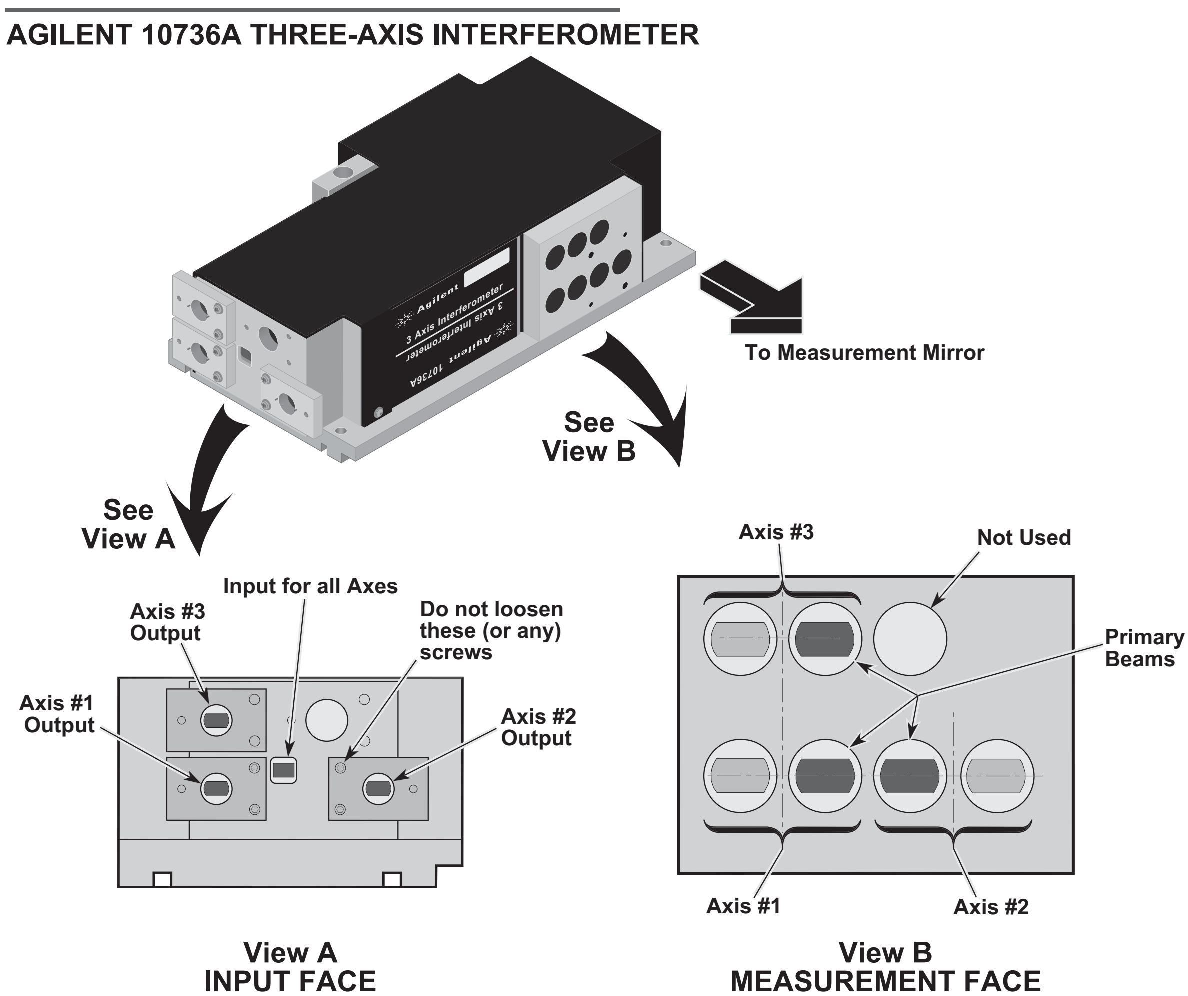


Figure 185 Agilent 10736A Three-Axis Interferometer

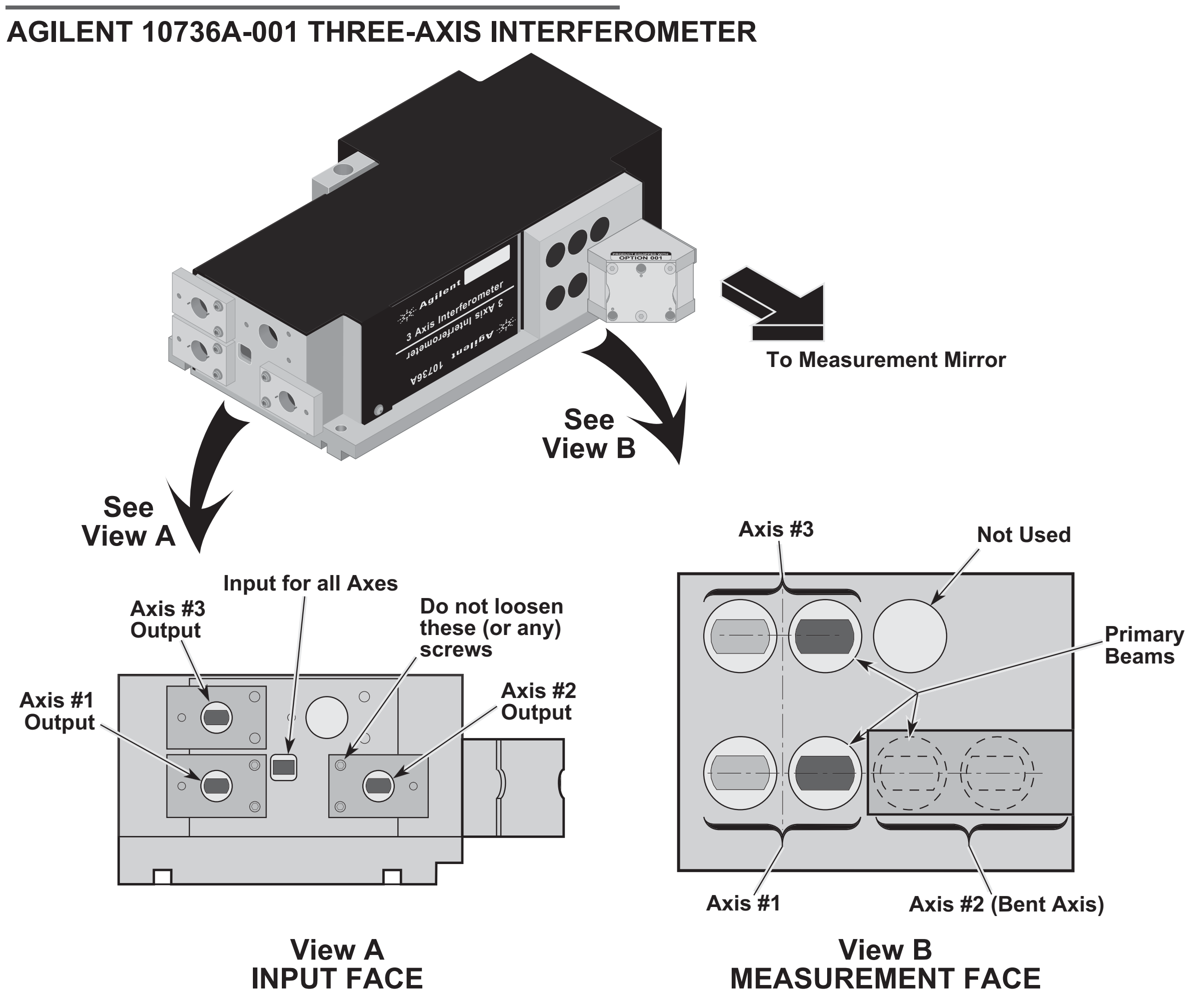


Figure 186 Agilent 10736A-001 Three-Axis Interferometer

Applications

General

The Agilent 10735A or Agilent 10736A interferometer, by making three simultaneous distance measurements along or parallel to the X-axis, can make these measurements:

- displacement along the X-axis
- rotation (pitch) about the Y-axis
- rotation (yaw) about the Z-axis

Because it has only two parallel measurement axes, the Agilent 10736A-001 can make the displacement measurement and one angular measurement.

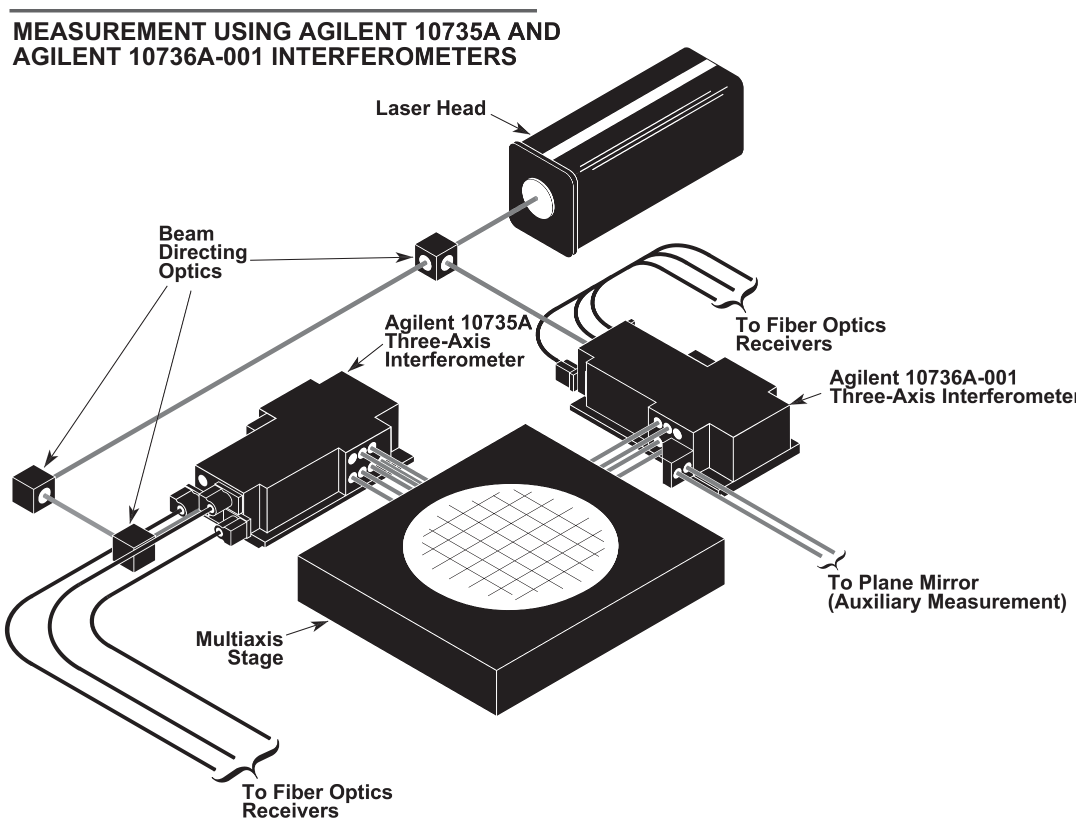


Figure 187 Measuring Using Agilent 10735A and Agilent 10736A-001 Interferometers

The angular measurements made by any of these interferometers can be calculated by taking the arctangent of the differences between two linear measurements involved, divided by their separation:

$$THETA = arc\tan\frac{(Y - Y')}{D}$$

This method for determining angle is described in more detail under the “Electronic yaw calculation method” and “Optical yaw calculation method” subsections under the “Three-axis measurement system using discrete plane mirror interferometers (X, Y, YAW)” section in Chapter 3, “System Design Considerations,” in Volume I of this manual.

X-Y stage

These interferometers are well suited for X-Y stage or multiaxis applications, such as lithography equipment. One Agilent 10735A or Agilent 10736A interferometer, used with any other one of these three-axis interferometers, can measure all X, Y, pitch, roll, and yaw motions of a stage. In these applications, the measurement mirrors are attached to the X-Y stage.

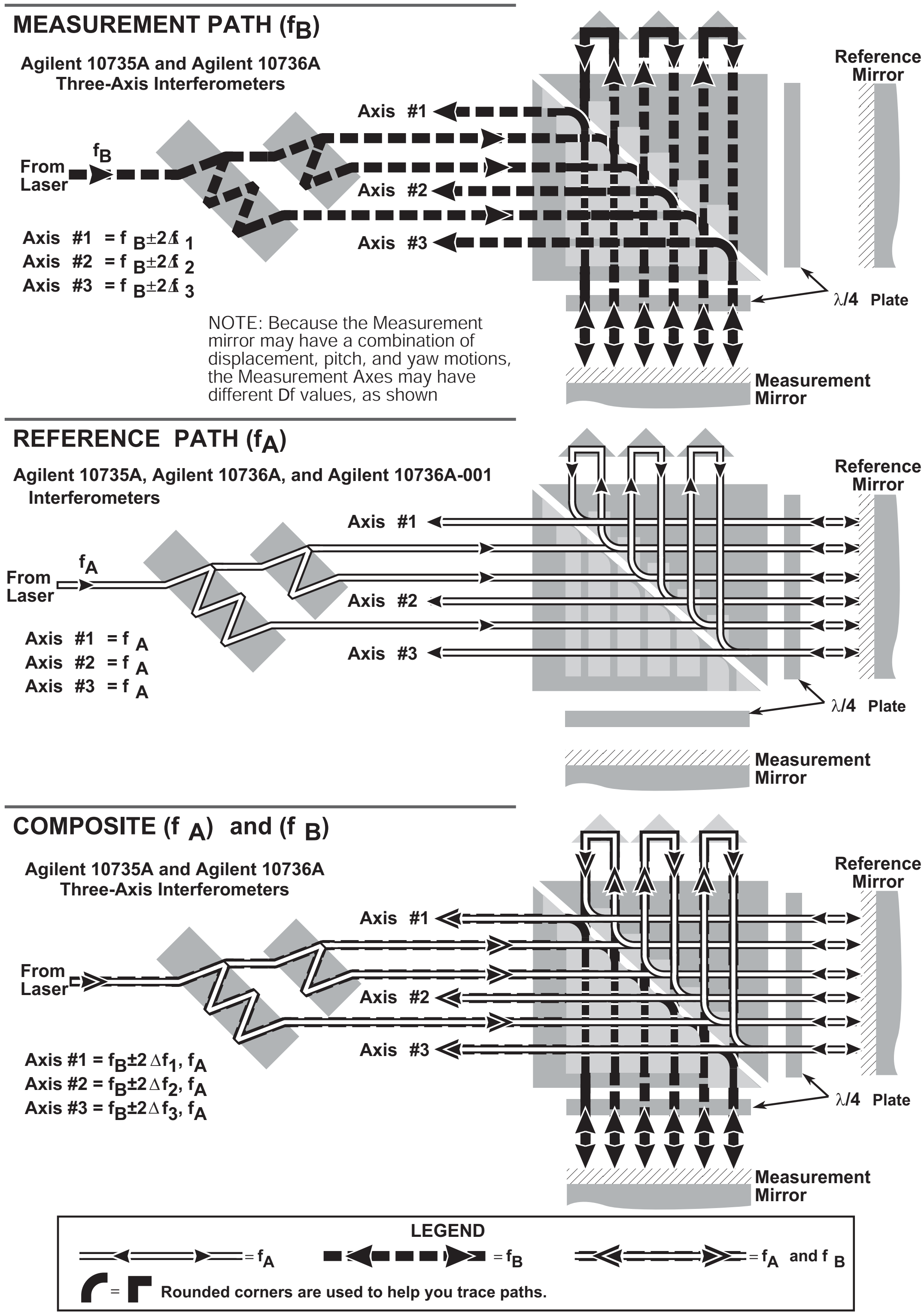


Figure 188A Agilent Three-Axis interferometers — beam paths

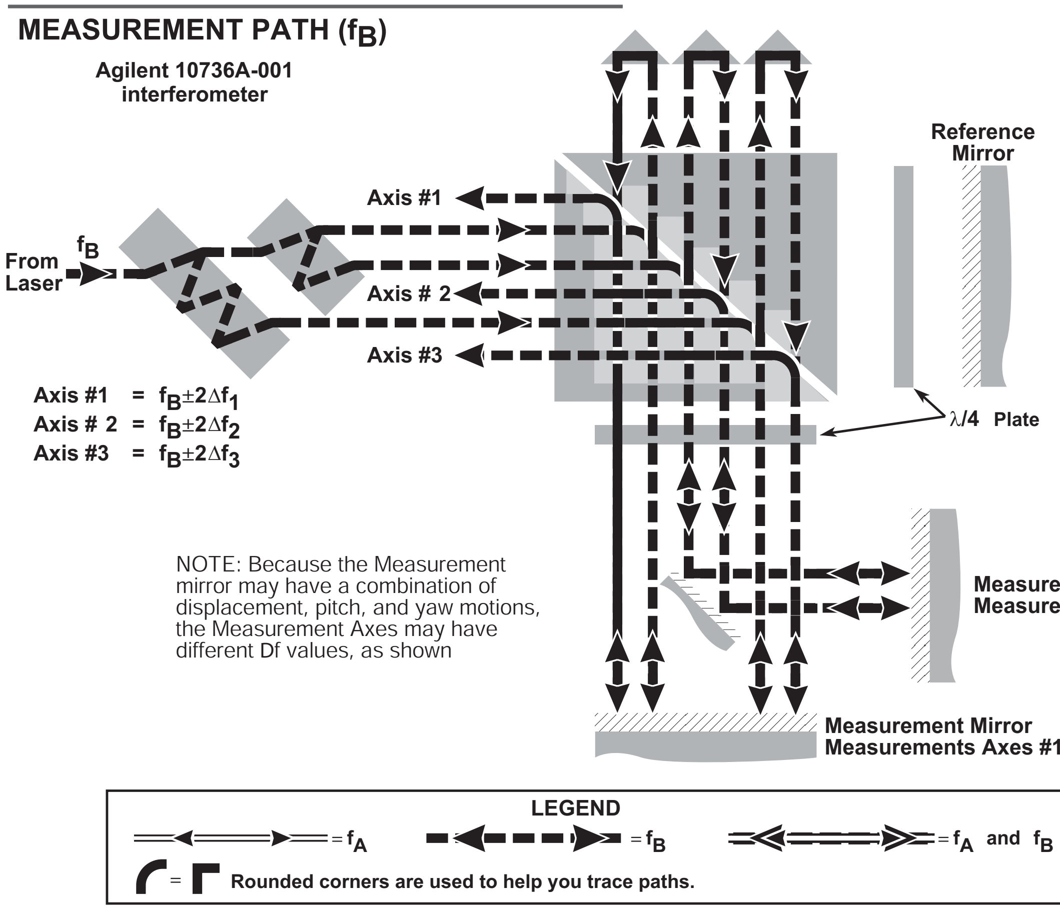


Figure 188B Agilent Three-Axis Interferometers — beam paths (continued)

Optical Schematics

Optical schematics for these interferometers are given in figures 188A and 188B. Each interferometer functions similarly to three parallel Agilent 10706B High Stability Plane Mirror Interferometers with a three-way beam splitter in front of them.

To reduce thermal drift errors, the measurement and reference beam paths have the same optical path length in glass. This minimizes measurement errors due to temperature changes in the interferometer.

Special Considerations

Laser beam power consideration

When working with an application that requires use of a separate beam splitter, make sure that you provide enough laser beam power to any multiaxis interferometer so all receivers connected to it receive adequate light power. This will help ensure that each measurement receiver in the system receives the optimum signal strength in the intended application.

9-mm laser beam considerations

These interferometers are designed to use a 9-mm laser beam.

The 9-mm beam is available from an Agilent 5517C-009 Laser Head.

For more information about this laser head, see Chapter 16, “Laser Heads,” in this manual.

Most Agilent beam-directing optics are designed for use with a 6-mm laser beam. For use in 9-mm installations, Agilent offers the Agilent 10725A Laser Beam Splitter and the Agilent 10726A Laser Beam Bender. These two optical devices do not include a housing or mounting hardware. For these optics, the user must devise mounts that will hold the required optics in position without causing stress that may distort the optic.

The recommended receiver for the 9-mm beam is an Agilent 10780F Remote Receiver.

The standard Agilent 10780C Receiver input aperture is designed for use with a 6-mm laser beam, so this receiver is not recommended for use in a 9-mm laser system.

Using a 6-mm laser source allows use of standard Agilent 10700A, Agilent 10701A, and Agilent 10707A beam-directing optics, and use of Agilent 10710B Adjustable Mounts; however, this also reduces the usable angle range.

Orientation

Note that although illustrations may show the interferometer in one orientation, you may orient the unit as required by your measurement application — vertically, horizontally, or upside-down.

Mounting

General

Before any of these interferometers are installed, a suitable mounting location must be prepared for it.

These are “referenced” interferometers; this means that the relationships of their internal optical components and laser beam paths to reference locations on their bases are specified. These dimensions are presented in the “Specifications and Characteristics” section at the end of this chapter and in Figure 189. The specifications, plus the information in this subsection, are intended to allow you to select, design, and build a mounting location for a three-axis interferometer. The interferometer’s mounting location defines the relationship of its measurement beams to the stage whose motion is to be measured. Figure 190 shows a recommended design for the interferometer’s mounting location.

Kinematic mounting should be used. This means that the interferometer’s mounting location is completely defined by a plane, a line, and a point.

The mounting plane is identified as datum A. It should be parallel to the plane of the X and Y axes of the stage being measured.

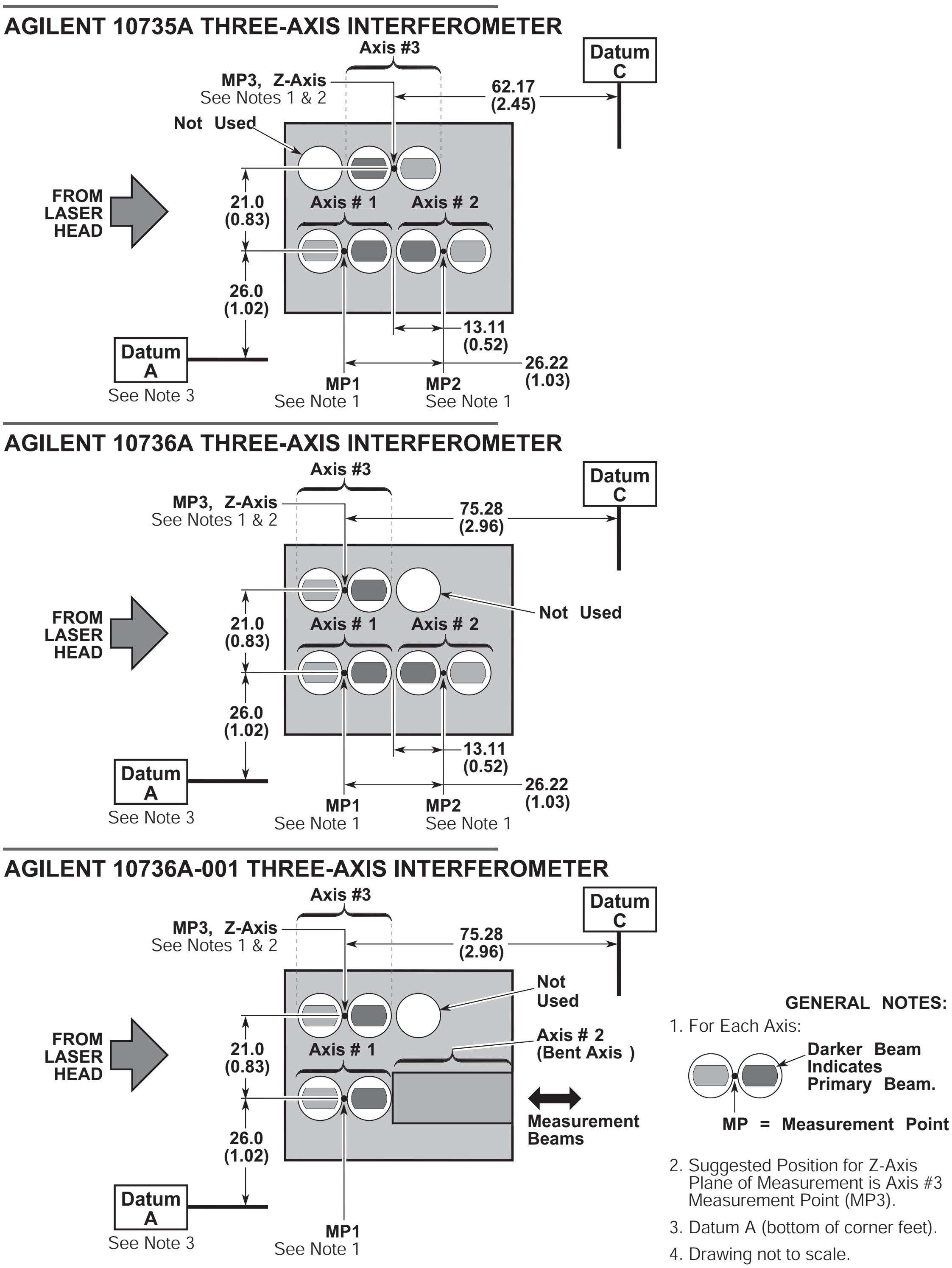


Figure 189 Three-Axis interferometers — beam patterns

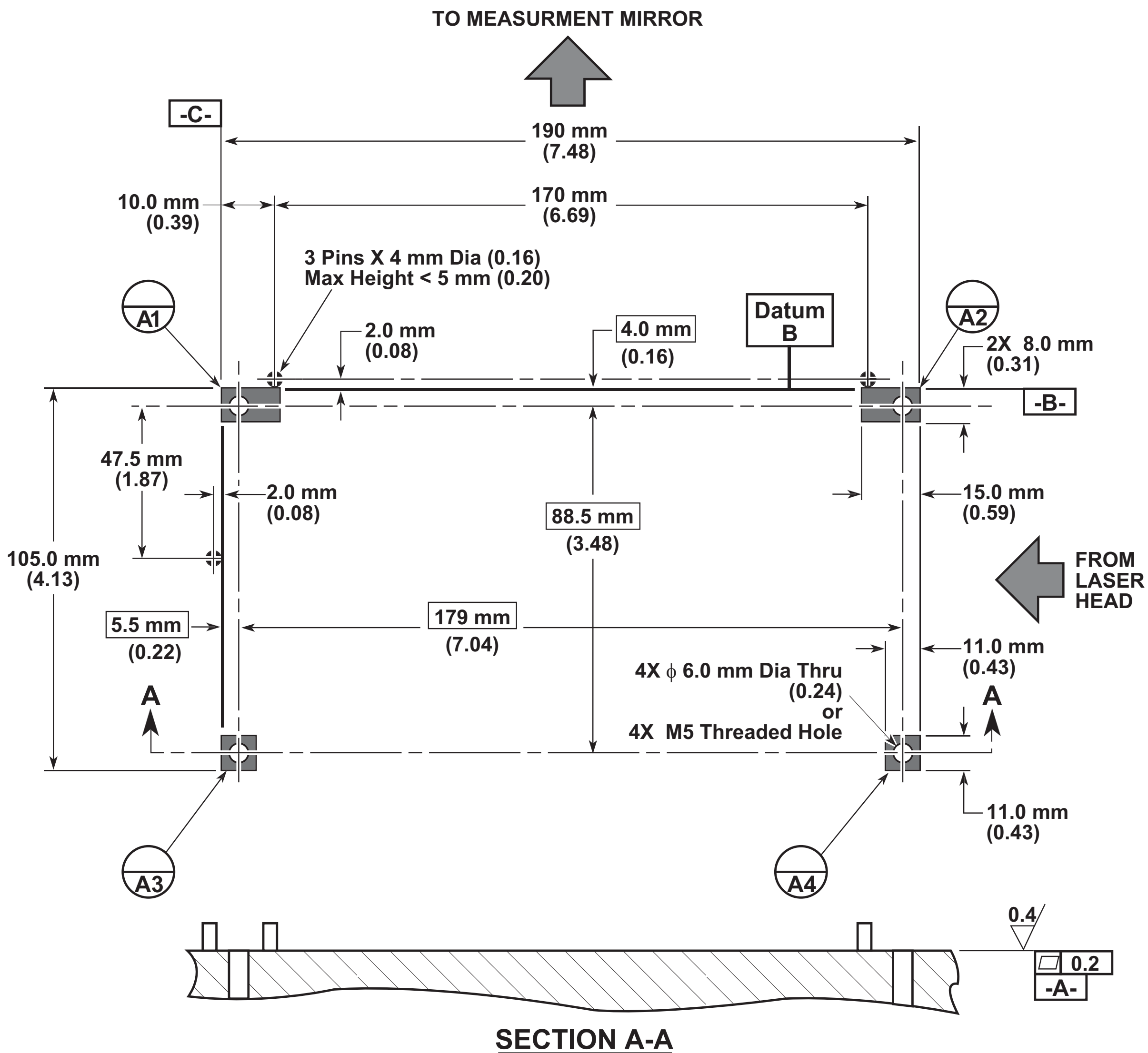


Figure 190 Three-Axis interferometer — mounting

The line of the interferometer’s mounting location is identified as datum B. It lies in datum A, and should be parallel to the surface of the stage mirror being measured. Physically, the datum B line is created by placing two dowel pins in the surface that forms the datum A plane.

The point of the interferometer’s mounting location is identified as datum C. It establishes a specific installation location for the interferometer along the line of datum B. Physically, the datum C point is created by placing a single dowel pin in the surface that forms the plane of datum A.

NOTE Although the general mounting arrangements for Agilent 10735A, Agilent 10736A, and Agilent 10736-001 interferometers are similar, they are not the same. The relation of their measurement beam patterns to the alignment point datum C are slightly different. An Agilent 10736A or Agilent 10736-001 interferometer installed in a mounting location designed for an Agilent 10735A interferometer (or vice-versa) may not give exactly the same results.

One important consideration in determining interferometer placement is the relationship of the interferometer's beam pattern to the coordinate origin of the system you want to measure. See Figure 189. Looking at the interferometer’s measurement aperture face, the coordinate origin should be aligned with the (imaginary) vertical centerline of measurement axis #3. For an Agilent 10735A interferometer, this will also be the mid-point of a line joining measurement axis #1 and measurement axis #2. For an Agilent 10736A interferometer, this line will also be the vertical centerline of measurement axis #1.

NOTE Datum C is at the end of the interferometer away from the interferometer’s input face. In the discussion below, your viewpoint of the interferometer is looking into its measurement face, with the interferometer’s mounting plate as the bottom surface. This is the view presented in the specifications dimension drawing at the end of this chapter.

For an Agilent 10735A interferometer, datum C should be 62.17 mm (2.448 inches) to the right of the origin, when looking into the interferometer’s measurement face. For an Agilent 10736A interferometer, datum C should be 75.28 mm (2.964 inches) to the right of the Z-axis, when looking into the interferometer’s measurement face.

The (vertical) distance between datum A (the interferometer mounting plane) and the common centerline of measurement axes #1 and #2 is 26 mm (1.024 inches).

With the interferometer installed in its predefined location, it is necessary to align the laser beam input to the interferometer. The input beam angle tolerance zone is defined as follows: When the interferometer’s measurement axis #1 primary beam is perpendicular to the measurement mirror and when the measurement mirror is perpendicular to datum A (the plane) and parallel to datum B (the line) of the mounting location (and, therefore, of the interferometer), the angular tolerance zone for the interferometer input beam is ±1 milliradian (mrad).

This input beam tolerance zone, plus the tolerance to which the stage measurement mirror is perpendicular to datum A (the plane) and parallel to datum B (the line) determines the range of angular adjustment required of the beam benders directing the laser beam to the interferometer's input aperture.

Installation

Installation and alignment procedures for these interferometers do not involve adjusting or aligning the interferometer itself. Instead, the procedures adjust the beam coming into the interferometer.

Pre-installation checklist

In addition to reading chapters 2 through 4, and Chapter 12, “Accuracy and Repeatability,” complete the following items before installing a laser positioning system into any application.

- ☐ Complete Beam Path Loss Calculation (see Calculation of signal loss” in Chapter 3, “System Design Considerations,” in Volume I of this manual).
- ☐ Supply plane mirror reflectors. See Chapter 12, “Accuracy and Repeatability,” or “Specifications and Characteristics” section at the end of this chapter for mirror specifications.
- ☐ Determine the direction sense for each axis, based on the orientation of the laser head, beam-directing optic, and interferometer. Enter the direction sense for each axis into the measurement system electronics. (See Chapter 16, “Laser Heads, Chapter 11, “Principles of Operation,” and Chapter 12, “Accuracy and Repeatability,” in this manual.)
- ☐ Supply suitable mounting means for all components of the laser measurement system, based on the recommendations given earlier in this chapter and elsewhere in this manual.
- ☐ Provide for aligning the optics, laser head, and receiver(s) on the machine. (Ideally, you want to be able to translate beam in two directions and rotate beam in two directions for each interferometer input. This typically takes two adjustment optics with proper orientations.)
- ☐ Be sure to allow for transmitted beam offset of beam splitters (Agilent 10700A and Agilent 10701A) in your design. (See the offset specifications under the “Specifications and Characteristics” section at the end of this chapter.)
- ☐ Allow for transmitted beam offset of beam splitters in your design.

Procedure

The positions of the interferometer's measurement beams (its outputs to and inputs from the stage mirror) are referenced to datums A, B, and C, as shown in Figure 190. Once the appropriately referenced mounting location is provided:

1 place the interferometer against the mounting plane (datum A), then

2 push the interferometer against the pins that physically define datums B and C, and

3 fasten the interferometer in position with four M5 mounting screws. Torque the mounting screws to 5 NM or 44 in-lbs while holding the interferometer firmly against the alignment pins, to keep it from moving.

After the interferometer has been installed and secured into position, install the receiver(s) that will be used with it. Recommended receivers for use with these interferometers are Agilent 10780F Remote Receivers. Interferometer output apertures have alignment pins to ease the work of attaching the receiver sensor heads.

Alignment

The installation and alignment procedures do not involve adjusting or aligning the interferometer itself. Instead, the procedures adjust the beam coming into the interferometer.

An Agilent 10735A, Agilent 10736A, or Agilent 10736A-001 interferometer has no user adjustments. Its optics are calibrated at the factory. You can treat it as a rigid pre-aligned optical bench. It is fastened in place against a referenced flat surface and against three reference pins to be supplied by the user in the measurement system. Adjustments required to align the system include positioning (translation, rotation, or both) of the laser head and of the beam-directing optics which deliver the laser beam to the interferometer input aperture.

Laser beam alignment

Objective

The objective of the laser beam alignment procedure is to have the interferometer's axis #1 measurement output beam perpendicular to the stage mirror when the mirror is in its zero-angle position (that is, perpendicular to the direction of stage travel). You can do this using autoreflection with the help of alignment aid (Agilent Part Number 10706-60001). The input beam should also be centered on the interferometer's input aperture.

Note that if the stage mirror is not perpendicular to the direction of stage travel, cosine errors can result.

When interferometer axis #1 is correctly aligned, the other measurement axes will automatically be aligned because of the parallelism designed into the interferometer.

Since the physical relationship of the interferometer and the stage (and its mirror) is fixed by the alignment pins at the interferometer's mounting location, the only way to change the angle of the interferometer measurement output beams is to change the angle of the laser beam at its input aperture.

The alignment procedure does not make any adjustment to or within the interferometer.

Procedure

The interferometer should not be moved during this procedure or afterward. Moving the interferometer will require that it be realigned.

Movement of the laser head is allowed, assuming an adjustable mounting for the laser head is provided.

Most of the alignment is performed by translating or rotating the optical devices that establish the laser path from the laser head to the interferometer. The goal of the alignment is to provide the four necessary degrees of adjustment of the input of each interferometer:

- vertical and horizontal translation to center the input beam on the interferometer input aperture, and
- pitch and yaw of the input beam to make the measurement beams perpendicular to the stage mirror.

You should have handy:

- a gage block or similar device you can use to autoreflect the beam back along its original path.
- a piece of white paper or card stock you can use to check for the presence of the laser beam by making it visible to you.

Initial angular alignment To achieve initial angular alignment of the input beam:

1 Adjust the laser head turret to select the small beam output.
2 Place a gage block over the interferometer's input aperture. Hold the gage block in place by hand or with a rubber band.
3 Adjust the angle of the input beam until the small beam from the laser head is autoreflected.
4 Adjust the laser head turret to select the large beam output.

5 Center the beam from the laser head on the interferometer's input aperture by translating the input beam.

6 Change back to the small beam aperture at the laser head.

7 Place a magnetic alignment aid (Agilent Part Number 10706-60001) over the interferometer's measurement axis #1 primary output aperture. (See Figure 189, earlier in this chapter.)

8 Adjust the input beam angle such that the measurement axis #1 primary beam is autoreflected by the stage mirror.

   You may have to reduce ambient lighting in order to be able to see the laser beam autoreflection back at the laser head. You can do this by providing a temporary hood over the laser head output.

9 Once the autoreflection described above has been achieved, change to the large aperture on the laser head and check to see that the input beam is centered on the interferometer's input aperture.

10 Lock down all beam benders, beam splitters, and the laser head.

11 If finer alignment is required, continue the alignment procedure as described below. Otherwise, the procedure ends here and you can remove the alignment target.

Finer alignment Perform the "Initial angular alignment" procedure above before you begin this procedure.

1 Connect an Agilent 10780F Remote Receiver to the interferometer's measurement axis #1 output aperture.

2 Connect a fast-responding voltmeter (preferably an analog type) to the receiver's test point. If necessary, adjust the interferometer's input beam angle (via beam-bender or beam-splitter manipulation) until the voltmeter jumps to a value greater than 0.25 volt. This indicates that a signal has been detected.

3 Continue adjusting the interferometer's input beam to obtain a maximum voltage indication on the voltmeter. (The voltmeter reading may fluctuate.)

4 Carefully adjust the interferometer's input beam until the voltmeter indication suddenly drops back to about 0.3 volt.

NOTE

The alignment should be adjusted such that the voltage reading from the receiver test point occurs just below the sudden jump up in voltage. If the alignment is fixed to sustain this peaked voltage, system operation will be degraded.

5 Remove the alignment aid from the interferometer.

This completes the interferometer (input beam) alignment procedure.

Operation

Measurements

For an interferometer setup to measure distances along the X-axis, measurements of displacement, pitch, and yaw are derived as described below. These computations are done via software on the system controller or computer.

Displacement

For the Agilent 10735A interferometer, displacement along the X-axis can be measured as the average of the data returned from measurement axis #1 and measurement axis #2:

$$\text{Displacement} = \frac{\text{measurement axis \#1} + \text{measurement axis \#2}}{2}$$

For the Agilent 10736A or Agilent 10736A-001 interferometer, displacement along the X-axis is simply the measurement axis #1 distance.

Pitch

For the Agilent 10735A interferometer, pitch (rotation about the Y axis) can be measured using data returned from all three measurement axes, and the vertical offset between the common centerline of measurement axes #1 and #2 and the centerline of measurement axis #3 (21.00 mm, or 0.827 inch):

$$\text{Pitch} = \frac{\text{Displacement} - \text{measurement axis \#3}}{\text{21.00 mm or 0.827 inch}}\ \text{radian}$$

For the Agilent 10736A or Agilent 10736A-001 interferometer, pitch (rotation about the Y axis) can be measured using data returned from measurement axis #1 and measurement axis #3, and the vertical offset between the centerline of measurement axis #1 and the centerline of measurement axis #3 (21.00 mm, or 0.827 inch):

$$\text{Pitch} = \frac{\text{Displacement} - \text{measurement axis \#3}}{\text{21.00 mm or 0.827 inch}}\ \text{radian}$$

Yaw

For the Agilent 10735A or Agilent 10736A interferometer, yaw (rotation about the Z-axis) can be measured as the difference between the data returned from measurement axis #1 and measurement axis #2, divided by the distance between them (26.22 mm, or 1.032 inches):

$$\text{Yaw} = \frac{\text{measurement axis \#1} - \text{measurement axis \#2}}{\text{26.22 mm or 1.032 inch}} \ \text{radian}$$

Because its measurement axis #2 is bent away from the path of its measurement axis #l and measurement axis #3, the Agilent 10736A-001 interferometer cannot make a yaw measurement.

Error

General

A true “zero-deadpath” condition cannot be achieved with these interferometers, because of the interferometer’s design. For all measurement paths except the bent path of the Agilent 10736A-001 interferometer, zero-deadpath requires that the measurement reflector would have to be inside the interferometer, 6.59 mm (0.259 inch) behind the interferometer’s measurement face.

To determine the true deadpath distance:

1 Move the measurement optics to their measurement “zero” position.

2 Measure the distance between interferometer’s measurement face and measurement mirror.

3 Add 6.59 mm (0.259 inch) to the distance you measured in step 2. Use this distance for determining deadpath compensation.

Agilent 10736A-001 Interferometer — Bent Axis

For the Agilent 10736A-001 bent measurement axis (measurement axis #2), zero-deadpath would require that the measurement reflector be inside the interferometer, 34.42 mm (1.355 inches) behind the interferometer’s beam bender measurement face.

To determine the true deadpath distance for this axis, use steps 1 and 2 the general procedure above, and then add 34.42 mm (1.355 inches) to the distance measured in step 2.

Specifications and Characteristics

Agilent 10735A Three-Axis Interferometer Specifications

USE: Multiaxis applications such as precise positioning of multiaxis stages, where linear and angular control of the stage is required. The Agilent 10735A provides three linear measurements. Two angular measurements can be calculated from this data. When the interferometer is placed along the X-axis, yaw (theta Z), and pitch (theta Y) can be derived in addition to linear (X) displacement. When it is placed on the Y-axis, yaw (theta Z), and roll (theta X) can be derived in addition to linear (Y) displacement. Redundant yaw is useful when mapping measurement mirrors, which provides improved accuracy. The interferometer can be made vacuum compatible.

SPECIFICATIONS:

Operating Temperature: 17 to 23°C

Weight: 5.5 kg (12 lbs)

Dimensions: see Figure 191 on the next page

Materials Used:

Housing: Invar and aluminum

Optics: Optical grade glass

Adhesives: Vacuum grade

Axis: 3 Linear axes which provide linear (X), pitch, and yaw; or linear (Y), roll or yaw.

Available Beam Size: 3, 6, or 9 mm

Thermal Drift Coefficient (Average):

Axes 1 & 2: ± 40 nm (1.6 µin.)/°C

Axis 3: ± 50 nm (2.0 µin.)/°C

Non-linearity Error: ± 1 nm for each axis

Resolution:*

Optical: λ /4

Linear: 5 nm (using 32 × resolution extension)
0.62 nm (using 256 × resolution extension)

Angular (pitch or roll): 0.24 µrad (0.049 arc-sec)-using X32 electronics
0.029 µrad (0.0061 arc-sec)-using X256 electronics

Yaw: 0.19 µrad (0.039 arc-sec, X32); 0.024 µrad (0.0049 arc-sec, X256)

Angular Range:**

	at distance = 150 mm	at distance = 300 mm
Pitch or roll	± 2 mrad (±6.8 arc-min)	±1 mrad (±3.4 arc-min)
Yaw (for 6 mm beam)	± 2 mrad (±6.8 arc-min)	±1 mrad (±3.4 arc-min)
Yaw (for 9 mm beam)	± 3 mrad (±10.2 arc-min)	±1.5 mrad (±5.1 arc-min)

Parallelism (Measurement beams):

Axes 1 & 2: <40 µrad (8 arc-sec)

Axes 1 & 3: <50 µrad (11 arc-sec).

Optical Efficiency (output beam/total input beam):

Average: 18%

Worst Case: 10%

INSTALLATION RECOMMENDATIONS

Installation and alignment: Kinematic installation procedure requires three referenced pins mounted onto a referenced surface.

Inter-axis Alignment: All internal optics are referenced to the mounting surface and have fixed alignment.

Receivers: Agilent 10780F fiber-optic remote receivers.

Receiver Alignment: Self-aligning when mounted to interferometer.

MEASUREMENT AND REFERENCE (PLANE) MIRROR RECOMMENDATIONS

Reflectance: 98% at 633 nm, normal incidence.

Flatness: Depending on accuracy requirements of the application, mirror flatness may range from λ /4 to λ /20 (0.16 to 0.03 µmeters, 6 to 1.2 µinches).

Optical Surface Quality: 60—40 per Mil-0-13830

NOTE: Flatness deviations will appear as measurement errors when the mirror is translated across the beam. Mount should be kinematic so as not to bend mirror. If accuracy requirements demand it, mirror flatness might be calibrated (scanned and stored in the system controller) to be used as a correction factor.

*Linear and angular resolutions are dependent on the electronics used. Optical resolution is dependent only on the interferometer, and can be used to determine linear and angular resolutions when the electronic resolution extension is known. The linear and angular specifications in this section are for interferometer use with the X32 resolution extension electronics (10885A, 10895A) or X256 resolution extension electronics (10897C, 10898A).

**Angular range for this specification is the maximum angle between the measurement mirror and the interferometer for a 6-axis system. Both angles (either pitch and yaw, or roll and yaw) can be at the angular limit concurrently.

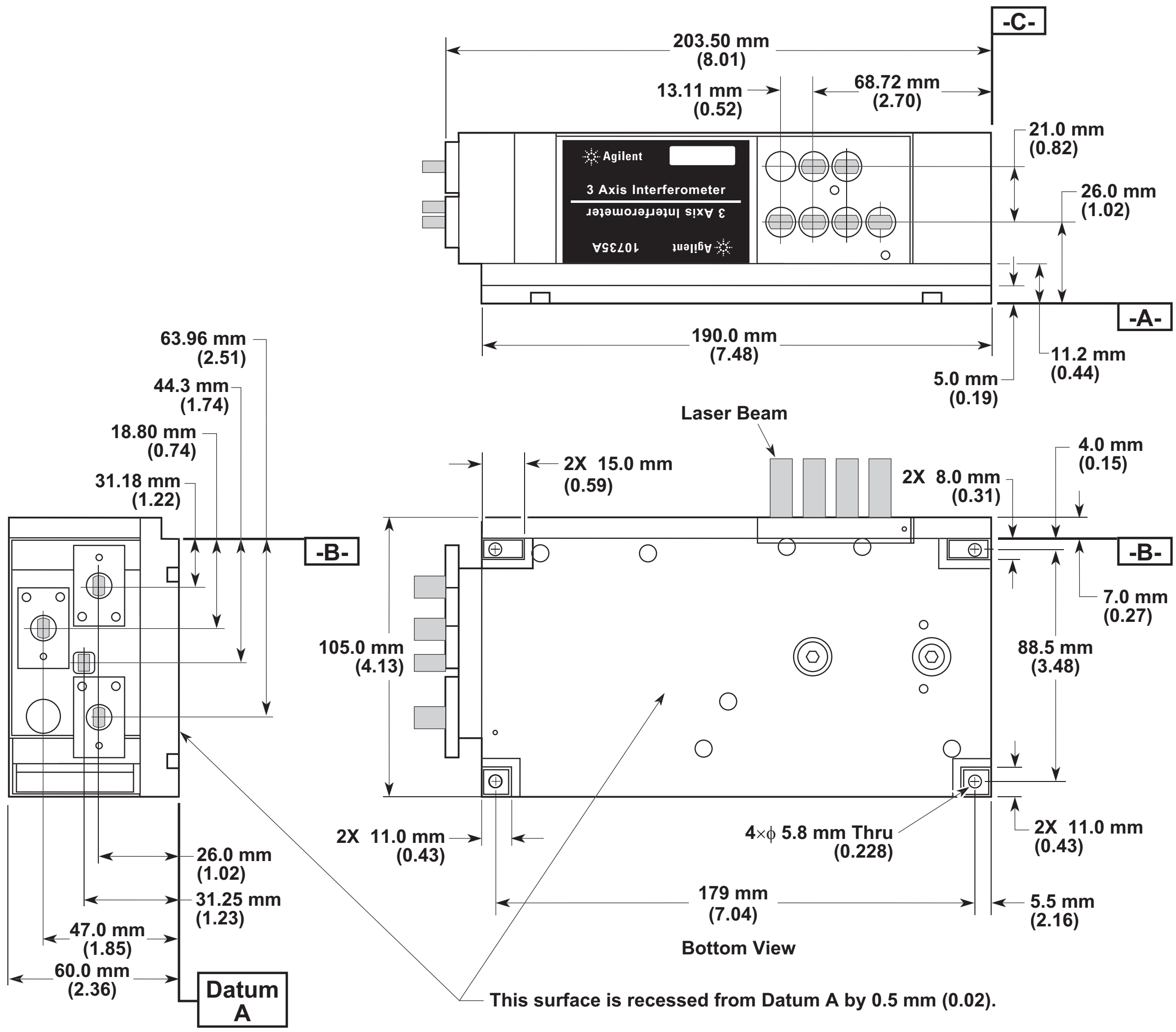


Figure 191 Agilent 10735A Three-Axis Interferometer — dimensions

Agilent 10736A Three-Axis Interferometer and Agilent 10736A-001 Three-Axis Interferometer with Beam Bender Specifications

USE: Multiaxis applications such as precise positioning of multiaxis stages, where linear and angular control of the stage is required. The Agilent 10736A provides three linear measurements. Two angular measurements can be calculated from this data. When the interferometer is placed along the X-axis, yaw (theta Z), and pitch (theta Y) can be derived in addition to linear (X) displacement. When it is placed on the Y-axis, yaw (theta Z), and roll (theta X) can be derived in addition to linear (Y) displacement. Redundant yaw is useful when mapping measurement mirrors, which provides improved accuracy. The Agilent 10736A-001 provides a beam bender for one measurement path. When 10736A-001 is installed, yaw is not measured. The interferometer and beam bender can be made vacuum compatible.

SPECIFICATIONS:

Operating Temperature: 17 to 23°C

Weight: 5.5 kg (12 lbs)

Dimensions: see figures 191 and 192 on following pages

Materials Used:

Housing: Invar and aluminum

Optics: Optical grade glass

Adhesives: Vacuum grade

Axis: 3 Linear axes which provide linear (X), pitch, and yaw; or linear (Y), roll or yaw.

Available Beam Size: 3, 6, or 9 mm

Thermal Drift Coefficient (Average):

Axes 1 & 2: ± 40 nm (1.6 µin.)/°C

Axis 3: ± 50 nm (2.0 µin.)/°C

Non-linearity Error: ± 1 nm for each axis

Resolution:*

Optical: λ /4

Linear: 5 nm (using 32 × resolution extension)
0.62 nm (using 256 × resolution extension)

Angular (pitch or roll): 0.24 µrad (0.049 arc-sec)-using X32 electronics
0.029 µrad (0.0061 arc-sec)-using X256 electronics

Yaw: 0.19 µrad (0.039 arc-sec, X32); 0.024 µrad (0.0049 arc-sec, X256)

Angular Range:**

	at distance = 150 mm	**at distance = 300 mm**
Pitch or roll	± 2 mrad (±6.8 arc-min)	±1 mrad (±3.4 arc-min)
Yaw (for 6 mm beam)	± 2 mrad (±6.8 arc-min)	±1 mrad (±3.4 arc-min)
Yaw (for 9 mm beam)	± 3 mrad (±10.2 arc-min)	±1.5 mrad (±5.1 arc-min)

Parallelism (Measurement beams):

Axes 1 & 2: <40 µrad (8 arc-sec)

Axes 1 & 3: <50 µrad (11 arc-sec).

Optical Efficiency (output beam/total input beam):

Average: 18%

Worst Case: 10%

INSTALLATION RECOMMENDATIONS

Installation and alignment: Kinematic installation procedure requires three referenced pins mounted onto a referenced surface.

Inter-axis Alignment: All internal optics are referenced to the mounting surface and have fixed alignment.

Receivers: Agilent 10780F fiber-optic remote receivers.

Receiver Alignment: Self-aligning when mounted to interferometer.

MEASUREMENT AND REFERENCE (PLANE) MIRROR RECOMMENDATIONS

Reflectance: 98% at 633 nm, normal incidence.

Flatness: Depending on accuracy requirements of the application, mirror flatness may range from λ /4 to λ /20 (0.16
to 0.03 µmeters, 6 to 1.2 µinches).

Optical Surface Quality: 60—40 per Mil-0-13830

NOTE: Flatness deviations will appear as measurement errors when the mirror is translated across the beam. Mount should be kinematic so as not to bend mirror. If accuracy requirements demand it, mirror flatness might be calibrated (scanned and stored in the system controller) to be used as a correction factor.

*Linear and angular resolutions are dependent on the electronics used. Optical resolution is dependent only on the interferometer, and can be used to determine linear and angular resolutions when the electronic resolution extension is known. The linear and angular specifications in this section are for interferometer use with the X32 resolution extension electronics (10885A, 10895A) or X256 resolution extension electronics (10897C, 10898A).

**Angular range for this specification is the maximum angle between the measurement mirror and the interferometer for a 6-axis system. Both angles (either pitch and yaw, or roll and yaw) can be at the angular limit concurrently.

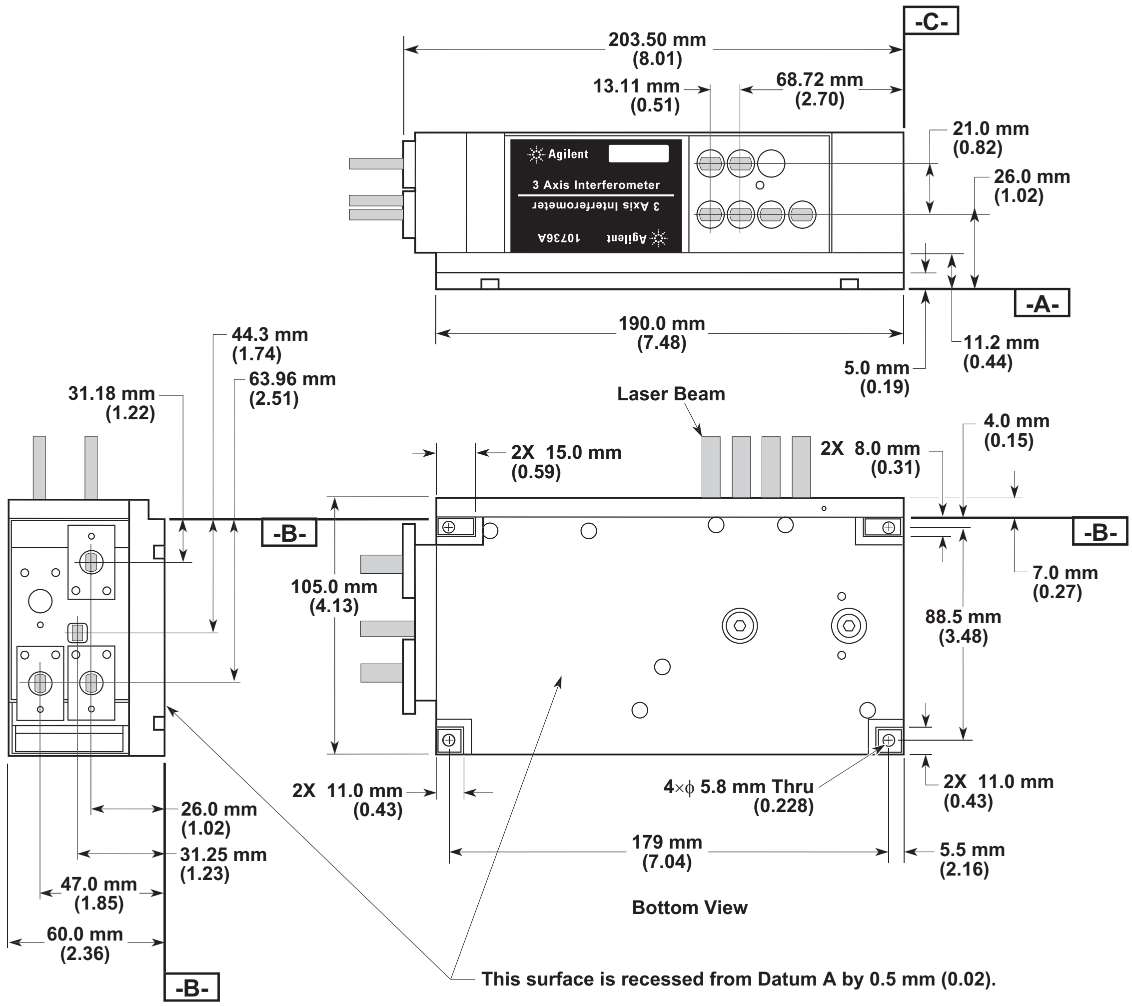


Figure 192 Agilent 10736A Three-Axis Interferometer — dimensions

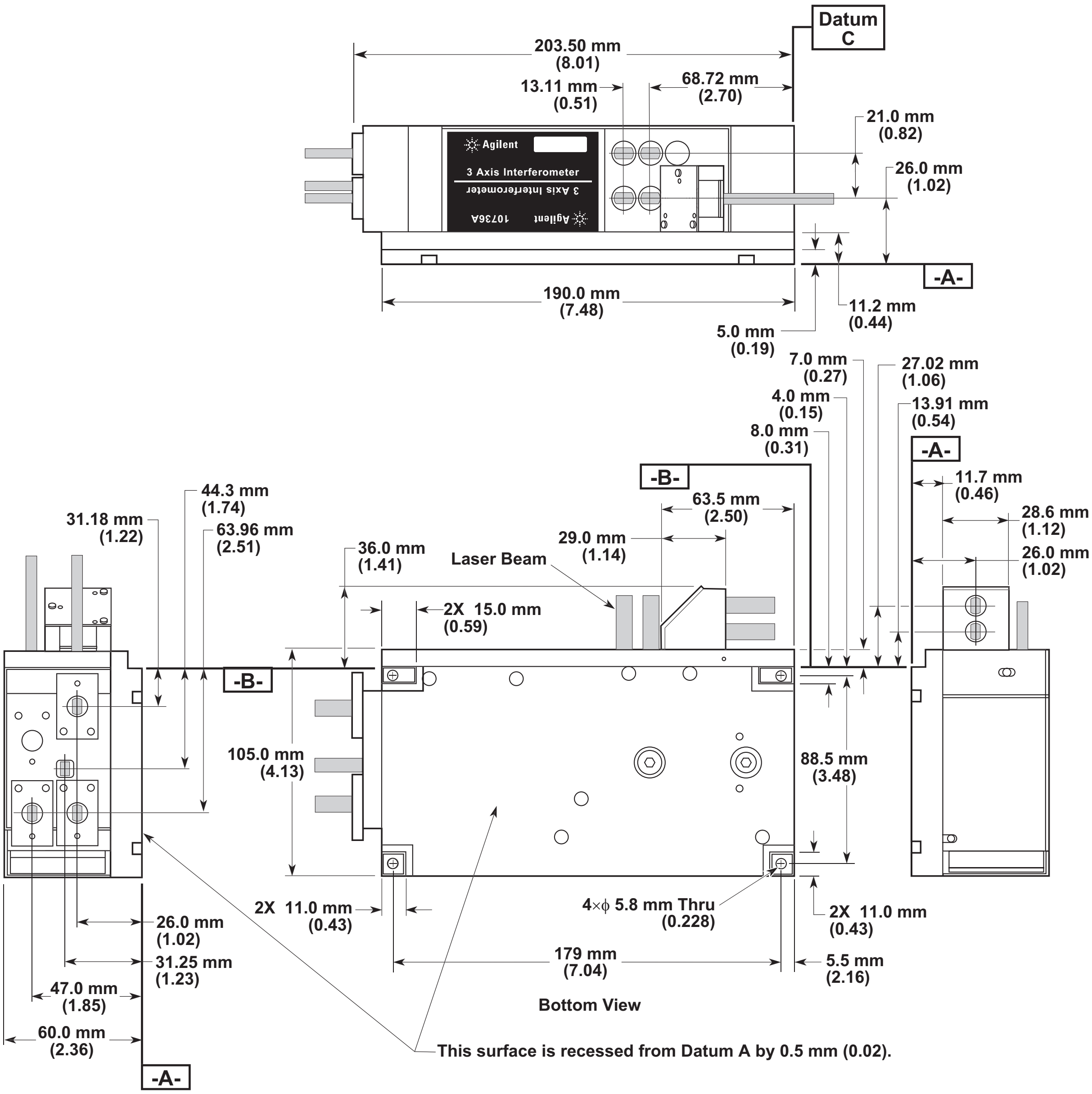


Figure 193 Agilent 10736A Three-Axis Interferometer with Beam Bender—dimensions

28
Agilent 10737L and Agilent 10737R Compact Three-Axis Interferometers

Description

NOTE

Statements In this chapter refer to either or both of the Agilent 10737L and Agilent 10737R interferometers.

The Agilent 10737L/R Compact Three-Axis interferometers (see figures Figure 194 through Figure 196) allow up to three measurements (displacement, pitch, and yaw) to be made on a single axis. The Agilent 10737L and Agilent 10737R interferometers are identical except that the “L” bends the measurement beams to the left and the “R” bends the beams to the right, as viewed from the incoming beam (see figures Figure 195 and Figure 196).

These interferometers are designed to use a 3 mm diameter laser beam, available from an Agilent 5517C-003 Laser Head.

The measurement beam parallelism inherent in the design of the Agilent 10737L/R interferometers ensures that there is essentially no cosine error between their three measurements and also ensures angle accuracy for pitch and yaw measurements.

These interferometers are designed for direct attachment of Agilent 10780F-037 Remote Receiver’s fiber-optic sensor head (one per axis). The Agilent 10780F-037 receiver is the same as the standard receiver, except it does not include the lens assembly that attaches to some Agilent interferometers; in this case, the required lens assembly is part of the Agilent 10737L/R interferometer. This simplifies user assembly, since no optical alignment of the receiver is required. The fiber-optic cables from the receivers attach directly to the axis output apertures on the input face of the interferometer. See figures Figure 195 and Figure 196.

The Agilent 10737L/R interferometers are based on the Agilent 10706B High-Stability Plane Mirror Interferometer’s design. Figure 194 shows two views of an Agilent 10737L interferometer. In addition to the Agilent 10706B components, the interferometer includes the following assemblies:

- The receiver assembly. This can be removed during alignment using the 4-40 socket-head cap screws. The 4-40 button-head screws hold the 0.100-inch-thick cover plate and the receiver assembly parts in place; do not try to loosen these screws or remove the plate.
- The shear plate assembly. This assembly is factory-aligned and must not be loosened or removed.
- The corner cube assembly. This assembly is factory-aligned to produce the required beam pattern. Do not remove the corner cube assembly or loosen the screws holding the assembly in place. Moving this assembly will change the output beam pattern.

1 Corner cube assembly
(Do not loosen or remove)

2 Reference mirror or high stability adapter

3 Plane mirror converter

4 Polarizing beam splitter

5 Shear plate assembly
(Do not loosen or remove)

6 Receiver assembly

7 4-40 socket-head cap screws attaching receiver assembly

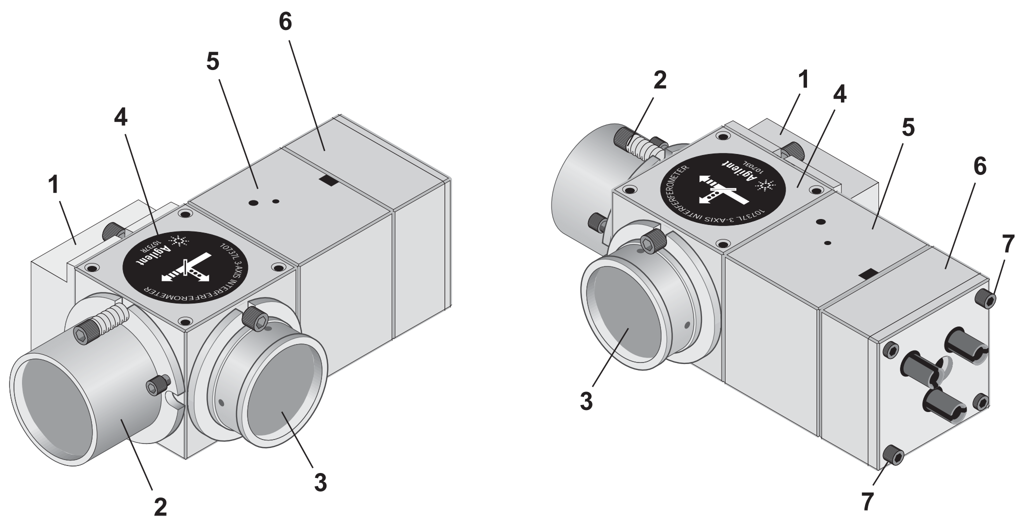


Figure 194 Agilent 10737L Compact Three-axis Interferometer

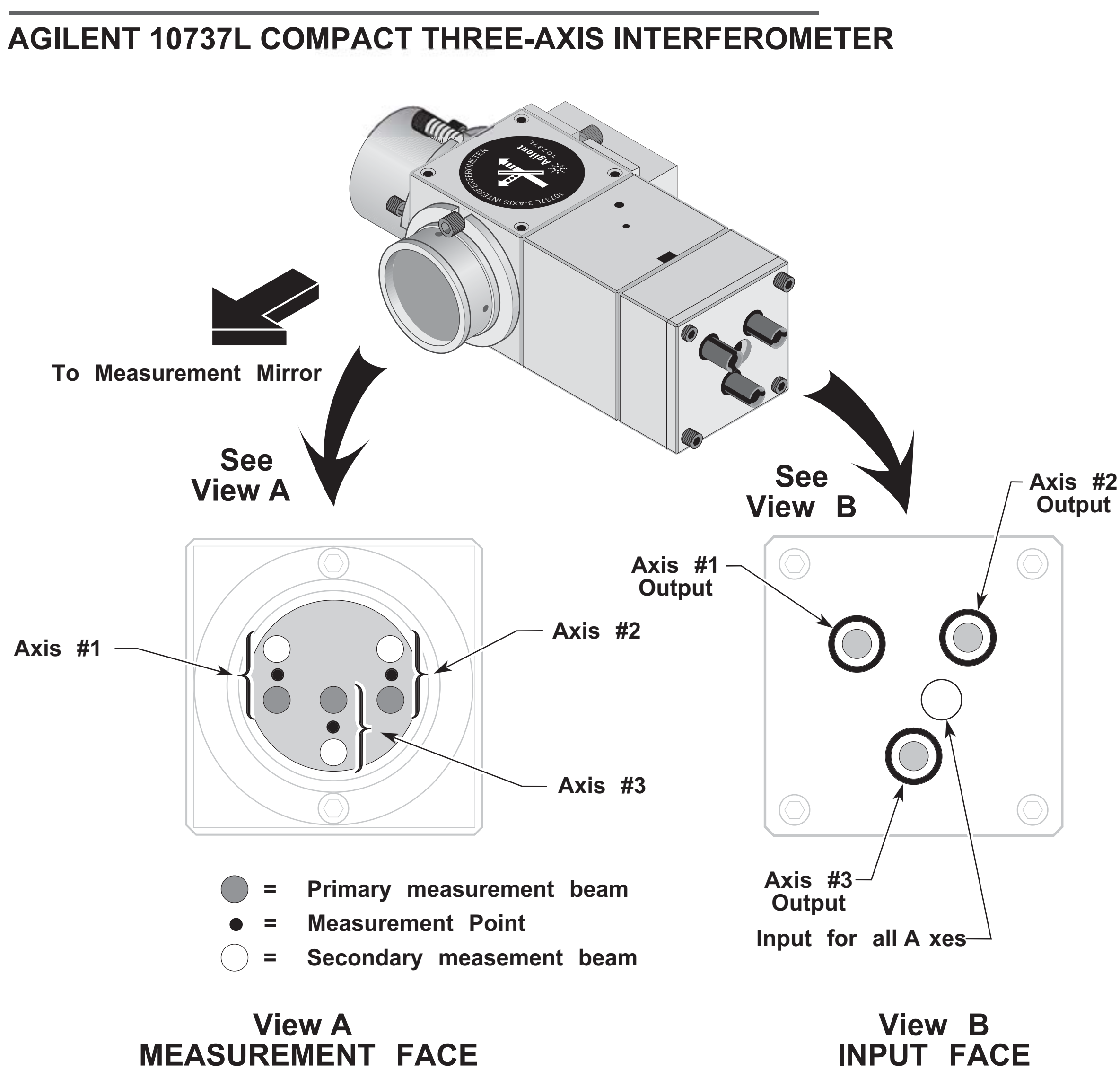


Figure 195 Agilent 10737L Compact Three-Axis Interferometer

AGILENT 10737R COMPACT THREE-AXIS INTERFEROMETER

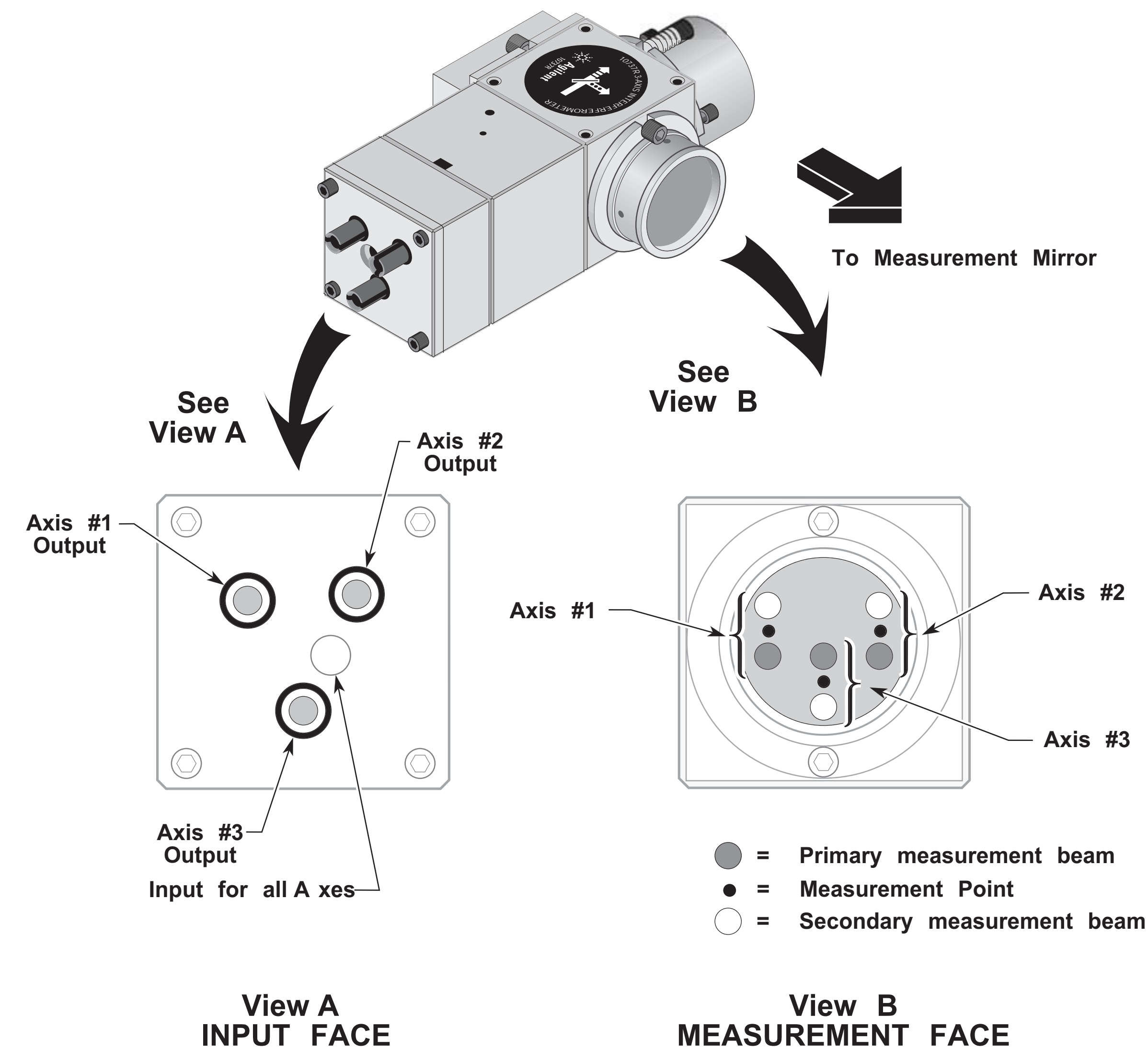


Figure 196 Agilent 10737R Compact Three-Axis Interferometer

Applications

General

The Agilent 10737L or Agilent 10737R interferometer, by making three simultaneous distance measurements along or parallel to the X-axis, can make these measurements:

- displacement along the X-axis
- rotation (pitch) about the Y-axis
- rotation (yaw) about the Z-axis

The angular measurements made by either of these interferometers can be calculated by taking the arctangent of the difference between two linear measurements involved, divided by their separation:

$$THETA = arc\tan\frac{(Y - Y')}{D}$$

This method for determining angle is described in more detail under the “Electronic yaw calculation method” and “Optical yaw calculation method” subsections under the “Three-axis measurement system using discrete plane mirror interferometers (X, Y, YAW)” section in Chapter 3, “System Design Considerations,” in Volume I of this manual.

X-Y Stage

These interferometers are well suited for X-Y stage or multiaxis applications, such as lithography equipment. Two of these interferometers, can measure all X, Y, pitch, roll, and yaw motions of a stage. Since only five axes are required to make all these measurements, the sixth axis can be used as a redundant yaw measurement (useful for mirror mapping). In these applications, the measurement mirrors are attached to the X-Y stage.

MEASUREMENT USING AGILENT 10737R/L COMPACT THREE-AXIS INTERFEROMETERS

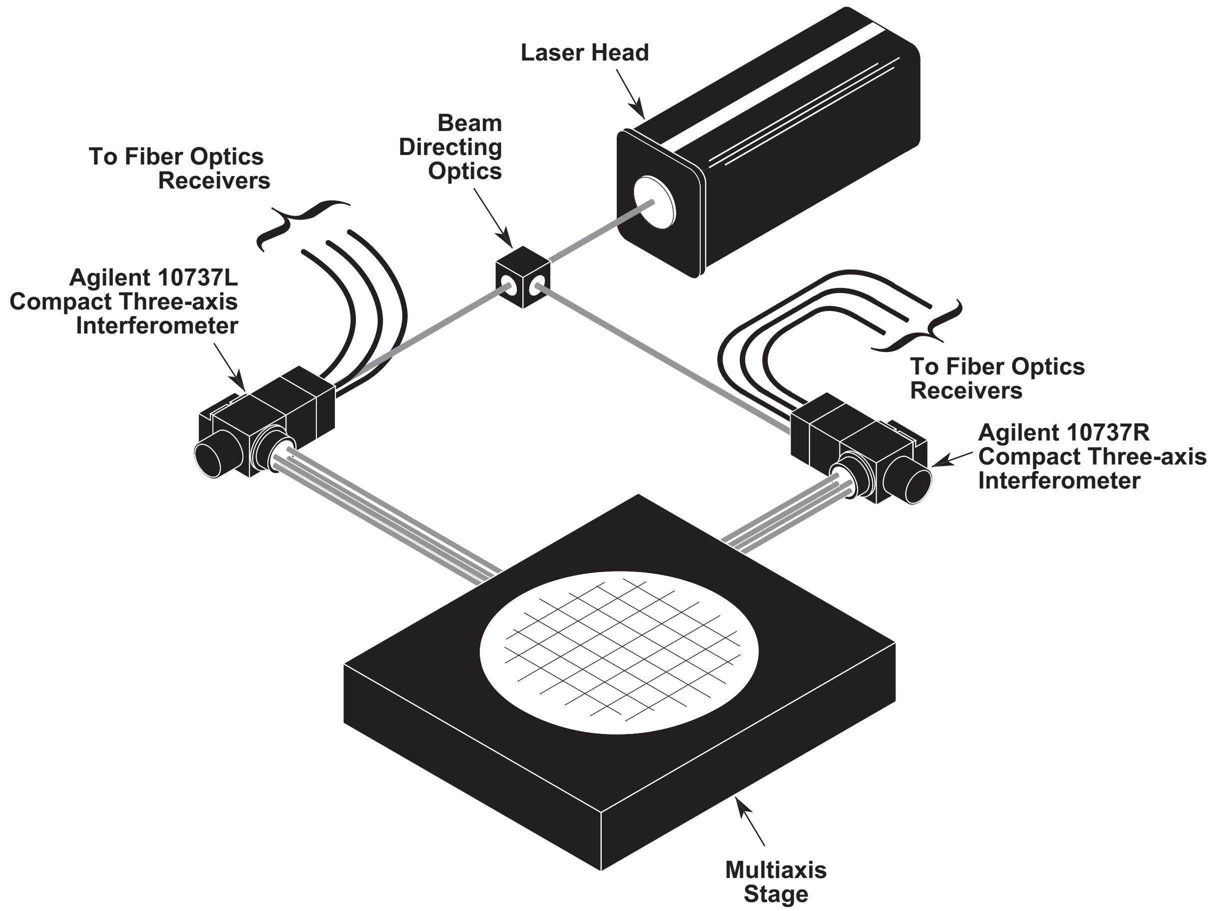


Figure 197 Measurement using two Agilent 10737R interferometers

Optical Schematics

Optical schematics for these interferometers are given in Figure 198. Each interferometer functions similarly to three parallel Agilent 10706B High Stability Plane Mirror interferometers with a three-way beam splitter in front of them.

To reduce thermal drift errors, the measurement and reference beam paths have the same optical path length in glass. This minimizes measurement errors due to temperature changes in the interferometer.

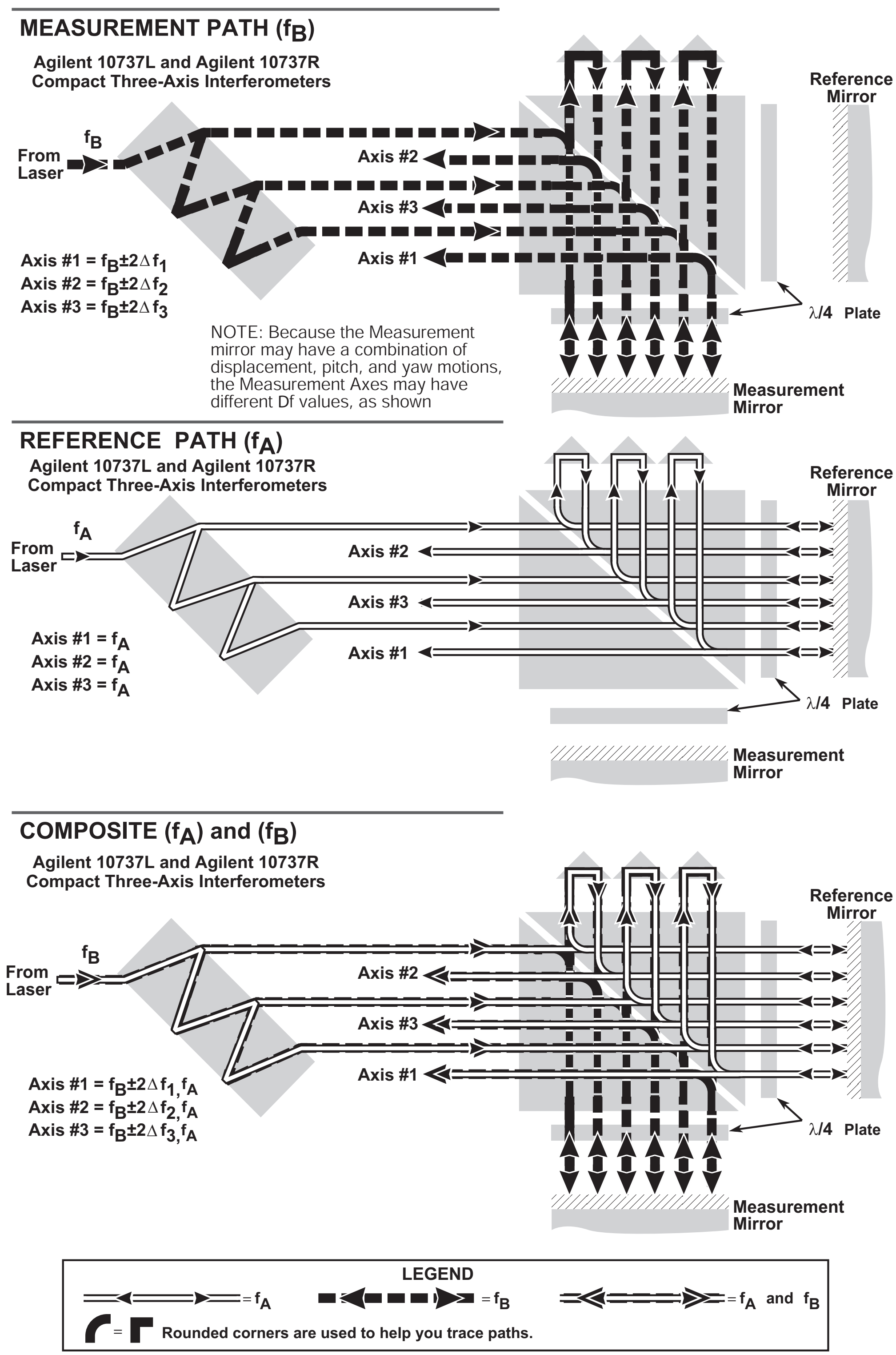


Figure 198 Agilent 10737L/R Compact Three-Axis interferometers — beam paths

Special Considerations

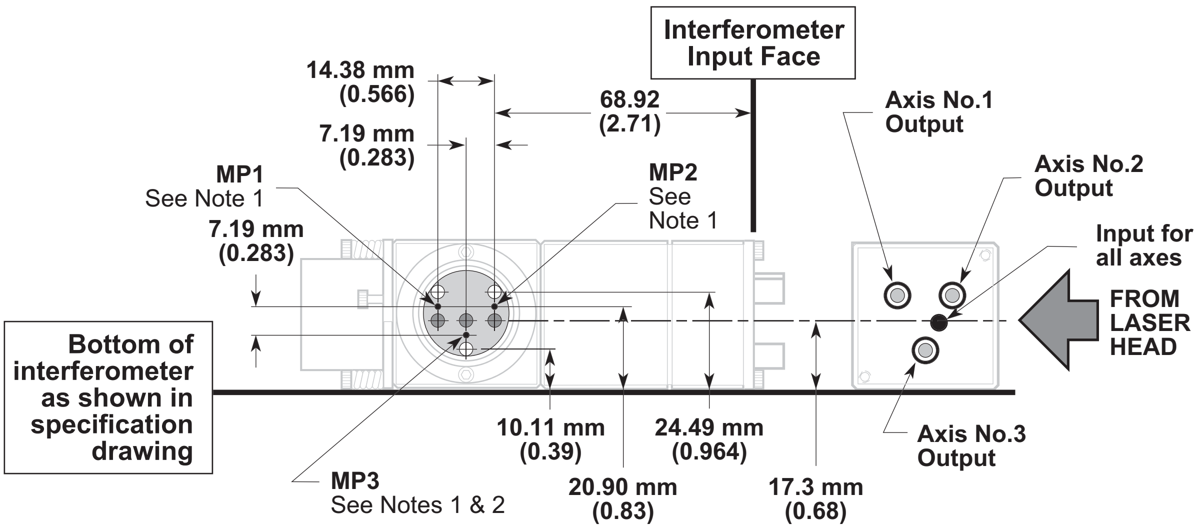
Laser beam power consideration

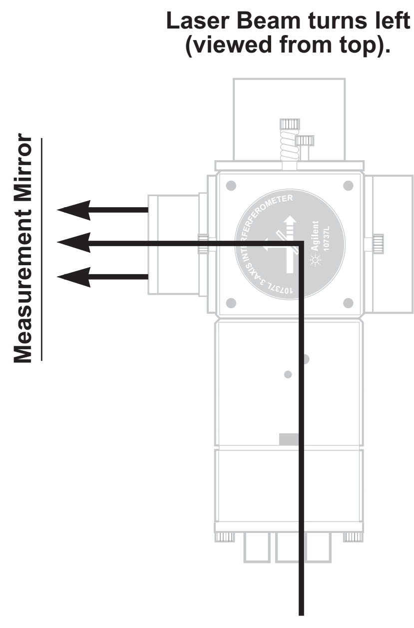
When working with an application that requires use of a separate beam splitter, make sure that you provide enough laser beam power to any multiaxis interferometer so all receivers connected to it receive adequate light power. This will help ensure that each measurement receiver in the system receives the optimum signal strength in the intended application.

Orientation

Note that although illustrations may show an interferometer in one orientation, you may orient the unit as required by your measurement application—vertically, horizontally, or upside-down.

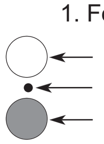
AGILENT 10737L THREE-AXIS INTERFEROMETER





GENERAL NOTES:

1. For Each Axis:



Secondary Measurement beam
MP = Measurement Point
Darker Beam Indicates Primary Measurement beam

2. Drawing not to scale.

Figure 199A Agilent 10737L Interferometer — beam patterns

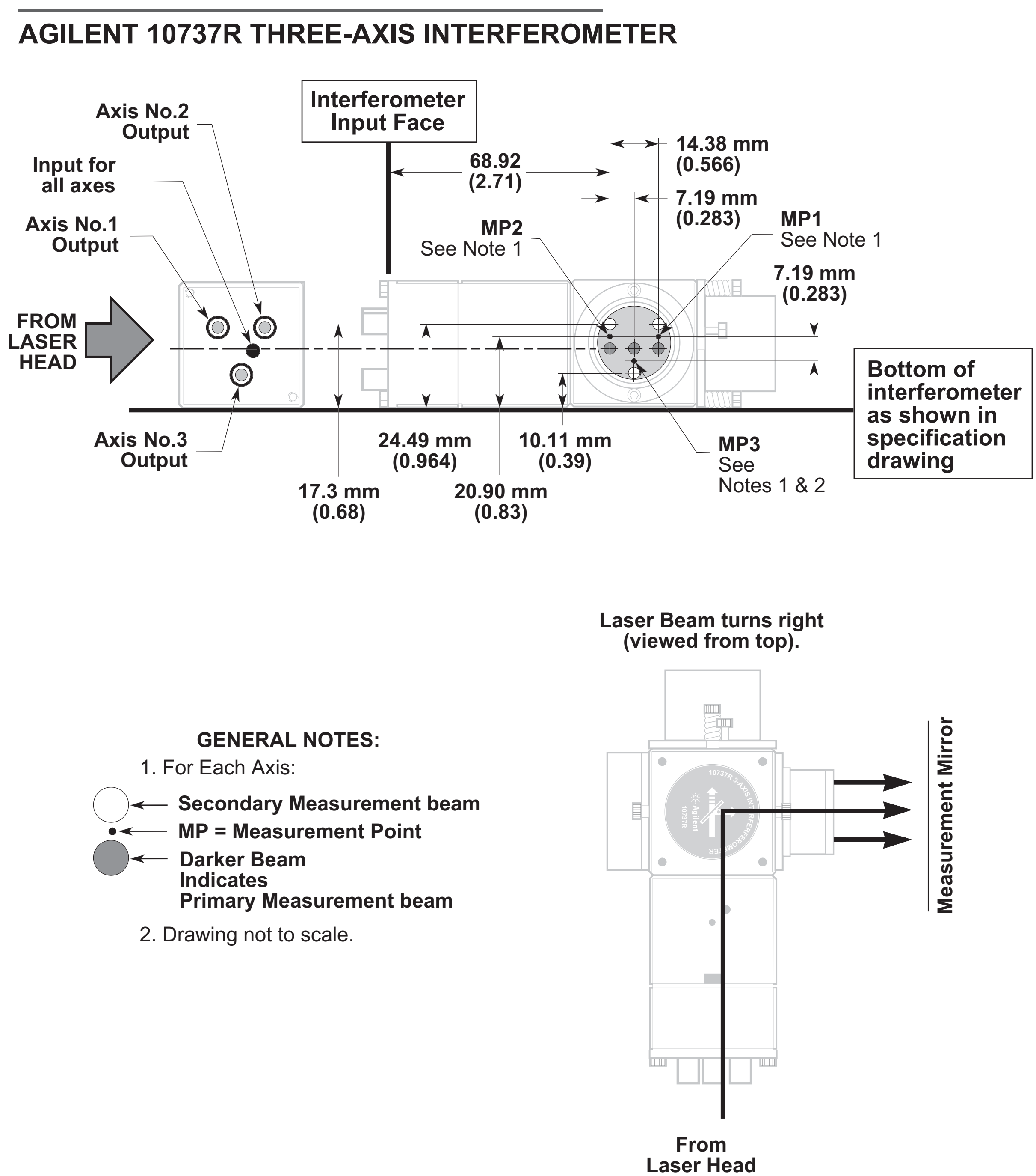


Figure 199B Agilent 10737R Interferometer—beam patterns

Mounting

Adjustable mounts

The Agilent 10711A Adjustable Mount provides a convenient means of mounting, aligning, and securely locking an Agilent 10737L or Agilent 10737R interferometer in position. Since the mount allows some tilt and yaw adjustment, the need for custom fixturing is minimized. The mount allows the interferometer to be rotated about its physical centerline, simplifying installation. Note however, that since the input aperture is not centered on the input face, some translation of the interferometer or beam delivery optics may be required when the interferometer is rotated.

Fasteners

The Agilent 10737L/R interferometers are supplied with English mounting hardware, which is required to fasten it to its adjustable mount.

Installation and Alignment

Summary

The installation and alignment procedure has two major parts:

- Planning and setting up the laser beam path(s)
- Installing and aligning the interferometer(s).

Objectives of the installation and alignment procedure are:

1. Minimizing cosine error.
2. Maximizing signal strength at the receivers.
3. Ensuring a symmetrical range of rotation about the zero angle point.

General

Refer to the Agilent 10706A interferometer "Installation" information in Chapter 20 of this manual.

Tools and Equipment Required or Recommended

Table 75 lists and describes the tools and equipment needed to install and align the Agilent 10737L and 10737R interferometers.

Table 75 Tools and Equipment Required or Recommended

Item and Description	Mfr. Part Number (Mfr = Agilent unless otherwise indicated)	Comment, Note, etc.
Penta prism or similar prism that bends light exactly 90 degrees	Prisms of this type are available from scientific or optical supply shops	Recommended, but not required. For setting up right angles in the beam paths from the laser head to the interferometers. An Agilent 10777A Optical Square may be used.
True square	L.S. Starret, Athol, Mass.	Recommended, but not required. For setting up beam paths parallel to or perpendicular to machine surfaces that are parallel to or perpendicular to the stage mirrors.
Washer, lock, 0.115 in id, 0.270 in od, internal tooth; qty = 6	2190-0004	Supplied with Agilent 10737L/R Interferometer.
Screw, cap, 4-40, 0.500 in lg, hex trim head 0.187 in (3/16 in) across flats; qty = 2	2940-0269	Supplied with Agilent 10737L/R Interferometer.
Screw, machine, 4-40, 1.75 in lg, pan head, pozidriv; qty = 6	2200-0127	Supplied with Agilent 10737L/R Interferometer.
Screw, socket head cap, 4-40, 0.250 in lg, hex recess 0.094 in (3/32 in) across flats; qty = 2	3030-0253	Supplied with Agilent 10737L/R Interferometer.
Screw, socket head cap, 2-56, 0.187 in lg, 0.064 in radius oval point, hex recess; qty = 2	3030-0983	Supplied with Agilent 10737L/R Interferometer.
Hex key, 5/64 in (0.078–in)	8710-0865	Supplied with Agilent 10737L/R Interferometer.
Hex key, 3/32-in (0.094 in)	8710-0896	Supplied with Agilent 10737L/R Interferometer.
Wrench, 3/16-in open-end	8710-1740	Supplied with Agilent 10737L/R Interferometer. Used to secure the Agilent 10711A Adjustable Mount.
Alignment Aid	10706-60001	Supplied with the Agilent 10737L/R Interferometer. See Figure 200 for illustration.
Alignment Aid	10706-60202	Supplied with the Agilent 10737L/R Interferometer. See Figure 200 for illustration.

a couple more figure references --> 195

there's another one on page 593 (303 of 478 pdf) --> 199

Alignment aid (Agilent Part Number 10706-60001) is the same as one used on the Agilent 10706B Plane Mirror Interferometer. Refer to the “Alignment aids” section for the Agilent 10706B Plane Mirror Interferometer, in Chapter 21 of this manual for a further discussion of its use.

Alignment aid (Agilent Part Number 10706-60202), shown in Figure 200, facilitates autoreflection alignment for the high stability adapter to achieve minimal thermal drift. It contains a quarter-wave plate which allows the reference beam to return to the laser head without offset. Figure 203 illustrates how the aid is positioned between the beam splitter and the high stability adapter during alignment.

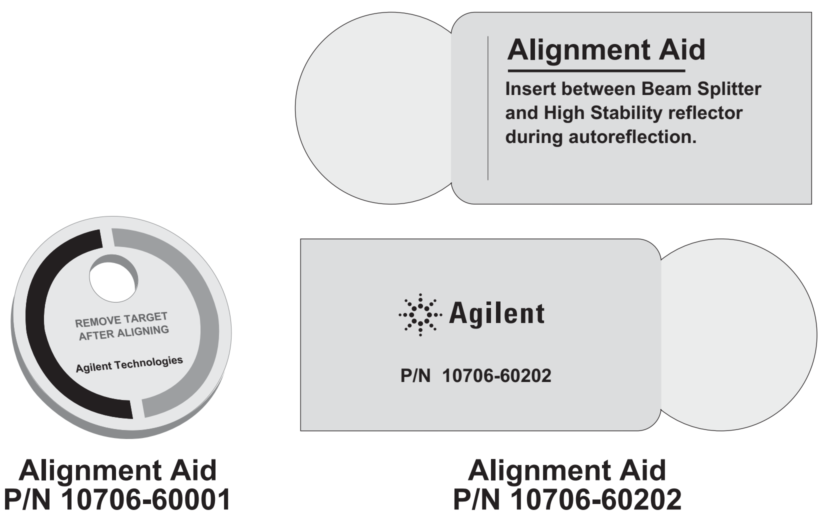


Figure 200 Agilent 10737L/R interferometers—alignment aids

Procedure

Planning the measurement setup

Determine the general plan for your measurement. Examples of measurement setups are given throughout this manual. Particularly, your plan should address:

1. Which axes you want to measure, and what measurements you want to make,
2. Where the interferometers will be positioned with respect to the stage mirrors,
3. Where the laser head will be positioned and how the laser beam will be delivered to the interferometers, and
4. Making sure you will have enough laser power to drive all receivers in your measurement system.

Good practice defines the plane and direction of all beam paths against machined surfaces known to be parallel or perpendicular to the stage plane.

You may need to provide special mounting arrangements for the laser head and the optics in order to place the measurement beams where you want them on the stage mirrors.

Initial installation and setup

1. Install the laser head, the beam-steering optics, and the beam-splitting optics in their general locations, as specified in your plan. The interferometer(s) will be installed after the beam paths have been established as described below.
2. Turn on power to the laser head and select the laser head's small output aperture.
3. Refer to Chapter 4, "System Installation and Alignment," in Volume I of this manual, beginning with the "Alignment principles," section, for additional information about aligning your measurement setup.

Installing and aligning an interferometer

CAUTION In performing the procedure below, perform only the removal, disassembly or assembly steps described. Do not remove or take apart anything you are not instructed. Do not touch any glass surface or allow it to be scratched, dirtied or otherwise harmed.

CAUTION Do not touch any glass surface of any optic. For cleaning instructions, see Chapter 7, “Maintenance,” in Volume I of this manual.

Perform this procedure for each interferometer in your measurement system.

This procedure assumes that the laser head and all optics except the interferometer(s) have been installed and that the appropriate beam path(s) to the stage mirror(s) have been established as described in Chapter 4, “System Installation and Alignment,” in Volume I of this manual.

The procedure has these major parts:

1 Removing the receiver assembly
2 Removing the high stability adapter (reference mirror)
3 Aligning the measurement beam path
4 Aligning the reference beam path
5 Comparing beam path alignments

Removing the receiver assembly

To remove the receiver assembly, refer to figures 194 and 201.

1 Use the 5/64-inch hex key to remove the two cap screws that hold the receiver assembly to the interferometer. Set the screws in a clean, safe place where they will not be lost.
2 Remove the receiver assembly from the interferometer. Set the receiver assembly in a clean, safe place.

Removing the high stability adapter (reference mirror)

To remove the high stability adapter, refer to figures 194 and 201, and:

1 Use the 5/64-inch hex key to remove the two cap screws with springs that hold the high stability adapter (reference mirror) to the interferometer. Set the screws in a clean, safe place where they will not be lost.

2 Remove the high stability adapter (reference mirror) from the interferometer. Set the high stability adapter in a clean, safe place.

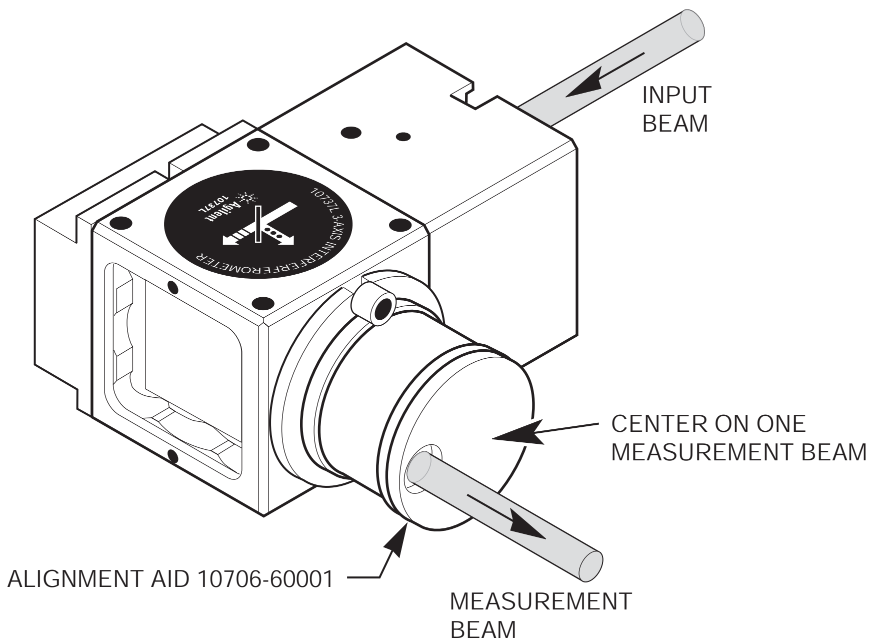


Figure 201 Agilent 10737L Compact Three-Axis Interferometer with Agilent 10706-60001 Alignment Aid

NOTE From here on, this procedure assumes that the interferometer is installed on an Agilent adjustable mount.

Aligning the measurement beam path

1 Remove the receiver assembly and high stability adapter, as described in the respective procedures, above.

2 Install the interferometer so the beam from the laser source enters its input aperture and is normal to its input face.

3 Set the alignment aid (Agilent Part Number 10706-60001) on the interferometer's Measurement beam aperture as shown in Figure 201.

With the alignment aid installed, the beam will be reflected off the stage mirror back to the laser head.

4 Set the laser head to the small aperture.

5 Roll and yaw the interferometer until the autoreflected beam is centered on the small aperture of the laser.

6 Select the laser head's large output aperture and translate the interferometer horizontally until the input beam is centered on the interferometer's input aperture.

A piece of translucent tape over the interferometer's input aperture will make the input beam visible. This procedure assumes that the vertical height of the beam was set before the interferometer was installed, (see the "Initial installation and setup" procedure); alternatively, fixturing for a vertical adjustment for the interferometer may be used.

7 Select the laser head's small output aperture and check that the beam is still autoreflecting.

8 Repeat steps 3 through 7 until the beam is both autoreflecting and centered on the interferometer's input aperture.

9 Tighten all mount adjustment screws.

10 Remove the alignment aid.

11 Check the position of the beams in the interferometer's output apertures (see Figure 202).

Once again, translucent tape is helpful for viewing the beams in the apertures. If any beam clipping occurs, or if the beams are far off from the desired location, check for obstructions and recheck the alignment (by performing steps 3 through 7 above).

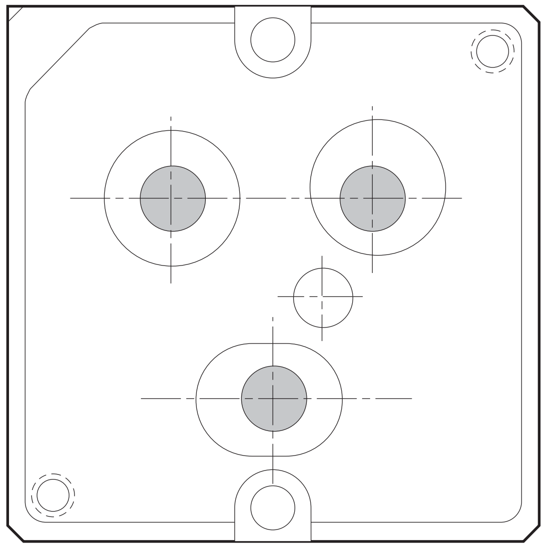


Figure 202 Agilent 10737L Compact Three-Axis Interferometer —return beam pattern

12 Install the receiver assembly.

To do this, reverse the “Removing the receiver assembly” procedure, above.

13 Plug in the fiber-optic cables.

14 Adjust each receiver’s gain by turning its gain adjustment screw to cause the receiver’s LED to light, then reduce the gain until the LED just turns off. For more information, see Agilent 10780F instructions in Chapter 35, “Receivers,” of this manual.

Aligning the reference beam path

NOTE — The measurement path must be aligned and the laser beam centered on the input aperture before aligning the reference mirror.

1 Remove the receiver assembly and the plane mirror converter (see figures 194 and 197), and set aside on a clean surface. Do not touch any glass surface of any optic.

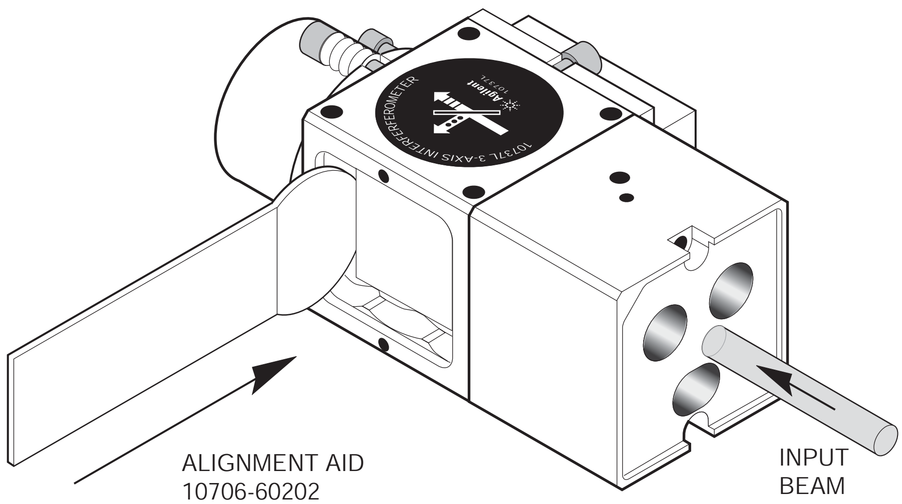


Figure 203 Agilent 10737L Compact Three-Axis Interferometer with 10706-60202 Alignment Aid

2 Install the reference mirror assembly (see figures 194 and 197).

The 4-40 screws on springs hold the mirror in place. The four 2-56 screws tilt the mirror for alignment. Back off the 2-56 screws so the mirror housing is flush with the interferometer. Tighten the 4-40 screws to compress the springs completely and then back off approximately 1-1/2 turns.

3 Place the 10706-60202 alignment aid between the beam splitting cube and the reference mirror (see Figure 203).

4 Block the beams going to the stage mirror.

5 Set the laser to the small aperture.

6 Tilt the reference mirror by adjusting the 2-56 screws until the beam from the reference mirror autoreflects back to the center of the laser small aperture.

7 Remove the alignment aid.

8 Check the position of the beams in the interferometer's output apertures (see Figure 202).

   Once again, translucent tape is helpful for viewing the beams in the apertures. If any beam clipping occurs, or if the beams are far off from the desired location, check for obstructions and recheck the alignment (by performing steps 6 through 10 above).

9 Install the receiver assembly.

10 To do this, reverse the “Removing the receiver assembly” procedure, above.

11 Plug in the fiber-optic cables.

12 Adjust each receiver's gain by turning its gain adjustment screw to cause the receiver's LED to light, then reduce the gain until the LED just turns off. For more information, see Agilent 10780F instructions in Chapter 35, “Receivers,” of this manual.

13 Unblock the stage mirror beams.

Comparing beam path alignments

1 Remove the receiver assembly.

2 Look for any lack of overlap between the reference and measurement return beams, translucent tape will help. If beams do not overlap, check reference mirror alignment.

3 Note that if you must realign the measurement mirror, you will also have to realign the reference mirror.

4 Install the receiver assembly and make sure all screws are tight.

Operation

Measurements

For an interferometer setup to measure distances along the X-axis, measurements of displacement, pitch, and yaw are derived as described below. These computations are done via software on the system controller or computer.

Displacement

For the Agilent 10737L/R interferometer, displacement along the X-axis can be measured as the average of the data returned from measurement axis #1 and measurement axis #2:

$$\text{Displacement} = \frac{\text{measurement axis \#1} + \text{measurement axis \#2}}{2}$$

Pitch

For Agilent 10737L/R interferometer, pitch (rotation about the Y axis) can be measured using data returned from all three measurement axes, and the vertical offset between the common centerline of measurement axes #1 and #2 and the centerline of measurement axis #3 (7.19 mm or 0.283 inch):

$$\text{Pitch} = \frac{\text{Displacement} - \text{measurement axis \#3}}{7.19 \text{ mm or } 0.283 \text{ inch}} \text{ radian}$$

Yaw

For the Agilent 10737L/R interferometer, yaw (rotation about the Z axis) can be measured as the difference between the data returned from measurement axis #1 and measurement axis #2, divided by the distance between them (14.38 mm, or 0.566 inch):

$$\text{Yaw} = \frac{\text{measurement axis \#1} - \text{measurement axis \#3}}{14.38 \text{ mm or } 0.5666 \text{ inch}} \text{ radian}$$

Error

The deadpath distance for an Agilent 10737L/R interferometer is the distance between the interferometer’s measurement face and the measurement mirror, at the measurement “zero” position. This is the same as for the Agilent 10706B interferometer, on which it is based.

Specifications and Characteristics

Specifications describe the device’s warranted performance. Supplemental characteristics (indicated by TYPICAL or NOMINAL) are intended to provide non-warranted performance information useful in applying the device.

Plane mirror systems have a fundamental optical resolution of one quarter wavelength (0.158 micron, 6.23 microinches).

Using electronic resolution extension, the system resolution is increased significantly. Depending on the system, an additional resolution extension factor of 32 (for Agilent 10885A and 10895A) or 256 (for Agilent 10897B and 10898A) is usually available.

Agilent 10737L/R Compact Three-Axis Interferometer Specifications

Optical Resolution:	λ/ 4 (158.2 nm, 6.2 µin)
Linear Resolution:	5 nm (using Agilent 10885A, or Agilent 10895A electronics) 0.6 nm (using Agilent 10897A, or Agilent 10898A electronics)
Yaw Resolution:	0.35 µrad (0.07 arc-sec) (using Agilent 10885A, or Agilent 10895A electronics) 0.04 µrad (0.01 arc-sec) (using Agilent 10897A, or Agilent 10898A electronics)
Pitch and Roll Resolution:	0.7 µrad (0.14 arc-sec) (using Agilent 10885A, or Agilent 10895A electronics) 0.1 µrad (0.02 arc-sec) (using Agilent 10897A, or Agilent 10898A electronics)
Yaw Range*:	±0.44 mrad (±1.5 arc-min)
Pitch and Roll Range:	±0.44 mrad (±1.5 arc-min)
Linear Range:	10 m (33 ft) total for all three axes.
Operating Temperature:	0–40 °C (17–23 °C to ensure system non-linearity specification)
Thermal Drift Coefficient:	Same as Agilent 10706B
Non-linearity Error:	± 1 nm for each axis
Weight:	490 g (18 oz)
Dimensions:	see Figure 204 on the next page
Materials Used:	Housing: stainless steel and aluminum Optics: optical grade glass Adhesives: vacuum grade, cyanoacrylate polarizer material Receiver inserts: urethane foam, acetal, 15% glass fill polyester
Installation:	Uses 3-mm beam available from Agilen 5517C-003. Requires three Agilent 10780F-037 Remote Receivers. Compatible with Agilent 10711A Adjustable Mount.
Measurement (Plane) Mirror Recommendations:	Reflectance: 98% at 633 nm at normal incidence Flatness: Flatness deviations will appear as measurement errors when the mirror is scanned perpendicular to the beam. Recommended range 1/4 (0.16 µm or 6 µin) to 1/20 (0.03 µm or 1.2 µin) dependent on accuracy requirements.
Optical Surface Quality:	60-40 per Mil 0-13830

*At a distance of 300 mm, maximum measurement mirror angle due to all components (i.e., yaw and pitch or yaw and roll) between the measurement mirror and the interferometer. A six-axis system is assumed.

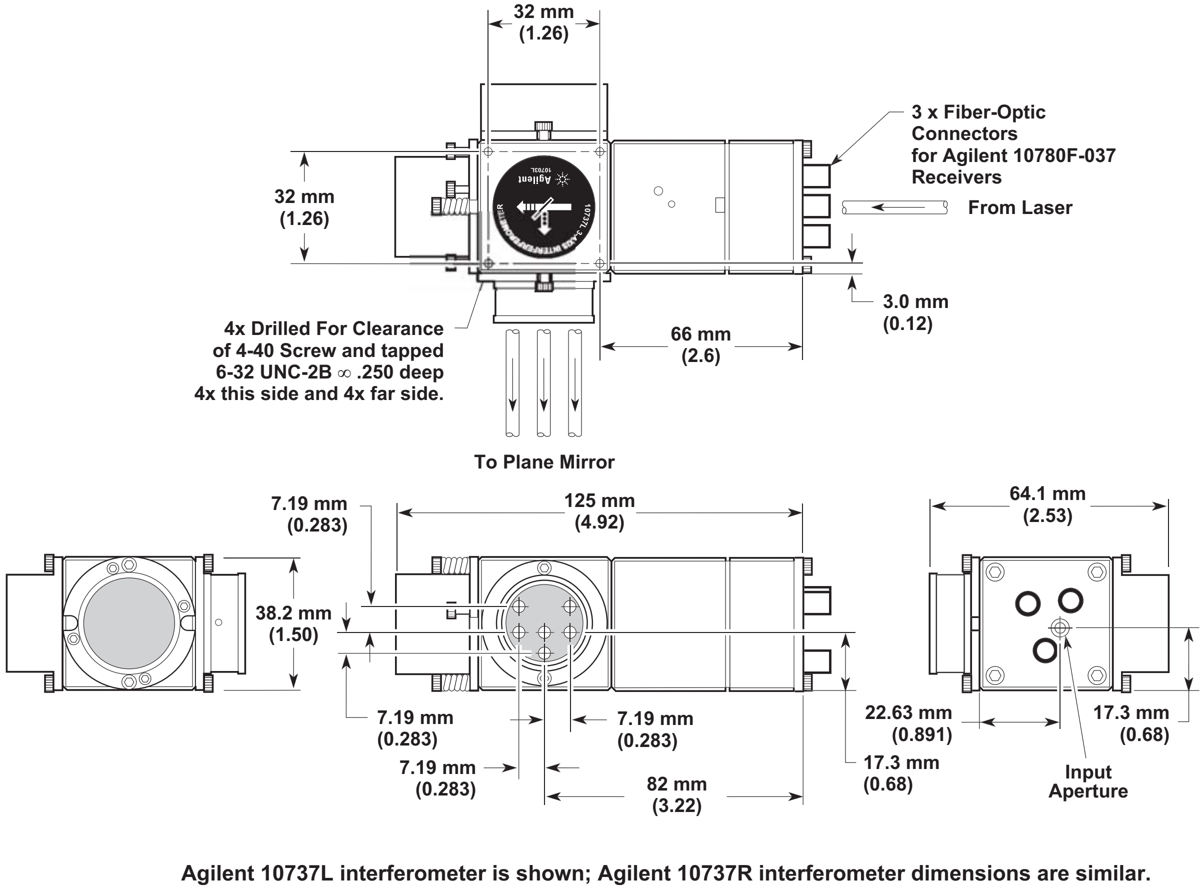


Figure 204 Agilent 10737L/R Compact Three-Axis Interferometer — dimensions

29
Agilent 10770A Angular Interferometer with Agilent 10771A Angular Reflector

Description

The Agilent 10770A Angular Interferometer and the Agilent 10771A Angular Reflector are normally supplied as part of the Agilent 55281A Angular Optics Kit. They are shown in Figure 205. These Angular Measurement optics are designed for use in a calibrator system such as the Agilent 5529A/55292A. More detailed information about the use of these optics can be found in Agilent calibrator system user’s documentation.

With these optics the angular rotation of the Agilent 10771A Angular Reflector can be measured over a range of ±10 degrees.

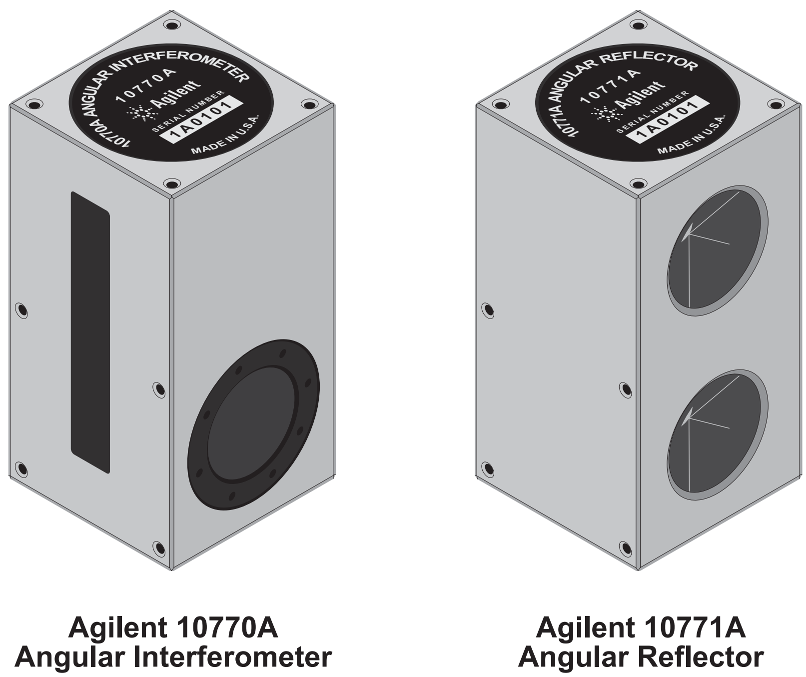


Figure 205 Agilent 10770A Angular Interferometer and Agilent 10771A Angular Reflector

Optical schematic

Figure 206 shows the laser beam path through the optics.

The angular optics create two parallel beam paths between the angular interferometer and the angular reflector. The spacing between the two paths (32.61 mm, or 1.28 inches) is precisely known because it is set by the optics and the retroreflectors within the angular reflector. Both components are positioned 32.61 mm apart at their centerlines. The optics are initially set parallel to each other and the system is initialized.

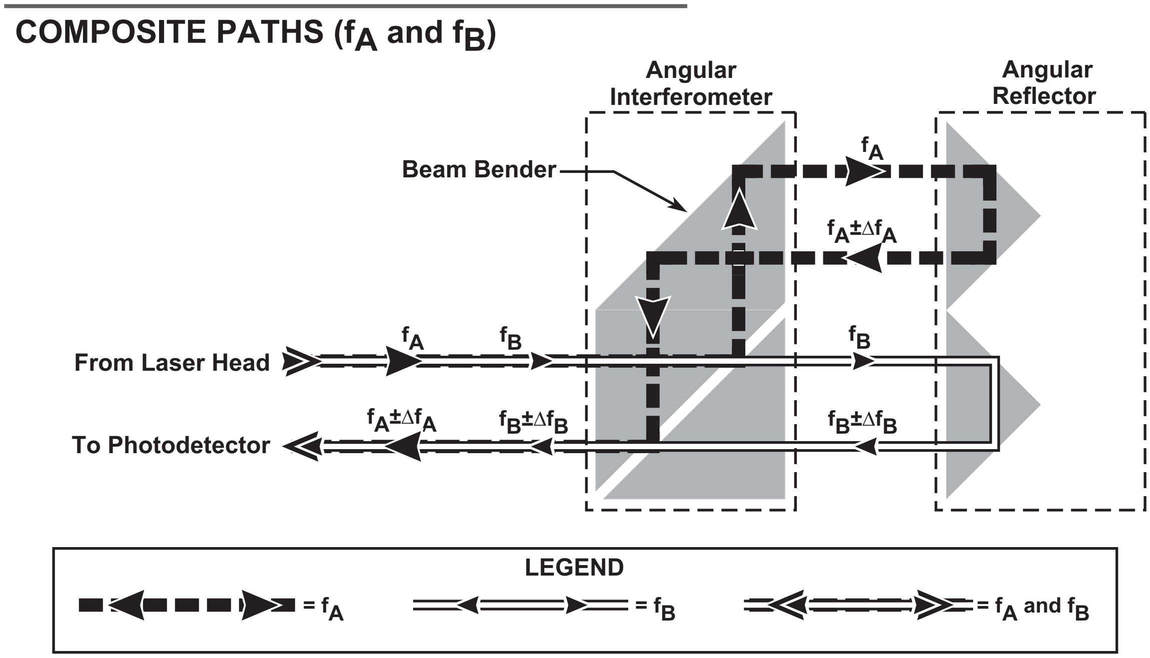


Figure 206 Angular optics — laser beam paths

The two beam paths are initially the same length. If either optic is rotated, the relative path lengths will change. This change will cause a Doppler-shifted frequency change in the beam returned from the interferometer to the receiver. The change will result in an indicated change in path length. From geometry, the angle of rotation is related to the change in relative path length by:

sin θ	=	D/32.61 mm
so θ	=	arcsin (D/32.61 mm),
where θ	=	the angle of rotation, and
D	=	the indicated change in relative path length in mm, and 32.61 mm is the spacing of the retroreflectors in the angular reflector, and also the spacing between the parallel beam paths from the angular interferometer to the angular reflector.

Installation and Alignment

General considerations

1 Carefully read chapters 2 through 4, and Chapter 12, “Accuracy and Repeatability,” and complete the following items before installing a laser positioning system into any application.

2 Alignment of the angular optics is similar to alignment of a Linear Interferometer. Read the alignment procedure for the Linear Interferometer given in Chapter 18 of this manual.

3 The angular interferometer must be located between the laser head and the angular reflector. The beam from the laser head must enter the angular interferometer either through the single opening on one side for an in-line measurement, or through the opening in the bottom for a measurement along an axis perpendicular to the laser beam. The side of the angular interferometer with two openings should always face the angular reflector.

4 When initializing the laser measurement system, the angular optics must be parallel to within 20 arc-minutes to achieve the specified accuracy (corresponds to 40 arc-minutes misalignment by autoreflection).

5 Supply a rigid mounting surface for both optics. The mounts should be adjustable for alignment. The adjustable mounts available from Agilent for these optics include the Agilent 10785A Height Adjuster and Post. The Agilent 10784A Base may be used as a support for the post. Dimension drawings for these items are provided in Chapter 35, “Receivers,” of this manual.

6 The Angular Interferometer’s apertures are 18.0 mm in diameter. With this aperture, the beam spacing will be 11.0 mm. This beam spacing (11.0 mm) differs from that used for other interferometers. This difference means that you cannot use the receiver’s alignment aid to establish proper spacing between the receiver and the beam from the laser head to the interferometer.

Alignment target

To help in aligning the Agilent 10770A Interferometer, an alignment target (Agilent Part Number 10767-67001) is included.

Alignment procedure

There are two techniques for aligning the angular optics. They are:

- Autoreflection Method, and
- Moving Dot Method.

Autoreflection Method

The principal alignment procedure for the angular optics is the same as that for the linear interferometer and retroreflector. The following is the step-by-step procedure that corresponds to the example in Chapter 4, “System Installation and Alignment,” of this manual. In this case, however, the angular optics, instead of the linear interferometer and retroreflector, will be used on the X-axis.

1 With all optical components in place, visually align the laser beam parallel to the axis of travel. Do this by blocking the laser beam with a piece of paper and moving the paper along the axis of travel.

2 With the laser beam passing through the 50% beam splitter, coarsely adjust optical components so the measurement beams strike the center of the receiver aperture. Use the “Moving Dot” method (described in the following subsection) to do this.

3 Place a referenced mirror between the interferometer and the reflector so the measurement beams from the interferometer strike this mirror. Align the referenced mirror with a precision indicator until the mirror’s reflective surface is perpendicular to the direction of travel.

4 Select the small aperture on the laser head by rotating the front turret.

5 Adjust the laser head angularly until the beam reflects back on itself from the referenced mirror and is centered on the small aperture of the laser head.

6 Lock down the laser head and interferometer securely. Make sure the alignment is not disturbed.

7 Reposition the reflector until the return measurement beams are centered on the receiver. Select the large aperture on the laser head.

NOTE — Placing a piece of translucent tape over the receiver lens will help in observing the impinging beams.

CAUTION — Do not let the tape adhesive touch any optical surface.

8 Verify that the receiver’s LED is ON and that the voltage at the receiver test point is between 0.6 and 1.3 Vdc (for 10780C/F), or 1.5 and 8.0 Vdc (for E1708A), or 1.8 and 10.0 Vdc (for E1709A).

Moving Dot Method

The principal steps used for the “moving dot” method of alignment are:

1. The laser head and optics are mounted in their desired locations.
2. Select the small beam aperture on the laser head.
3. With the reflector as close as possible to the interferometer, adjust any component (laser head, interferometer, or reflector) to center the measurement beams on the receiver aperture.

NOTE Placing a piece of translucent tape over the receiver lens will help in observing the impinging beams.

CAUTION Take care that you do not let the tape stick to any optical surface.

4. Move the reflector away from the interferometer. If the laser beam is not parallel to the axis of travel, the measurement beams will begin to move away from their original position on the receiver aperture. The impinging beams will move until the beam is cut off by the edge of the interferometer’s aperture. Stop moving the reflector before the beam is blocked, or when the end of travel is reached. Figure 207 illustrates this situation.
5. Adjust the laser beam by angularly moving the beam until the dots again overlap at the receiver. This adjustment of the laser beam is accomplished by moving the laser head, beam bender, or interferometer depending on the optical layout.

NOTE Some translations of either the laser head or interferometer may also be necessary to achieve alignment.

6. Select the large aperture on the laser head. Verify that the receiver’s LED is ON and that the voltage at the receiver test point is between 0.6 and 1.3 Vdc (for 10780C/F), or 1.5 and 8.0 Vdc (for E1708A), or 1.8 and 10.0 Vdc (for E1709A).

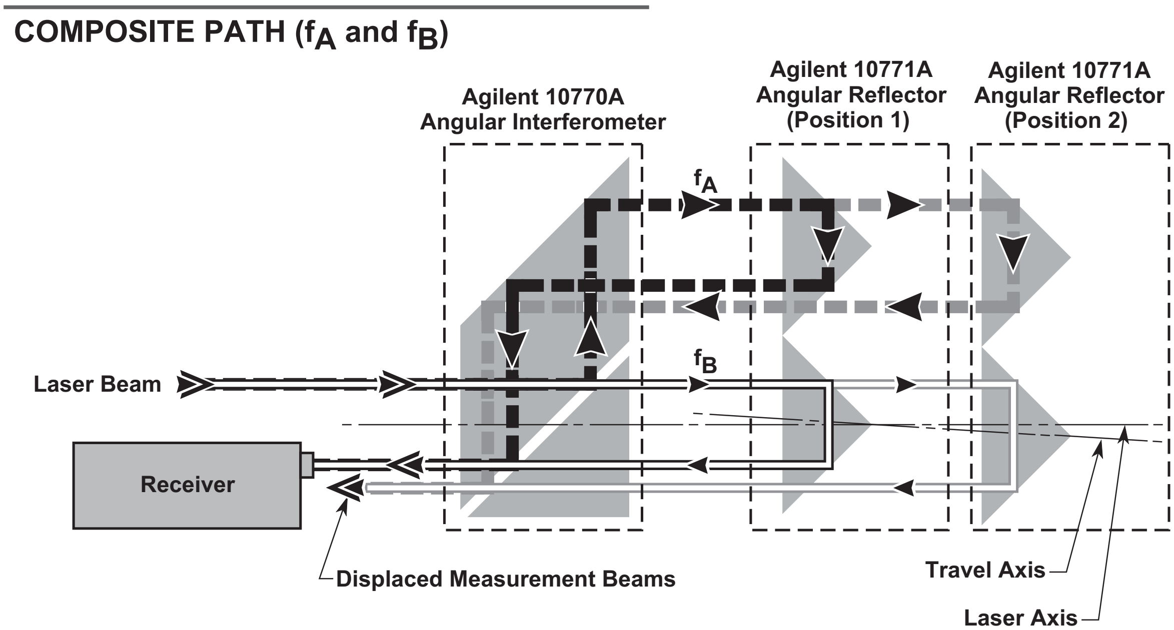


Figure 207 Measurement beam dots movement

Operation

Accuracy considerations

There are three error sources that are controlled by the operator:

1. The accuracy depends on the nodal point spacing. The optics must be temperature-stabilized in the 15-to-25 degree C range or thermal expansion will change the nodal point spacing, causing excessive error.
2. Misalignment in roll effectively reduces the nodal point spacing in the plane of the measurement. The accuracy specification includes allowance for 1 degree of roll misalignment by the operator.
3. The initial angle must be near zero when the system is initialized or the measured change in angle will have an error. The accuracy specification includes allowance for 20 arc-minutes of initial angle. The error in measured path length due to an initial angle error is given by:

Dt	=	$Dm\{\sin\theta t/[\sin(\theta t - \theta i) + \sin\theta i]\}$
Where Dt	=	the true change in path for the true angle of rotation,
θt	=	the true angle of rotation,
Dm	=	the measured change in path length caused by an initial angle error, and
θi		the initial angle error.

Specifications

Specifications describe the device’s warranted performance. Supplemental characteristics (indicated by TYPICAL or NOMINAL) are intended to provide non-warranted performance information useful in applying the device.

Accuracy: Angle measurements are accurate to ±0.2% of calculated value ±0.05 arc-second per meter of distance traveled by the moving optic. This assumes that the Agilent 10771A Reflector is aligned within 40 arc-minutes using retroreflection techniques, roll alignment by the operator is within l° relative to the measurement plane, and the temperature of all optics is stabilized in the range 15-25° C.

Resolution: 0.06 arc-second

Range: ± 36000 arc-seconds (± 10°)

Axial Separation: (Typical, with proper alignment, 15-25° C, distance between the laser head and the reflector): 15 meters (50 feet).

Agilent 10770A Angular Interferometer Specifications

Dimensions: see figure below

Weight: 553 grams (19.5 ounces)

Materials Used:

Housing: Stainless Steel (416)
Apertures: Plastic (Nylon)
Optics: Optical Grade Glass
Adhesives: Low Volatility (Vacuum Grade)

Maximum Angular Beam Deviation: ± 30 arc-seconds

Optical Efficiency:

Typical: 75%
Worst Case: 71%

Non-linearity Error: ≤4 nm

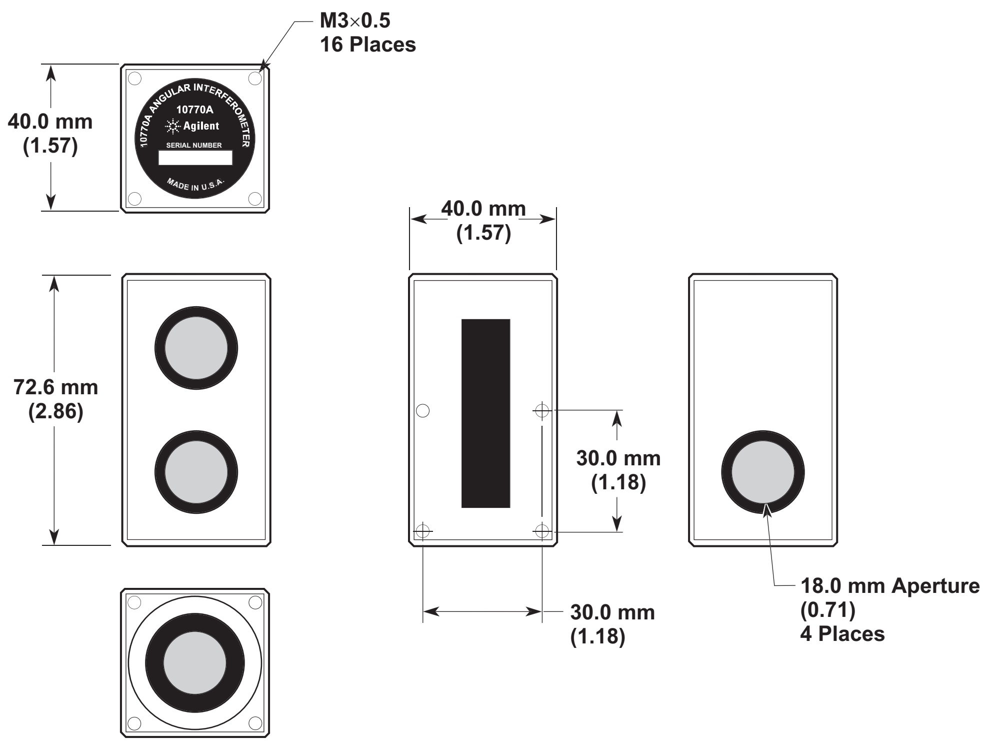


Figure 208 Agilent 10770A Angular Interferometer

Agilent 10771A Angular Reflector Specifications

Dimensions: see figure below

Weight: 650 grams (23 ounces)

Materials Used:

Housing: Stainless Steel (416)
Apertures: Plastic (Nylon)
Optics: Optical Grade Glass
Adhesives: Low Volatility (Vacuum Grade)

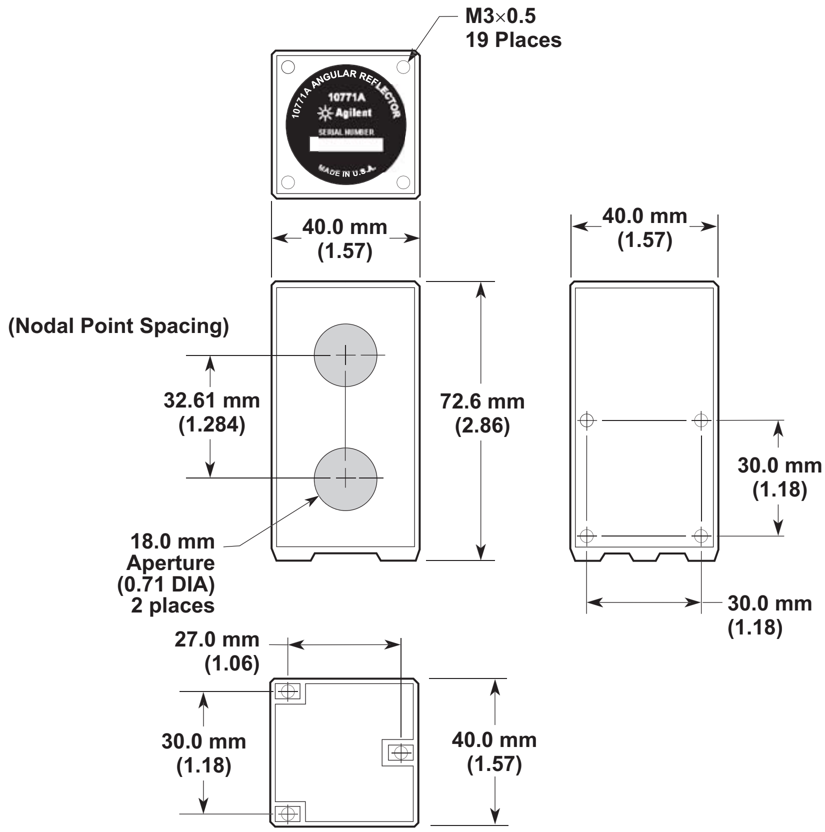


Figure 209 Agilent 10771A Angular Reflector

30
Agilent 10774A Short Range Straightness Optics and Agilent 10775A Long Range Straightness Optics

Introduction

Straightness measures displacement perpendicular to the axis of intended motion of the optics. The straightness measurement optics described in this chapter are designed for use in a calibrator system such as the Agilent 5529A/55292A. More detailed information about the use of these optics can be found in Agilent calibrator system user's documentation.

Agilent offers two different sets of straightness-measuring optics (see Figure 210):

- The Agilent 10774A Short Range Straightness Optics will measure straightness over a range of 0.1 meter to 3 meters (4 inches to 120 inches).
- The Agilent 10775A Long Range Straightness Optics will measure straightness over a range of 1 meter to 30 meters (3 feet to 100 feet).

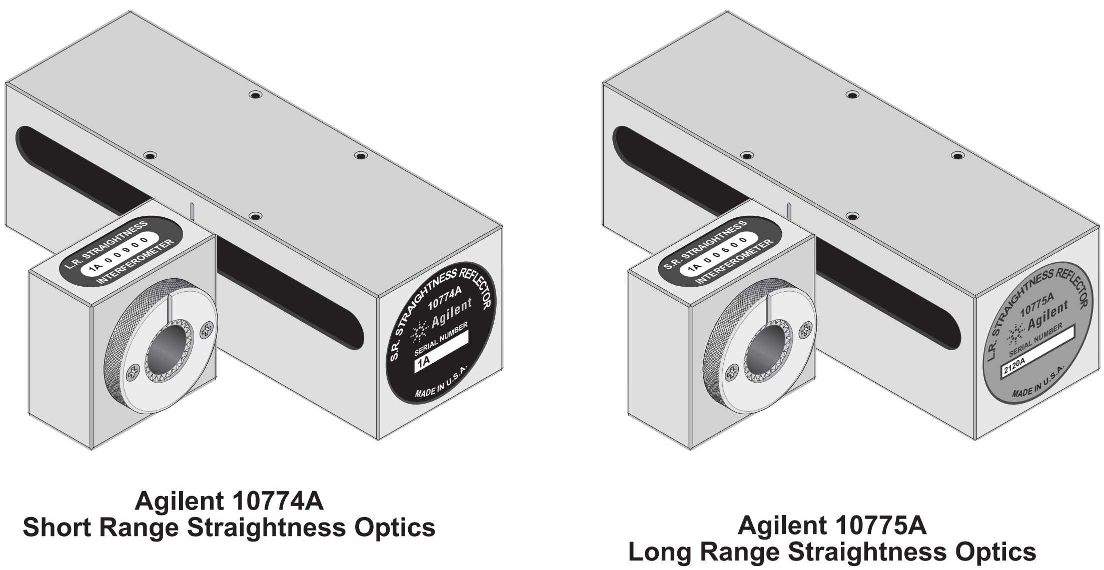


Figure 210 Straightness optics

The Agilent 10774A is available separately or as part of the Agilent 55283A Straightness Measurement Kit, which also includes the Agilent 10776A Straightness Accessory Kit, the Agilent 10772A Turning Mirror with Mount, and the Agilent 10787A Case.

This chapter describes only the basic measurements using the Agilent 10774A and Agilent 10775A straightness optics. For descriptions of other optics included in the Agilent 10776A kit, see the *Agilent 5529A/55292A Dynamic Calibrator Measurement Reference Guide*.

Squareness and Parallelism

A squareness measurement consists of two perpendicular straightness measurements made from the same straightness reflector.

Perpendicularity is achieved using the Agilent 10777A Optical Square. Squareness is calculated by adding or subtracting the slopes from each straightness measurement based on a right angle. For details, see the *Agilent 5529A/55292A Dynamic Calibrator Measurement Reference Guide*.

A parallelism measurement is similar to a squareness measurement, except that it does not use an optical square. A parallelism measurement consists of two straightness measurements made along the same axis from the same straightness reflector. Parallelism is calculated by comparing the slopes of the two straightness measurements. For details, see the *Agilent 5529A/55292A Dynamic Calibrator Measurement Reference Guide*.

Principles of Operation

Figure 211 shows the laser beam path in the straightness optics.

Initially, the two paths from the interferometer to the straightness reflector have the same length.

As the interferometer or reflector is moved along the axis of travel, without lateral motion, both of the beams between them will increase or decrease in length at the same rate. If either the interferometer or the reflector moves perpendicular to the intended axis of motion, the relative lengths of the two beams will change. The change in relative path lengths will be:

X	=	$2D \sin(\theta/2)$,
where D	=	the distance of offset (out of straightness),
θ	=	the angle between the two beams leaving the interferometer, and
X	=	the indicated change in path length

Then:

D	=	$X/2 \sin(\theta/2)$.
		the angle of the Short Range Interferometer is 1.5916 degrees.
		the angle of the Long Range Interferometer is 0.1592 degrees.

Thus, for short range optics, D = 36X, and for long range optics, D = 360X.

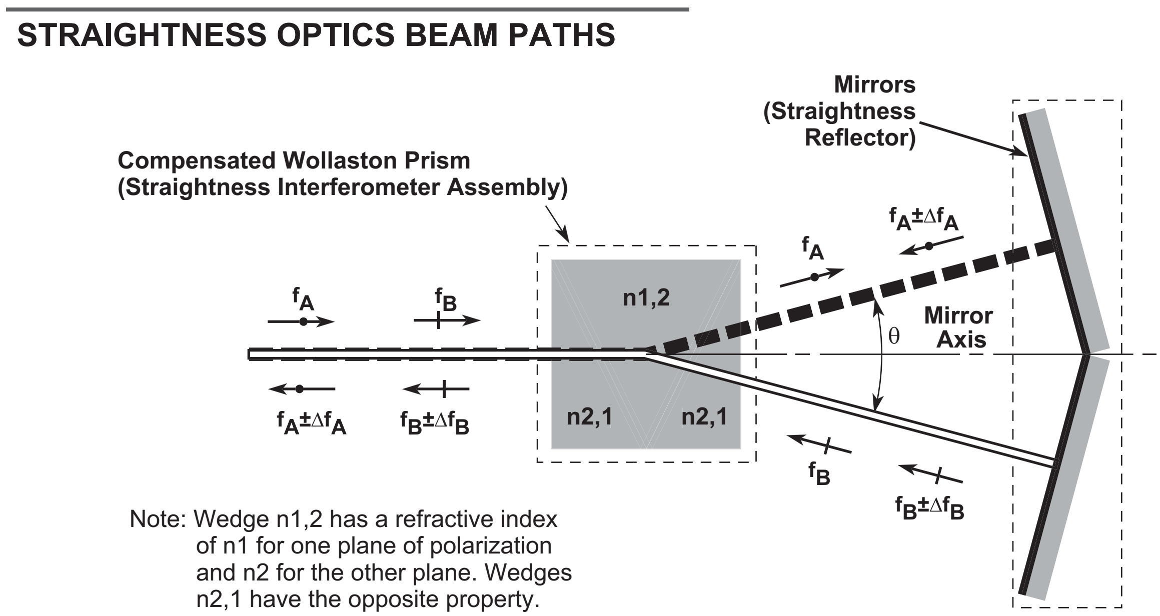


Figure 211 Straightness optics — beam paths

In practice, the interferometer angles can vary due to manufacturing tolerances. Therefore, the result must be multiplied by the calibration factor, K which is stamped on each interferometer. The final result is D = 36KX for short range optics and D = 360KX for long range optics.

Small pitch, yaw, or roll motions of the interferometer do not create a path difference and therefore do not affect the measurement accuracy.

This is an advantage of using the interferometer as the moving optic. The two return beams from the Straightness Reflector combine in the prism at the same point where the beam from the laser head was split. The combined beam is returned along the same path as the laser head's exit beam.

Installation and Alignment

Pre-installation checklist

In addition to reading chapters 2 through 4, and Chapter 12, “Accuracy and Repeatability,” complete the following items before installing a laser positioning system into any application.

- ☐ Complete Beam Path Loss Calculation (see Calculation of signal loss” in Chapter 3, “System Design Considerations,” in Volume I of this manual).
- ☐ Determine the direction sense for each axis, based on the orientation of the laser head, beam-directing optic, and interferometer. Enter the direction sense for each axis into the measurement system electronics. (See Chapter 16, “Laser Heads,” Chapter 11, “Principles of Operation”, and Chapter 12, “Accuracy and Repeatability,” in this manual.
- ☐ Provide for aligning the optics, laser head, and receiver(s) on the machine.

Alignment targets

To help in aligning the straightness interferometers, the alignment targets shown in Figure 212 are included with each.

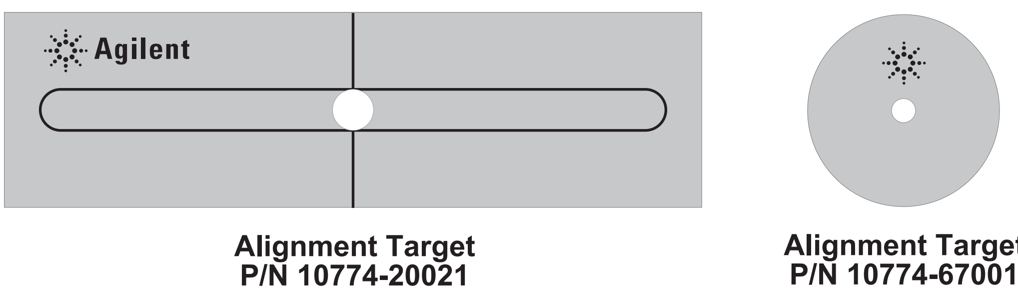


Figure 212 Alignment Targets for use with straightness interferometers

General considerations

1 Choose the optical configuration carefully for best results. The diagrams in figures 213 and 214 indicate which of the possible configurations are acceptable. The diagrams in figures 215 and 216 also indicate system performance based on minimizing power returned to the laser head (which can cause instability of the laser output) and maximizing power returned to the receiver.

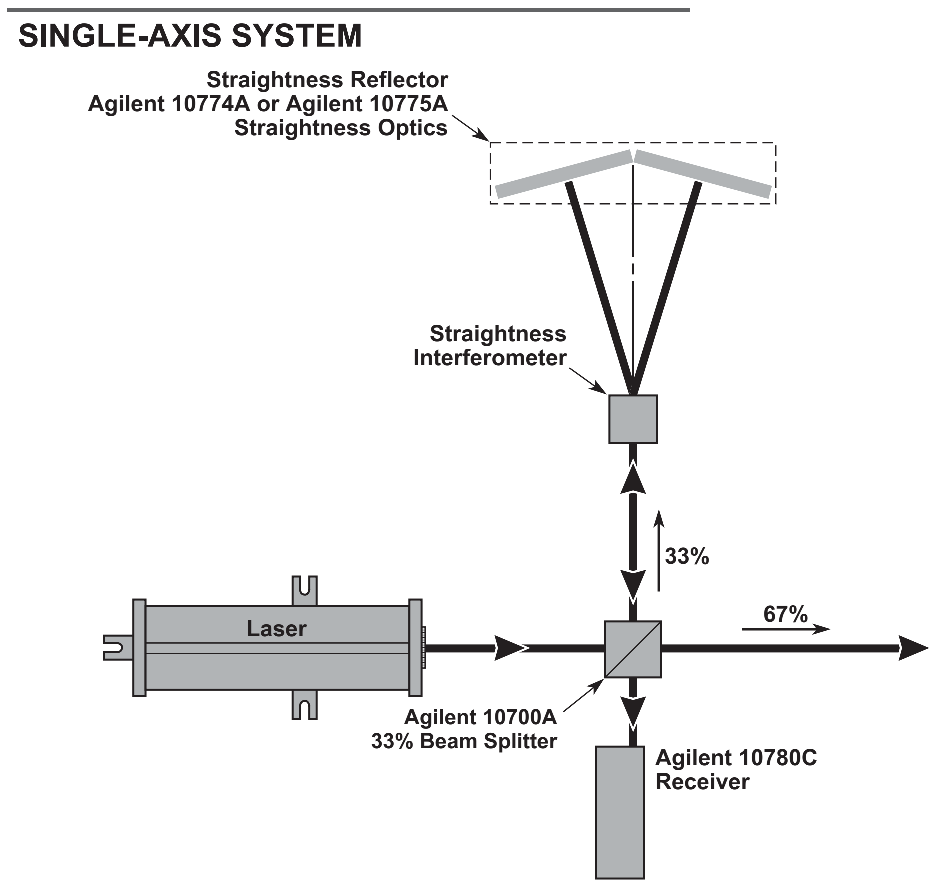
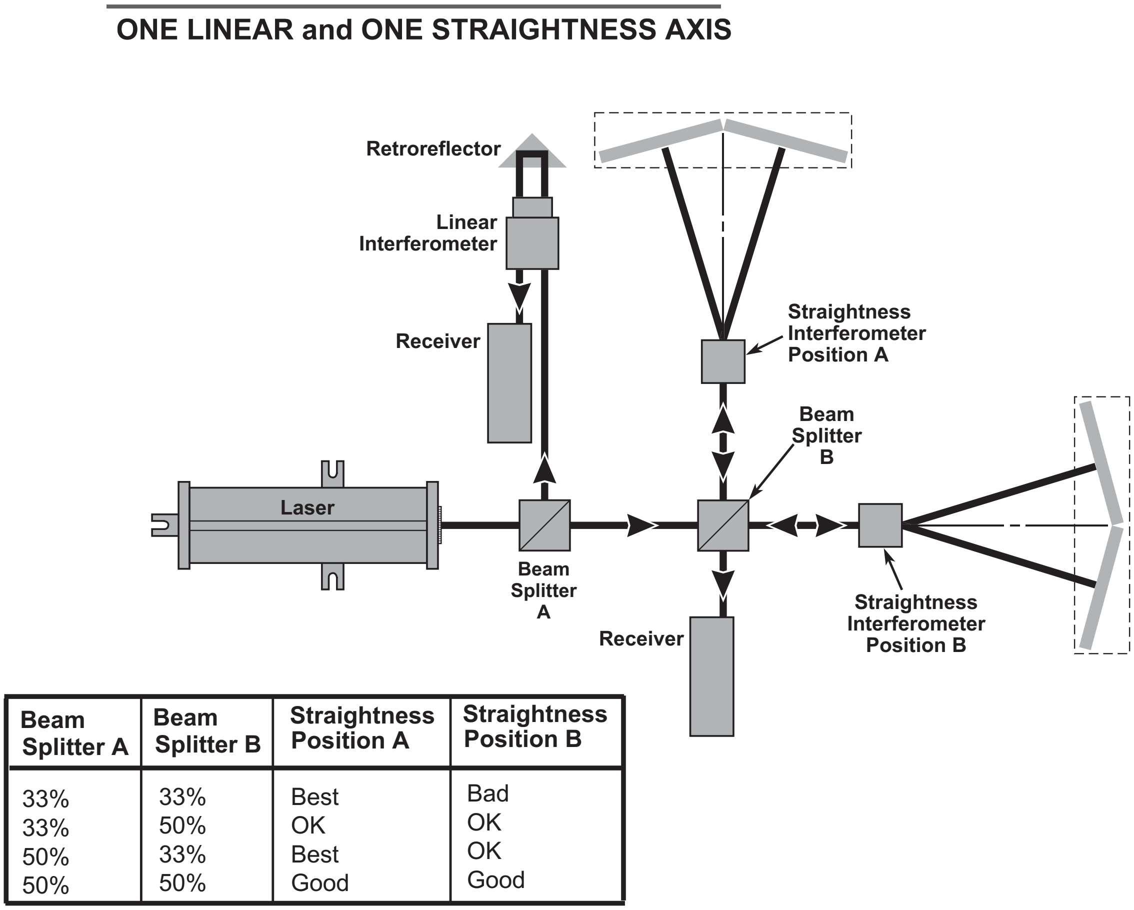


Figure 213 Single axis system



Beam Splitter A	Beam Splitter B	Straightness Position A	Straightness Position B
33%	33%	Best	Bad
33%	50%	OK	OK
50%	33%	Best	OK
50%	50%	Good	Good

Figure 214 One linear and one straightness axis

1 Supply a rigid mounting surface for both optical components. Fine position adjustments of both components will be necessary. The Straightness Reflector Mount gives full angular adjustment capability for the reflector.

2 The Straightness Interferometer must be located between the laser head (or beam-directing optic) and the Straightness Reflector.

3 The measurement beams are returned to the receiver. See the previous configuration diagrams.

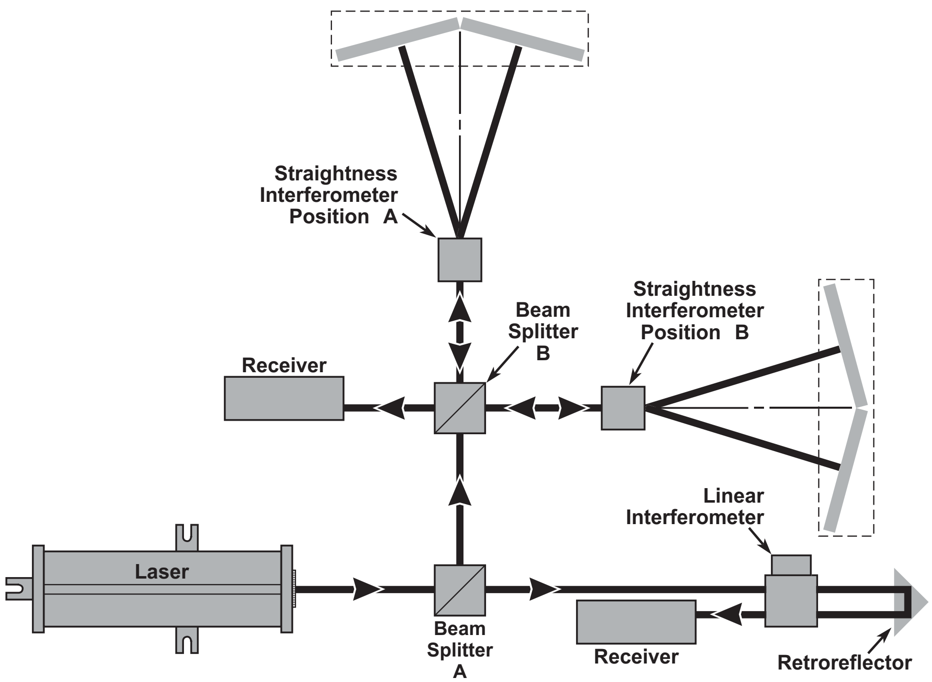
Principal alignment steps

The principal steps used to align the Straightness optics are listed below, followed by a detailed alignment procedure for a specific configuration.

1 The laser head and optics are mounted in the desired locations and the laser beams are visually aligned parallel to the axes of travel.

2 Align the laser beam parallel to the axis of travel by using the “Gunsight” or “Autoreflection” alignment method.

ONE LINEAR and ONE STRAIGHTNESS AXIS



Beam Splitter A	Beam Splitter B	Straightness Position A	Straightness Position B
33%	33%	OK	OK
33%	50%	Good	Good
50%	33%	OK	Best
50%	50%	Good	Good

Figure 215 One linear and one straightness axis

3 Align the Straightness Reflector so that its mirror axis (see Figure 211) is parallel to the laser beam and axis of travel. This mirror axis forms the optical straight-edge (analogous to traditional straight-edge).

4 Adjust the interferometer to align its optic to the reflector to obtain a measurement signal at the receiver (green LED is on).

5 Fine adjust the interferometer bezel and reflector to obtain maximum measurement signal at the receiver (monitor the voltage at the receiver test point).

6 Remove measurement slope. This slope refers to the angle inscribed by the mirror axis and the axis of travel (see Figure 219).

Alignment procedures

The following procedure describes the step-by-step alignment of an axis of straightness optics. Figure 213 shows the measurement setup with only the straightness axis shown.

1 With all optical components in place, visually align the laser beam parallel to the axis of travel. This may be done by blocking the laser beam with a piece of paper and moving this paper along the axis of travel while watching the beam creative to the axis.

2 Align the laser beam even closer to the axis of travel. This may be done by using the “Autoreflection” or “Gunsight” alignment method. Instructions for these methods are presented after this procedure.

   Refer to the basic explanation of this method in Chapter 4, “System Installation and Alignment,” in Volume I of this manual.

3 Remove the interferometer from its mount if not already done. Select the large aperture on the laser head by rotating the front turret. The laser beam should strike the center of the reflector. When properly centered the laser beam will be reflected back as two semicircles. See Figure 216.

4 Adjust the Straightness Reflector angularly (if using the Straightness Reflector Mount, adjust its micrometers) until the reflected semicircular dots are centered about the aperture of the beam splitter. Place a piece of cardboard, with a hole cut in the middle, between the beam splitter and the reflector. This will help locate these dots. The mirror axis of the reflector (the optical straight edge) should now be aligned parallel to the laser beam and the axis of travel.

5 Install the Straightness Interferometer so that it is centered about the laser beam. The interferometer should also be perpendicular to the laser beam. This may be done by autoreflecting off the front face with a gage block.

6 Rotate the Interferometer’s bezel to bring the scribed line parallel to the Straightness Reflector’s aperture slot. See Figure 217. Turn the bezel until the dots overlap on the reflector side of the interferometer. Use a card to locate the return beam and make the appropriate angular adjustments to

the reflector to get the beam back through the interferometer and the beam splitter.

7 Adjust the receiver position to center the laser beam in its aperture.

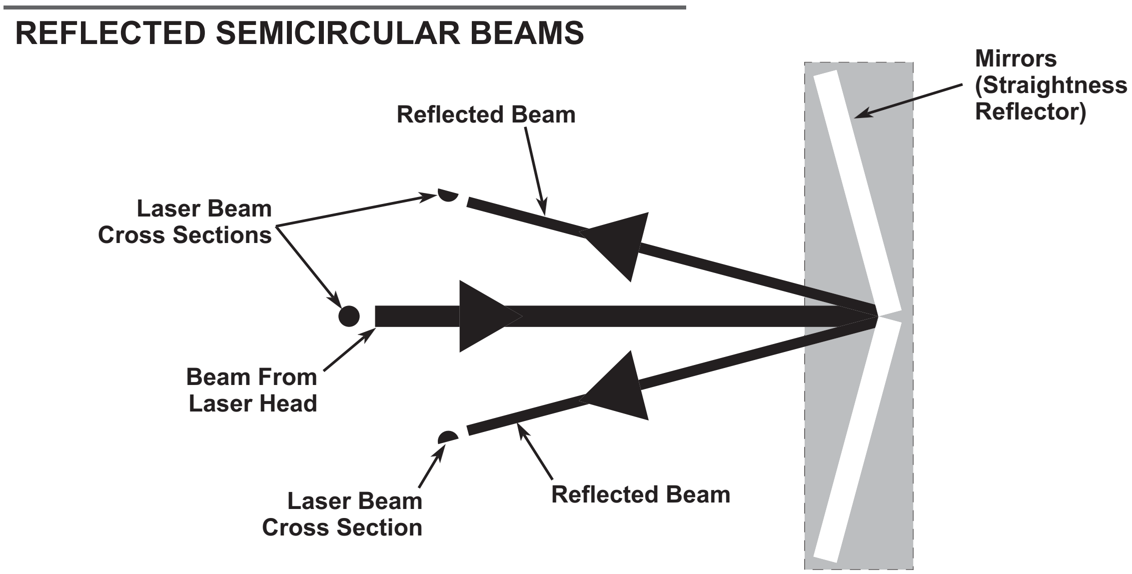


Figure 216 Reflected semicircular beams

a If the receiver LED is not on, carefully rotate the interferometer's bezel until the LED goes on. To maximize the receiver signal, attach a fast responding voltmeter or oscilloscope to the receiver test point and receiver case ground. Only very slight rotation of the bezel is required, typically less than 1 degree.

b Fine adjust the Interferometer's bezel and Reflector until the receiver test voltage is maximized. See Chapter 35, "Receivers," in this manual for the adjustment procedures of the Receiver.

c Move the optic over its full travel range, making sure that the receiver signal strength is adequate (0.7 to 1.3 Volts) over the entire travel range.

The straightness optics are now aligned. There may be further fine adjustment to be done, but first make several measurement passes and observe the data. If a steady change in the data occurs, rather than either a random scattering of numbers or a constant number, this indicates misalignment between the axis of travel and the reflector's mirror axis. See Figure 219 for an illustration of this error. This error is called "slope", and must be removed to obtain proper straightness information.

Autoreflection method

1 Remove the Straightness Interferometer from its mount surface.
2 Place a referenced mirror or gage block between the beam splitter and reflector so that the laser beam strikes its reflective surface.
3 Align the referenced mirror until its reflective surface is perpendicular to the axis of travel.
4 Select the small aperture on the laser head by rotating the front turret.
5 Adjust the laser beam angularly until the beam reflects back on itself from the referenced mirror and is centered on the small aperture of the laser head. Make sure that the laser beam is centered over the intended measurement axis.
6 Lock down the laser head and beam splitter securely. Make sure not to disturb the alignment. Remove the referenced mirror.
7 Orient the Straightness Reflector horizontally or vertically to match the type of measurement to be made (horizontal or vertical straightness).
8 Center the reflector about the laser beam. The laser beam should strike centered between the two mirrors in the reflector. The laser beams should now be aligned parallel to the axis of travel.

This ends the “Autoreflection” alignment method.

Gunsight method

1 Position the optics for their near-end of travel, that is when the interferometer and reflector are nearest each other. For short range measurements this should be about 100 mm (4 inches). For long range measurements this should be about 1 meter (3 feet).
2 Orient the Straightness Reflector horizontally or vertically to match the type of measurement to be made (horizontal or vertical straightness).
3 Select the small aperture on the laser head by rotating the front turret.
4 Attach the round target (supplied with the straightness optics) to the entrance face of the interferometer. Make sure that the target is centered over the interferometer bezel.
5 Adjust the interferometer (or laser beam) so the laser beam goes through the target's hole. The interferometer should be mounted perpendicular to the laser beam. This may be done by autoreflecting off the front face with a gage block.
6 Rotate the interferometer’s bezel until the bezel’s scribe line (see Figure 217) is oriented perpendicular to the aperture slot on the Straightness reflector. Two beams should now exit the interferometer in a plane perpendicular to the aperture slot on the reflector.

AGILENT 10774A OR HP 10775A STRAIGHTNESS INTERFEROMETER

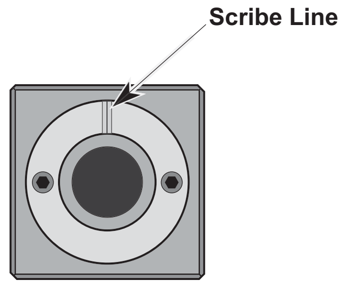


Figure 217 Agilent 10774A or Agilent 10775A Interferometer scribe line

7 Position the reflector so that the two dots are located over the scribed center-line of the reflector housing and the face is square relative to the incoming beam. See Figure 217.

8 Move the optics to their far-end of travel.

9 Realign the laser beam, in this case by using the 33% beam splitter, so that the two dots are located over the scribed center-line of the reflector housing. See Figure 218.

   Since the dots will move apart as the optics move, you may have to hold a card on each side of the reflector's slot to follow their movement. The beam splitter may need to be translated to re-center the laser beam in the interferometer target. The laser beam should now be aligned parallel to the axis of travel.

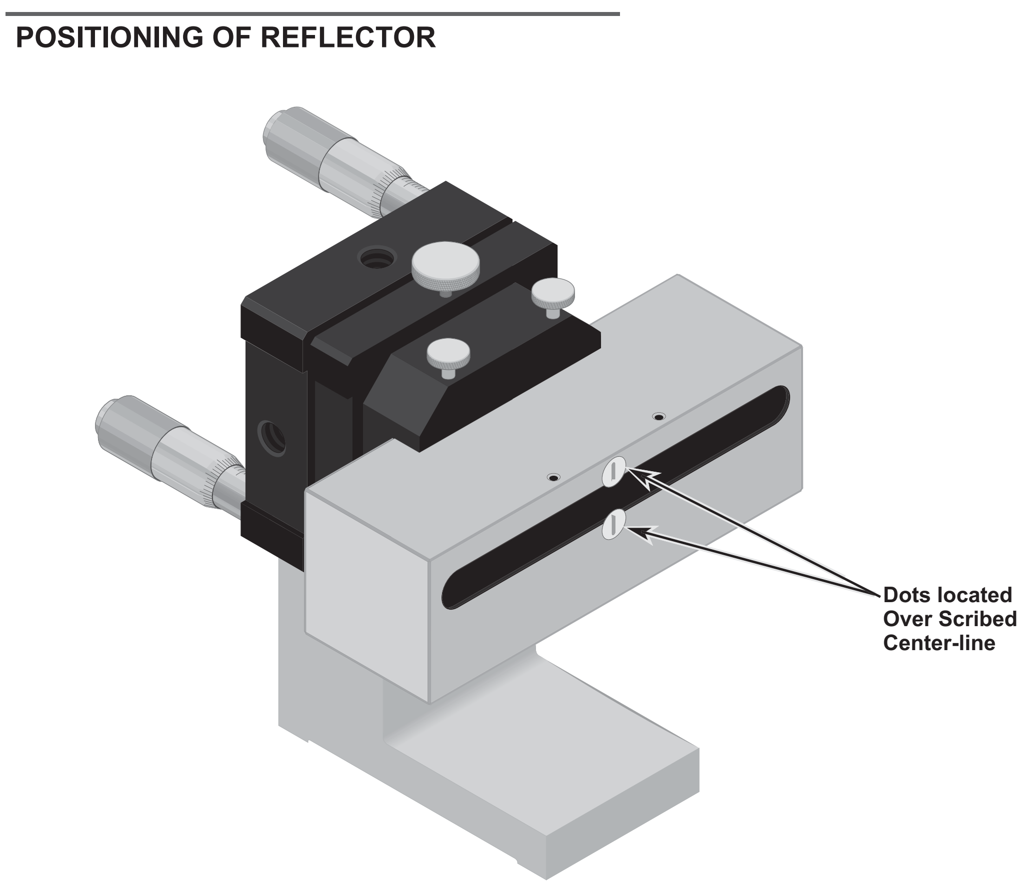


Figure 218 Initial Positioning of Reflector

This ends the “Gunsight method” alignment method.

Slope removal

The slope should be removed as much as possible by readjusting the Straightness Reflector’s mirror axis. Slope removal is typically required only for the short range optics because long range alignment is normally more accurate. Slope removal can be done by the following procedure.

1 Reset the measurement (reset the counter to zero) with the optics at the near-end of travel.

2 Move the optics to the far-end of travel and note the last data point (see Figure 219).

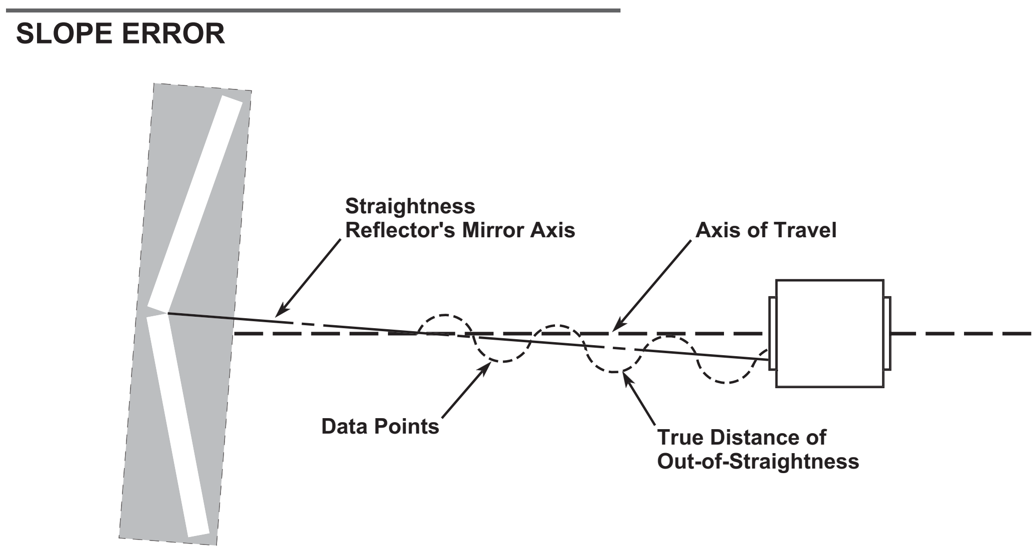


Figure 219 Slope Error

3 Adjust the reflector (if using the straightness mount, adjust the micrometer) in the plane of the reflector's aperture slot to cause the straightness measurement to change to the following calculated value.:

x	=	(r/s)d
where x	=	the new value
r	=	distance between optics at near-end of travel,
s	=	distance of moving optic at far-end of travel, and
d	=	old value read.

See Figure 220 for a representation of this.

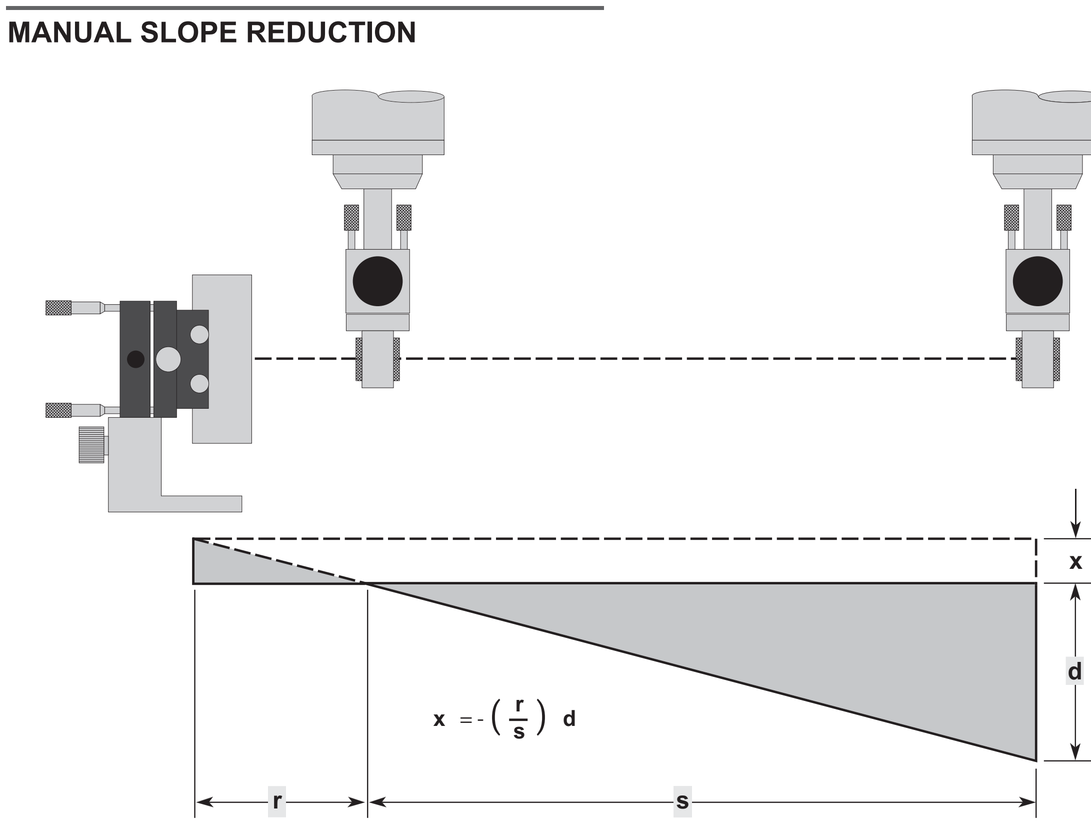


Figure 220 Manual Slope Reduction

4 Reset the measurement again, and return the optics to the near-end of travel.

5 If the signal strength gets too low, adjust the laser beam to achieve peak signal strength.

6 Repeat steps a through e as often as necessary to make the straightness measurement at both ends of travel to be near “zero”.

The alignment procedure for the straightness optics is now complete.

Operation

When taking straightness data, there will still be some residual slope that has not been removed. During data reduction the best-fit straight line should be determined and the straightness errors recalculated based on that line.

Accuracy considerations

There are several sources of error under the control of the operator.

- The calibration factor on the interferometer must be used to obtain the correct value. Multiply the measured value by the interferometer calibration factor number to get the correct straightness.
- The optical reference accuracy term can be eliminated by rotating the mirror 180° and making another measurement.
- The slope must be removed manually or in software.
- Environmental conditions (such as temperature changes of the machine or optics, vibration, and air turbulence) can cause errors.

Errors due to thermal expansion can be minimized by allowing the machine and optics to reach thermal equilibrium before making a measurement.

The effects of vibration can be reduced by good fixturing, averaging successive runs, reducing the slew rate, and more accurate manual slope removal.

Air turbulence effects can be minimized by using baffles, while thermal gradient effects can be minimized by mixing the air with fans.

Specifications

Specifications describe the device’s warranted performance. Supplemental characteristics (indicated by TYPICAL or NOMINAL) are intended to provide non-warranted performance information useful in applying the device.

Agilent 10774A Short Range Straightness Optics and Agilent 10775A Long Range Straightness Optics Specifications

ACCURACY:

Overall accuracy =

Optical Reference Accuracy + Measurement Accuracy

(This is analogous to the traditional straight-edge and indicator method of measuring straightness, where Optical Reference Accuracy corresponds to the straight-edge accuracy, and Measurement Accuracy corresponds to the indicator accuracy.)

OPTICAL REFERENCE ACCURACY:

This can be eliminated by using straight-edge (mirror) reversal techniques.

Short Range Optics:

Metric Units Mode: ±0.15 M^2 micron

English Units Mode: ±0.5 F^2 microinch

where M = distance of travel of the moving optic in meters, and

F = distance of travel of the moving optic in feet.

Long Range Optics:

Metric Units Mode: ±0.015 M^2 micron

English Units Mode: ±0.5 F^2 microinch

where M = distance of travel of the moving optic in meters, and

F = distance of travel of the moving optic in feet.

MEASUREMENT ACCURACY:

Short Range Optics

Temperature Range	Displayed Value	
	0-10 µm (0-400 µin)	**10-1500 µm (400-60000 µin)**
15-26 °C	±3.5%	±1 ±0.25µm (10 µin)
0-40 °C	±6%	±1% ±0.5µm (20 µin)

Long Range Optics

Temperature Range	Displayed Value	
	0-100 µm (0-4000 µin)	**100-1500 µm (400-60000 µin)**
15-26 °C	±3.5%	±1 ±0.25µm (10 µin)
0-40 °C	±6%	±1% ±0.5µm (20 µin)

STRAIGHTNESS MEASUREMENT RESOLUTION:

	Basic	
Short Range Optics:	.35 micron (14.0 microinches)	0.01 micron (0.4 microinch)
Long Range Optics:	3.6 microns (140 microinches)	0.01 micron (4.0 microinch)

STRAIGHTNESS MEASUREMENT RANGE: ±1.5 mm 0.060 in.

AXIAL SEPARATION:

(Typical, with proper alignment, 15-25° C, distance between the interferometer and reflector)

Short Range Optics: 0.1-3 m (4-120 in)

Long Range Optics: 1-30 m (3-100 feet)

Dimensions: see Figure 221 on next page

Weight:

Straightness Interferometer: 164 grams (5.8 ounces)

Straightness Reflector: 800 grams (28.2 ounces)

Materials Used:

Housing: Stainless Steel (416)

Apertures: Plastic (Nylon)

Optics: Optical Grade Glass

Adhesives: Low Volatility (Vacuum Grade)

Optical Efficiency: 90% (Worst Case)

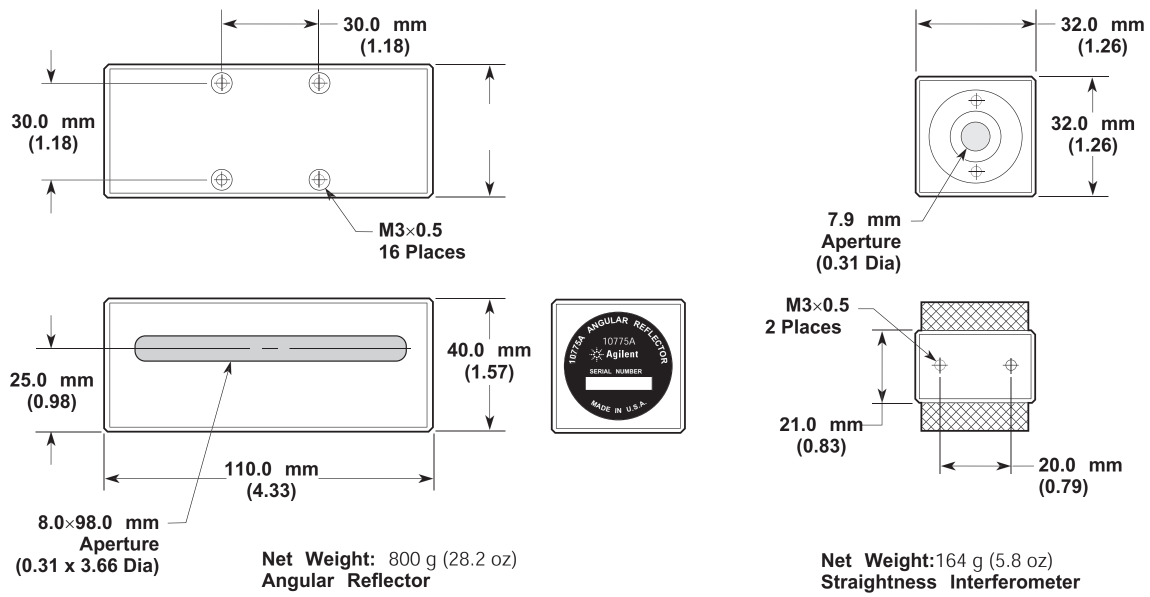


Figure 221 Agilent 10774A Short Range Straightness optics and Agilent 10775A Long Range Straightness optics

31
Agilent E1826E/F/G One-Axis Plane Mirror Interferometer

Description

NOTE See Chapter 6, "NGI Measurement Optics (General Information)," in Volume I of this manual for general description, and alignment and mounting procedures.

The Agilent E1826E/F/G One-Axis Plane Mirror Interferometer provides one measurement (displacement).

The Agilent E1826E interferometer has a right turn configuration design (see figures 222 and 223).

The Agilent E1826F interferometer has a left turn configuration design (see figures 224 and 225).

The Agilent E1826G interferometer has a straight-through configuration design (see figures 226 and 227).

The Agilent E1826E/F/G interferometer can be mounted using three screws in either the upright or hanging position.

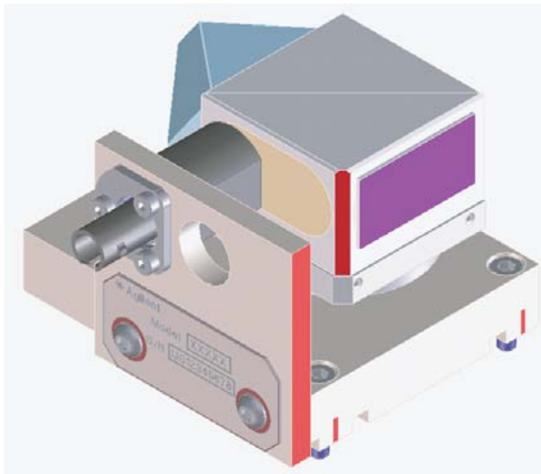


Figure 222 Agilent E1826E One-Axis Plane Mirror Interferometer

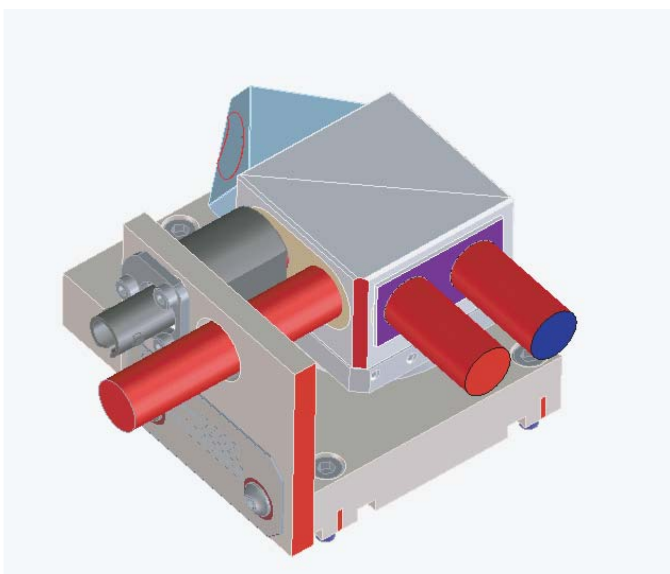


Figure 223 Agilent E1826E One-Axis Plane Mirror Interferometer — beams shown

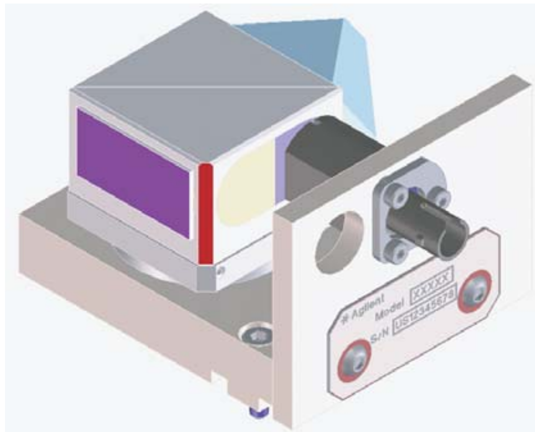


Figure 224 Agilent E1826F One-Axis Plane Mirror Interferometer

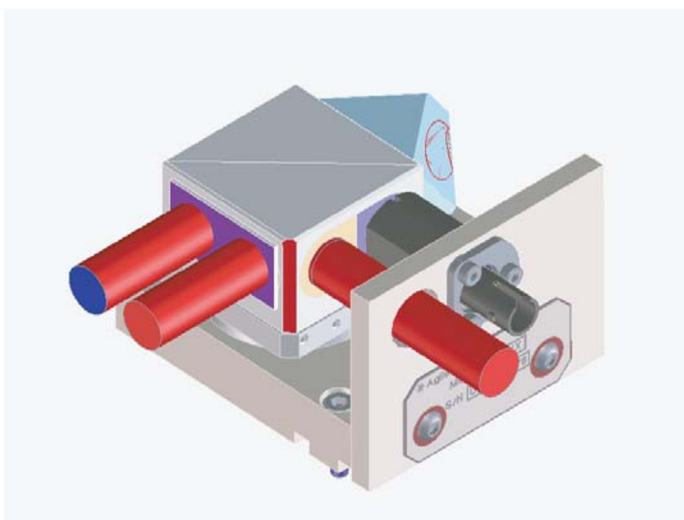


Figure 225 Agilent E1826F One-Axis Plane Mirror Interferometer — beams shown

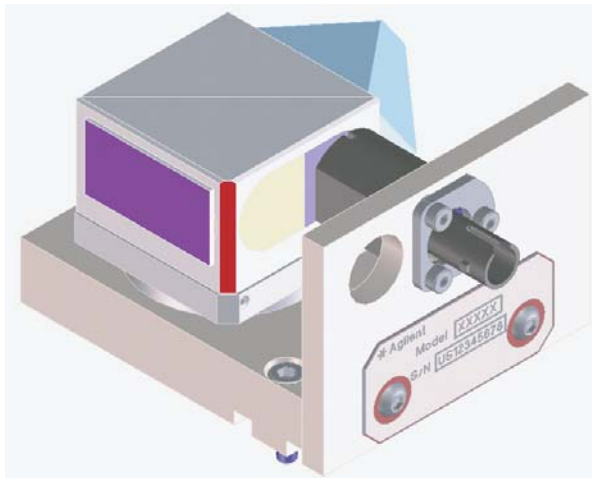


Figure 226 Agilent E1826G One-Axis Plane Mirror Interferometer

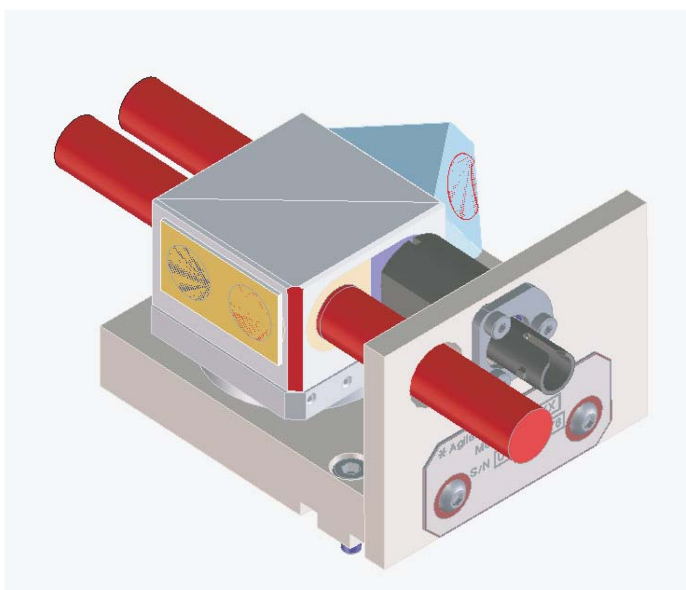


Figure 227 Agilent E1826G One-Axis Plane Mirror Interferometer — beams shown

These interferometers are not meant to be the replacements for the Agilent 10706A/B. Different from the Agilent 10706A/Bs, these interferometers have ST connectors pre-aligned at the factory so the customer needs only to connect the fibers that can be obtained at Agilent. Either glass or plastic fibers can be used. Contact Agilent for your requirements. If an ST type bulk head feed-through is necessary for connecting the fibers, customers can use AMP’s 504021-1 Fiber Optic Connectors ST Coupling Receptacle.

Available Options

Table 76 lists the options that are available for the Agilent E1826E/F/G Interferometer.

Table 76 Available options for Agilent E1826E/F/G

Agilent Product Numbers	Product Name
082/083	082: With installation cover (standard configuration) 083: Without installation cover
090/091	090: With reference mirror installed (standard configuration) 091: Without reference mirror installed
070/071	070: Invar base plate (standard configuration) 071: SS416 base plate

Agilent E1826E One-Axis Plane Mirror Interferometer Specifications

Weight:	0.40 kg (.89 lbs)	**Thermal Drift due to Glass Path Imbalance:**	< 10 nm/°C
Dimensions:	See Figure 228 on page 642	**Non-linearity Error:**	± 1 nm
Glass Dimensions:	See Figure 231 on page 647	**Output Efficiency**	
Materials:		Typical	65%
Baseplate	Invar (Option 070), Passivated 416 Stainless Steel (Option 071)	Worst case	50%
Coefficient of Thermal Expansion	1.5×10^{-6} mm/mm/°C (Invar), 9.9×10^{-6} mm/mm//°C (SS416)	**Measure Point Tolerance:**	± 0.15 mm
Optics	BK-7	**Input Beam Cone Angle (IBCA):**	<1 mrad
Natural Frequency	~ 1 kHz	**Operating Temperature:**	19 to 26 °C
Mounting Interface		**Measurement and Reference Mirror Recommendations:**	
Fasteners	3 × M3 Socket Head Captive Screw (SHCS)	Reflectivity	>92%
Surface Profile	0.02 mm	Flatness	λ/20
Surface Finish	0.4 µm		
Beam Diameter:	ϕ 9 mm, maximum (visible)		
Resolution:			
Optical	λ/4		
Linear[1]	0.62 nm (using 256 × resolution extension) 0.15 nm (using 1024 × resolution extension)		
Angular (pitch or roll)[1]			
See "NGI Angular Resolution" section in Chapter 6, "NGI Measurement Optics (General Information)," in Volume I of this manual for explanation of angular resolution.			

[1] Linear and angular resolutions are dependent on the electronics used. Optical resolution is dependent only on the interferometer, and can be used to determine linear and angular resolutions when the electronic resolution extension is known. The linear and angular specifications in this section are for interferometer use with the X256 resolution extension electronics (10897B/C, 10898A) or X1024 resolution extension electronics (N1231B, N1225A).

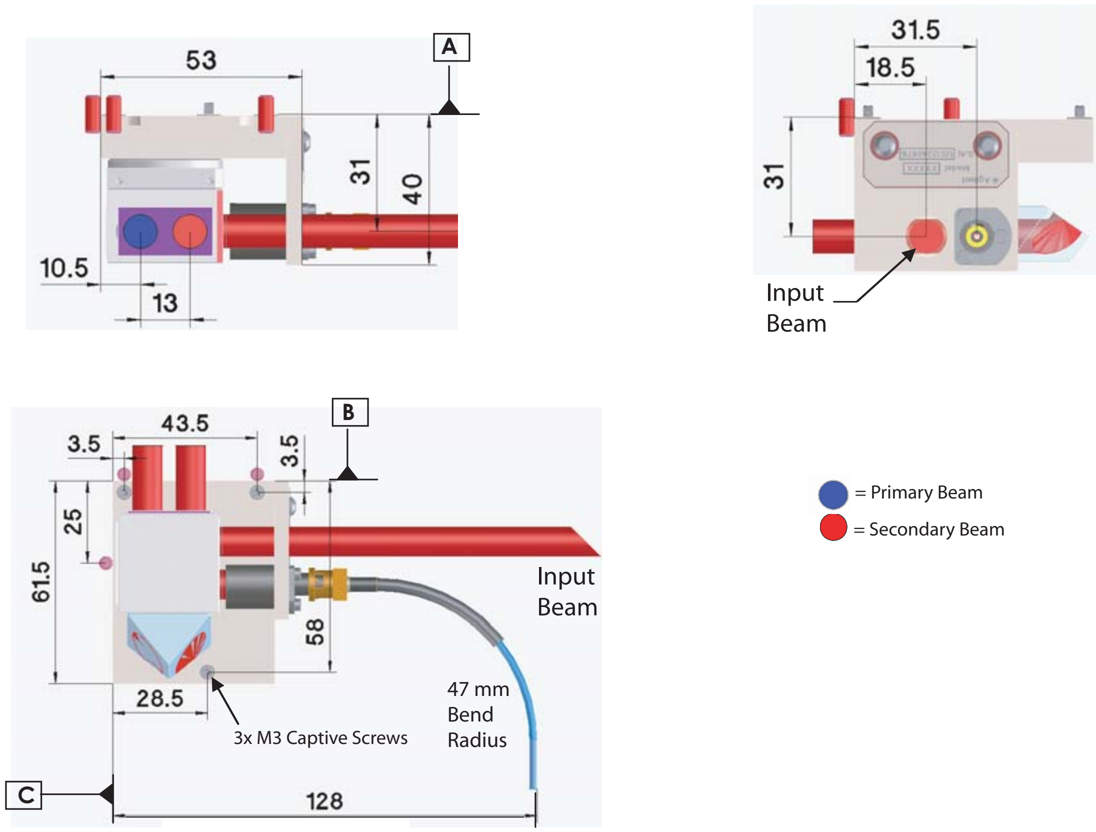


Figure 228 Agilent E1826E One-Axis Plane Mirror Interferometer (right turn) — dimensions and beam pattern

Agilent E1826F One-Axis Plane Mirror Interferometer Specifications

Weight:	0.41 kg (.91 lbs)
Dimensions:	See Figure 229 on page 644
Glass Dimensions:	See Figure 231 on page 647
Materials:	
Baseplate	Invar (Option 070), Passivated 416 Stainless Steel (Option 071)
Coefficient of Thermal Expansion	1.5×10^{-6} mm/mm/°C (Invar), 9.9×10^{-6} mm/mm//°C (SS416)
Optics	BK-7
Natural Frequency	~ 1 kHz
Mounting Interface	
Fasteners	3 × M3 Socket Head Captive Screw (SHCS)
Surface Profile	0.02 mm
Surface Finish	0.4 µm
Beam Diameter:	ϕ 9 mm, maximum (visible)
Resolution:	
Optical	λ/4
Linear[1]	0.62 nm (using 256 × resolution extension) 0.15 nm (using 1024 × resolution extension)
Angular (pitch or roll)[1]	

See “NGI Angular Resolution” section in Chapter 6, “NGI Measurement Optics (General Information),” in Volume I of this manual for explanation of angular resolution.

Thermal Drift due to Glass Path Imbalance:	< 10 nm/°C
Non-linearity Error:	± 1 nm
Output Efficiency	
Typical	65%
Worst case	50%
Measure Point Tolerance:	± 0.15 mm
Input Beam Cone Angle (IBCA):	<1 mrad
Operating Temperature:	19 to 26 °C
Measurement and Reference Mirror Recommendations:	
Reflectivity	>92%
Flatness	λ/20

[1] Linear and angular resolutions are dependent on the electronics used. Optical resolution is dependent only on the interferometer, and can be used to determine linear and angular resolutions when the electronic resolution extension is known. The linear and angular specifications in this section are for interferometer use with the X256 resolution extension electronics (10897B/C, 10898A) or X1024 resolution extension electronics (N1231B, N1225A).

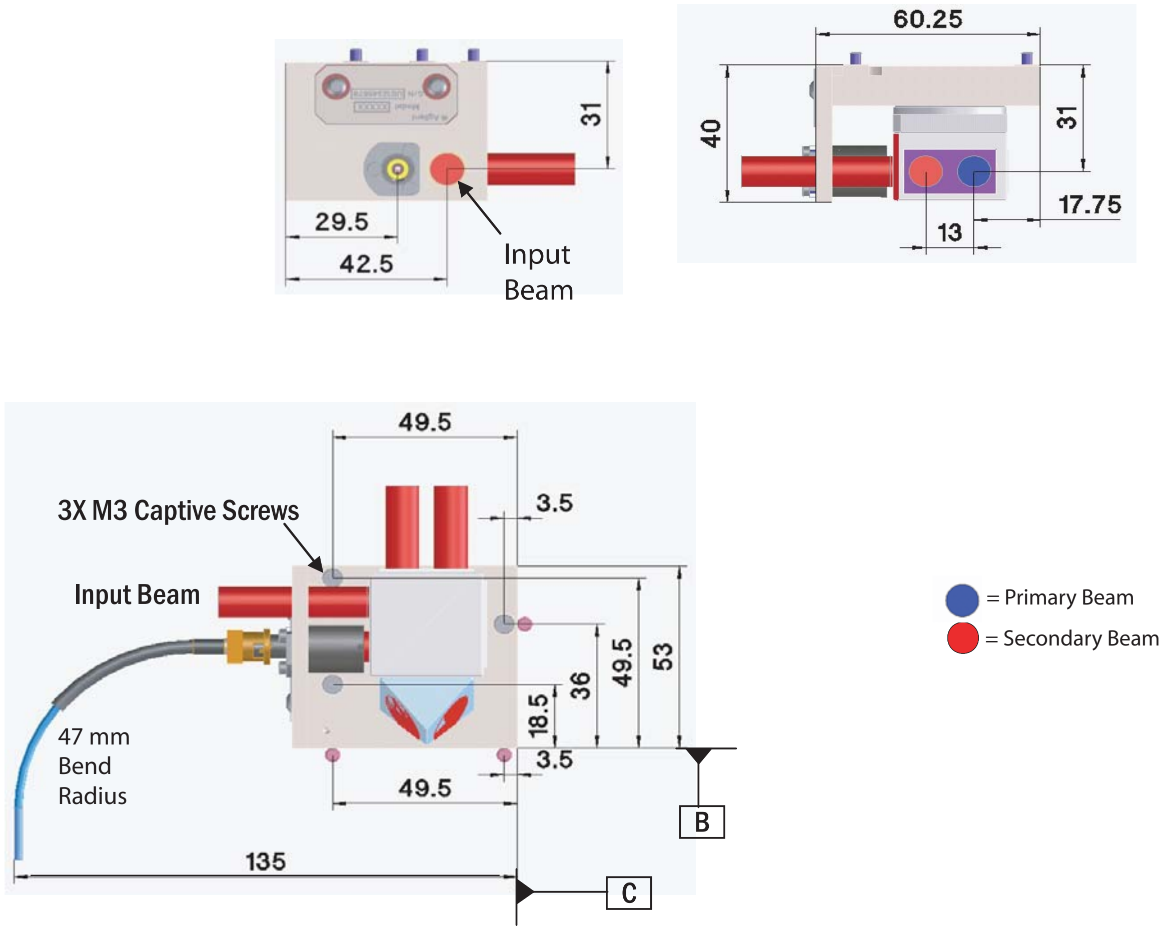


Figure 229 Agilent E1826F One-Axis Plane Mirror Interferometer (left turn) — dimensions and beam pattern

Agilent E1826G One-Axis Plane Mirror Interferometer Specifications

Weight:	0.41 kg (.91 lbs)
Dimensions:	See Figure 230 on page 646
Glass Dimensions:	See Figure 231 on page 647
Materials:	
Baseplate	Invar (Option 070), Passivated 416 Stainless Steel (Option 071)
Coefficient of Thermal Expansion	1.5×10^{-6} mm/mm/°C (Invar), 9.9×10^{-6} mm/mm//°C (SS416)
Optics	BK-7
Natural Frequency	~ 1 kHz
Mounting Interface	
Fasteners	3 × M3 Socket Head Captive Screw (SHCS)
Surface Profile	0.02 mm
Surface Finish	0.4 µm
Beam Diameter:	ϕ 9 mm, maximum (visible)
Resolution:	
Optical	λ/4
Linear[1]	0.62 nm (using 256 × resolution extension) 0.15 nm (using 1024 × resolution extension)
Angular (pitch or roll)[1]	

See "NGI Angular Resolution" section in Chapter 6, "NGI Measurement Optics (General Information)," in Volume I of this manual for explanation of angular resolution.

Thermal Drift due to Glass Path Imbalance:	< 10 nm/°C
Non-linearity Error:	± 1 nm
Output Efficiency	
Typical	65%
Worst case	50%
Measure Point Tolerance:	± 0.15 mm
Input Beam Cone Angle (IBCA):	<1 mrad
Operating Temperature:	19 to 26 °C
Measurement and Reference Mirror Recommendations:	
Reflectivity	>92%
Flatness	λ/20

[1] Linear and angular resolutions are dependent on the electronics used. Optical resolution is dependent only on the interferometer, and can be used to determine linear and angular resolutions when the electronic resolution extension is known. The linear and angular specifications in this section are for interferometer use with the X256 resolution extension electronics (10897B/C, 10898A) or X1024 resolution extension electronics (N1231B, N1225A).

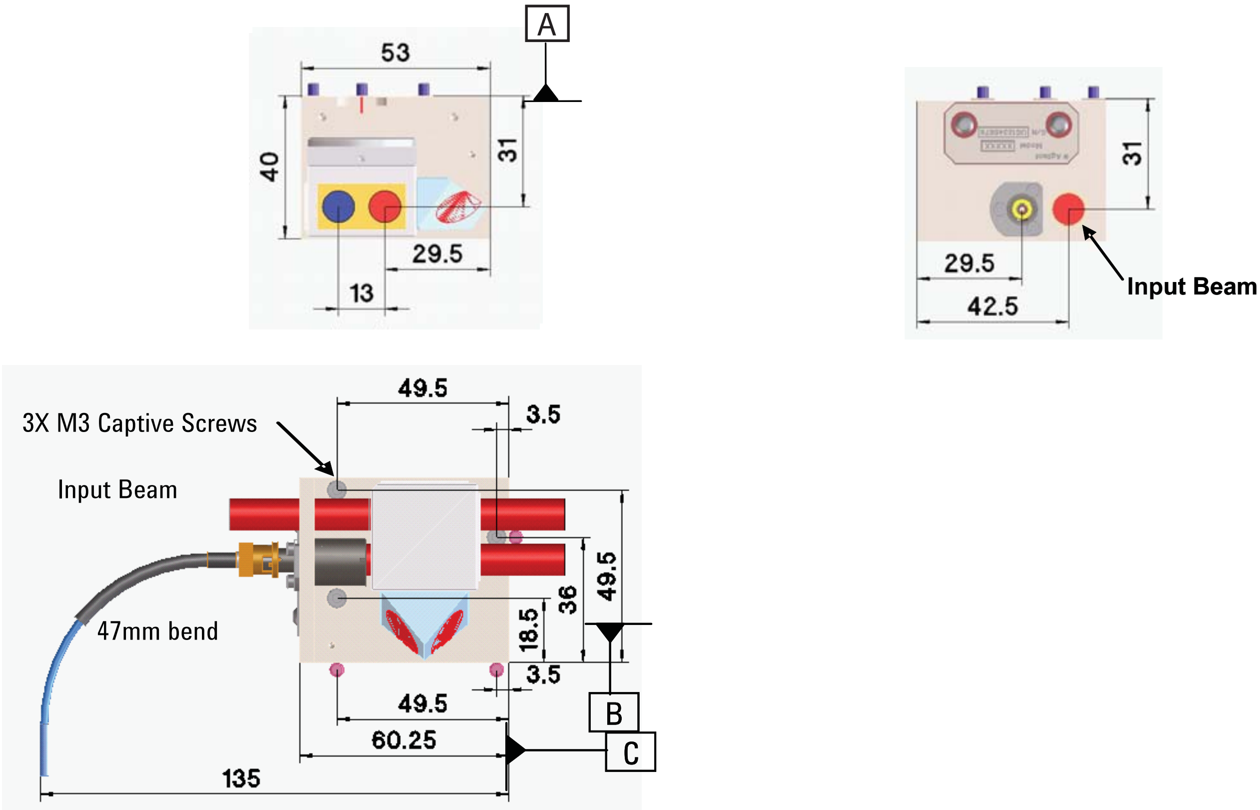


Figure 230 Agilent E1826G One-Axis Plane Mirror Interferometer (straight through) — dimensions and beam pattern

Agilent E1826E/F/G glass dimensions

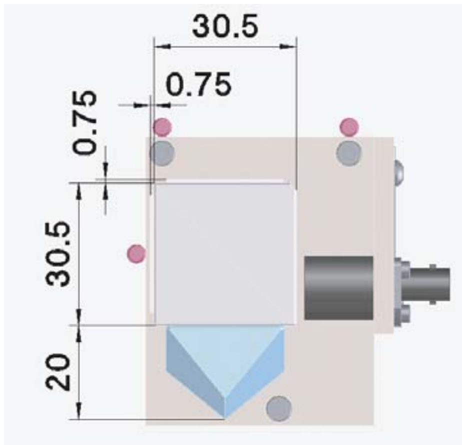


Figure 231 Agilent E1826E/F/G glass dimensions

32
Agilent E1827A Two-Axis Vertical Beam Interferometer

Description

NOTE

See Chapter 6, “NGI Measurement Optics (General Information),” in Volume I of this manual for general description, and alignment and mounting procedures.

The Agilent E1827A Two-Axis Interferometer is described in this chapter. The interferometer uses the compact monolithic interferometer (MIF) design. The outputs of the interferometer are coupled to a 400-micron fiber with an ST connector and NA of 0.39.

The Agilent E1827A interferometer (see figures 232 and 233) produces a two-axis set of beams used for measurements of translation along or rotation around an axis of motion.

The Agilent E1827A interferometer can be mounted using three screws in either the upright or hanging position.

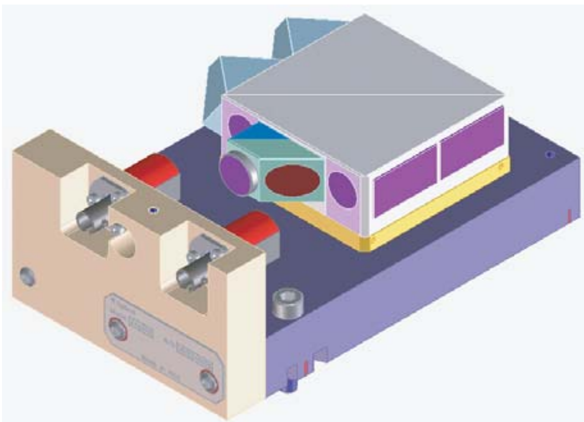


Figure 232 Agilent E1827A Two-Axis Interferometer

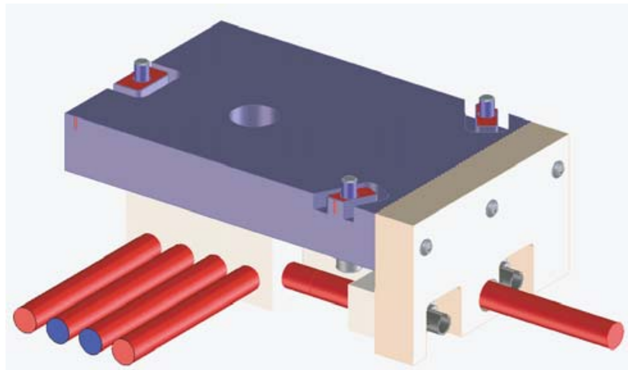


Figure 233 Agilent E1827A Two-Axis Beam Interferometer — beams shown

Agilent E1827A Beam Pattern, Spacing, and Labels

Figure 234 shows the beam pattern and spacing of the Agilent E1827A interferometer, viewing from the stage to the interferometer position.

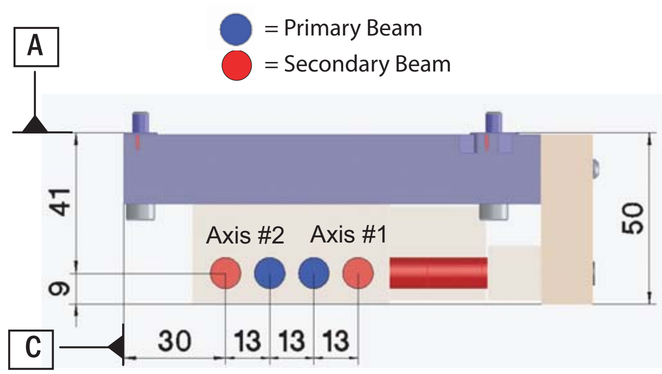


Figure 234 Agilent E1827A beam labels and relative positions

Agilent E1827A Two-Axis Interferometer Specifications

Weight:	2.35 kg (5.22 lbs)
Dimensions:	See Figure 235 on page 654
Glass Dimensions:	See Figure 236 on page 655
Materials:	
Baseplate	Passivated 416 Stainless Steel
Coefficient of Thermal Expansion	9.9×10^{-6} /°C
Optics	BK-7
Resonance Frequency	~1kHz
Mounting Interface	
Fasteners	M5 x 0.8 Socket Head Captive Screw (SHCS)
Surface Profile	0.02 mm
Surface Finish	0.4 µm
Beam Diameter:	ϕ 9 mm, maximum (visible)
Resolution:	
Optical	λ/4
Linear[1]	0.62 nm (using 256 × resolution extension) 0.15 nm (using 1024 × resolution extension)
Angular (yaw)[1]	

See “NGI Angular Resolution” section in Chapter 6, “NGI Measurement Optics (General Information),” in Volume I of this manual for explanation of angular resolution.

Thermal Drift due to Glass Path Imbalance:	≤ 10nm/°C
Non-linearity Error:	± 1 nm
Output Efficiency:	
Typical of all axes	26%
Worst case for all axes	19%
Measure Point Tolerance[2]:	
Mean	± 0.15 mm
Deviation	± 0.05 mm
Input Beam Cone Angle (IBCA):	< 1 mrad
Beam Parallelism[3]:	Figure 234 on page 652
Axis #1 - Axis #2	<25 µrad
Operating Temperature Range	19 to 26 °C
Measurement and Reference Mirror Recommendations:	
Reflectivity	>92%
Flatness	λ/20

[1] Linear and angular resolutions are dependent on the electronics used. Optical resolution is dependent only on the interferometer, and can be used to determine linear and angular resolutions when the electronic resolution extension is known. The linear and angular specifications in this section are for interferometer use with the X256 resolution extension electronics (10897B/C, 10898A) or X1024 resolution extension electronics (N1231B, N1225A).

[2] See “Measure Point Tolerance” in Chapter 6 of Volume I of this manual for a description of these tolerances.

[3] Beam Parallelism is specified between primary beams. See Figure 234 on page 652.

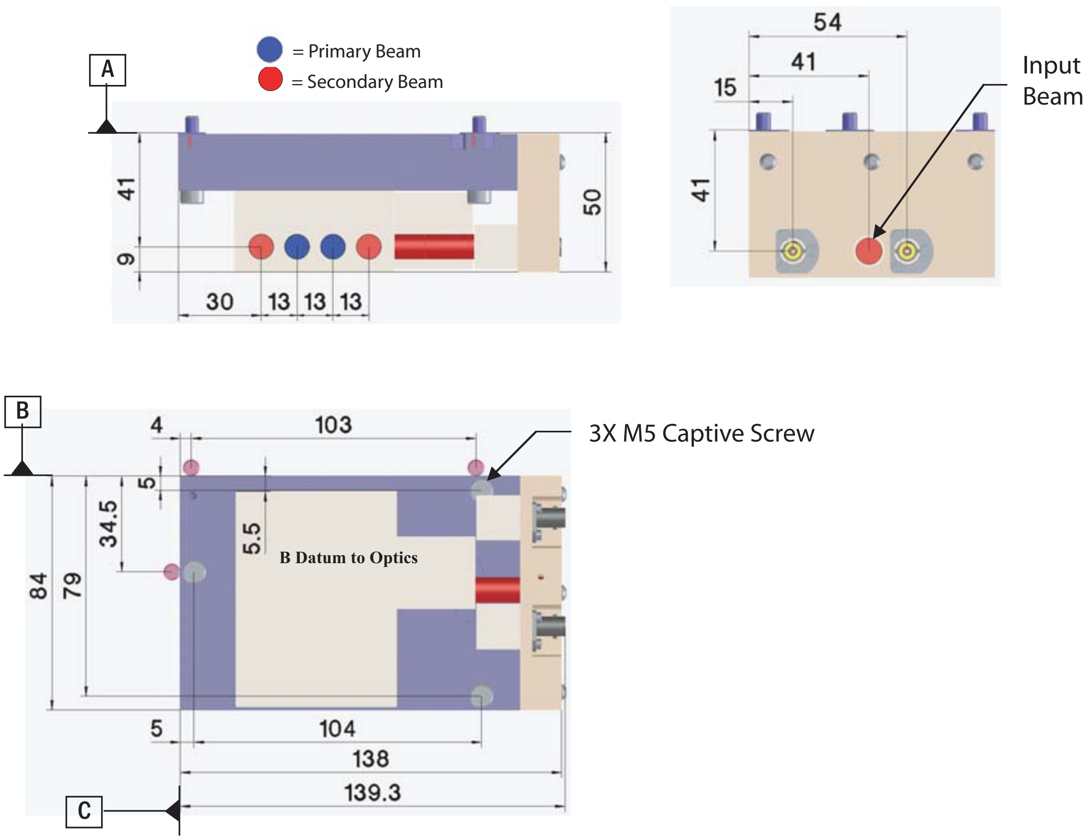


Figure 235 Agilent E1827A Two-Axis Interferometer — dimensions

Agilent E1827A glass dimensions

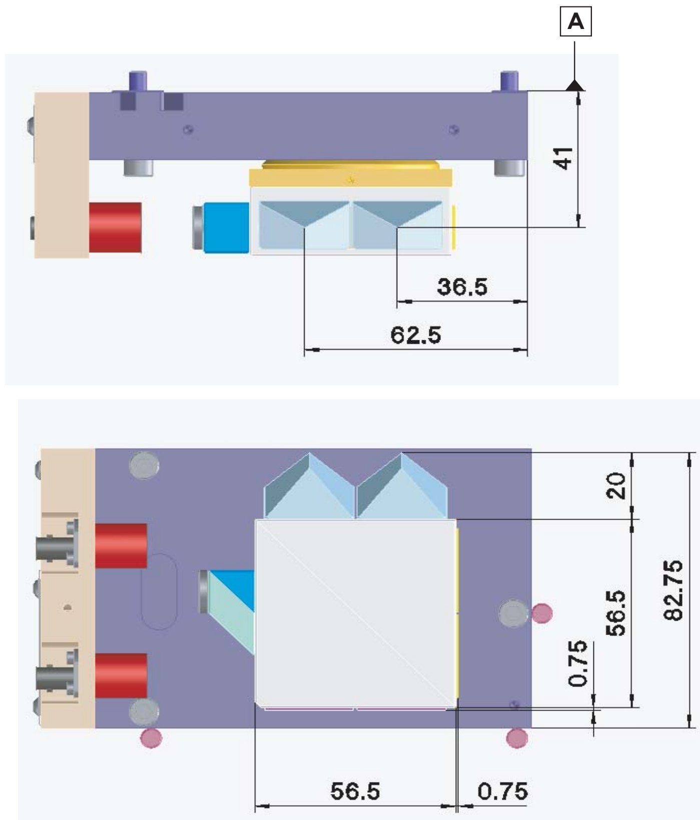


Figure 236 Agilent E1827A glass dimensions

33
Agilent E1837A, Z4399A, and Z4422B Three-Axis Interferometers

Description

NOTE

See Chapter 6, “NGI Measurement Optics (General Information),” in Volume I of this manual for general description, and alignment and mounting procedures.

The Agilent E1837A, Agilent Z4399A, and Agilent Z4422B Three-Axis interferometers are described in this chapter. All three interferometers use the compact monolithic interferometer (MIF) design. The outputs of these interferometers are coupled to a 400-micron fiber with an ST connector and NA of 0.39.

The Agilent E1837A, Agilent Z4399A, and Agilent Z4422B interferometers can be mounted using three screws in either the upright or hanging position.

Agilent E1837A Three-Axis Vertical Beam Interferometer

The Agilent E1837A Three-Axis Interferometer is used for measurements of translation along or rotation around an axis of motion (see figures 237 and 238).

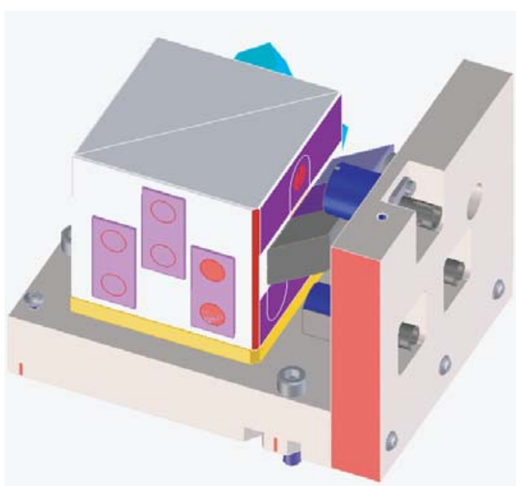


Figure 237 Agilent E1837A Three-Axis Vertical Beam Interferometer

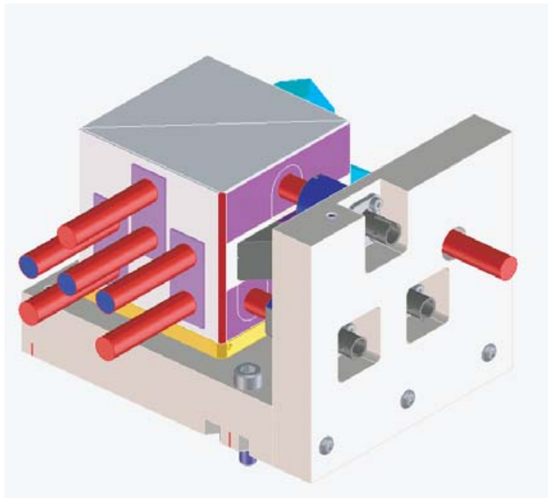


Figure 238 Agilent E1837A Three-Axis Vertical Beam Interferometer — beams shown

Agilent E1837A beam pattern, spacing, and labels

Figure 239 shows the beam pattern and spacing of the Agilent E1837A interferometer, viewing from the stage to the interferometer position.

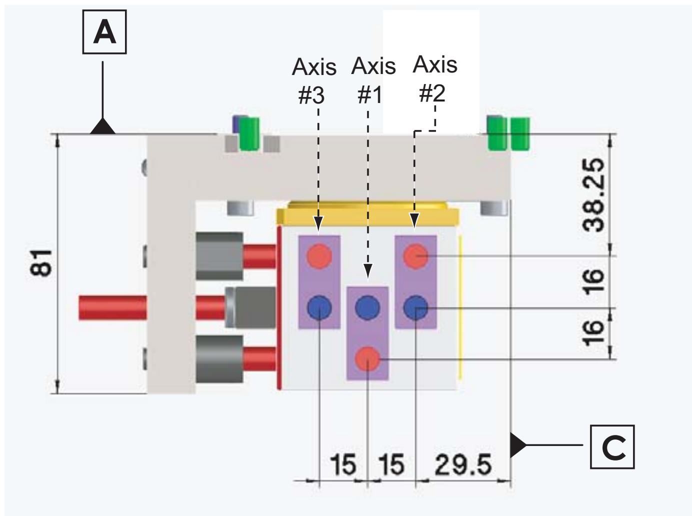


Figure 239 Agilent E1837A beam labels and relative positions

Agilent E1837A Three-Axis Interferometer specifications

Weight:	2.67 kg (5.93 lbs)	**Non-linearity Error:**	± 2 nm
Dimensions:	See Figure 240 on page 662	**Output Efficiency (input power/axis output power)**[2]	
Glass Dimensions:	See Figure 241 on page 663	Typical for all axes	18%
Materials:		Worst case for all axes	12%
Baseplate	Passivated 416 Stainless Steel	**Measure Point Tolerance:**[3]	
Coefficient of Thermal Expansion	9.9×10^{-6} /°C	Mean	± 0.5 mm
Optics	BK-7	Deviation	± 0.1 mm
Resonance Frequency:	~ 800 Hz	**Input Beam Cone Angle (IBCA):**[4]	< 1 mrad
Mounting Interface:		**Beam Parallelism:**	(see Figure 244 on page 665)
Fasteners	M5 x 0.8 Socket Head Captive Screw (SHCS)	Axis #1 - Axis #3	< 100 µrad
Surface Profile	0.02 mm	Axis #2 - Axis #3	< 100 µrad
Surface Finish	0.4 µm	**Operating Temperature (T_{set}):**	19 to 26 °C
Beam Diameter:	**ϕ 9 mm, maximum (visible)**	**Measurement and Reference Mirror Recommendations:**	
Resolution:			
Optical	λ/4	Reflectivity	>92%
Linear[1]	0.62 nm (using 256 × resolution extension) 0.15 nm (using 1024 × resolution extension)	Flatness	λ/20
Angular (yaw or roll)[1]	See “NGI Angular Resolution” section in Chapter 6, “NGI Measurement Optics (General Information),” in Volume I of this manual for explanation of angular resolution.		

[1] Linear and angular resolutions are dependent on the electronics used. Optical resolution is dependent only on the interferometer, and can be used to determine linear and angular resolutions when the electronic resolution extension is known. The linear and angular specifications in this section are for interferometer use with the X256 resolution extension electronics (10897B/C, 10898A) or X1024 resolution extension electronics (N1231B, N1225A).

[2] ($AC_{Signal\ Out}$ / $DC_{Signal\ Out}$) / ($AC_{Signal\ In}$/ $DC_{Signal\ In}$) at nominal zero stage angle.

[3] See “Measure Point Tolerance” in Chapter 6 in Volume I of this manual for a description of these tolerances.

[4] See “Adjusting the input beam angle” in Chapter 6 in Volume I. Deviation from the ideal location reduces angle range.

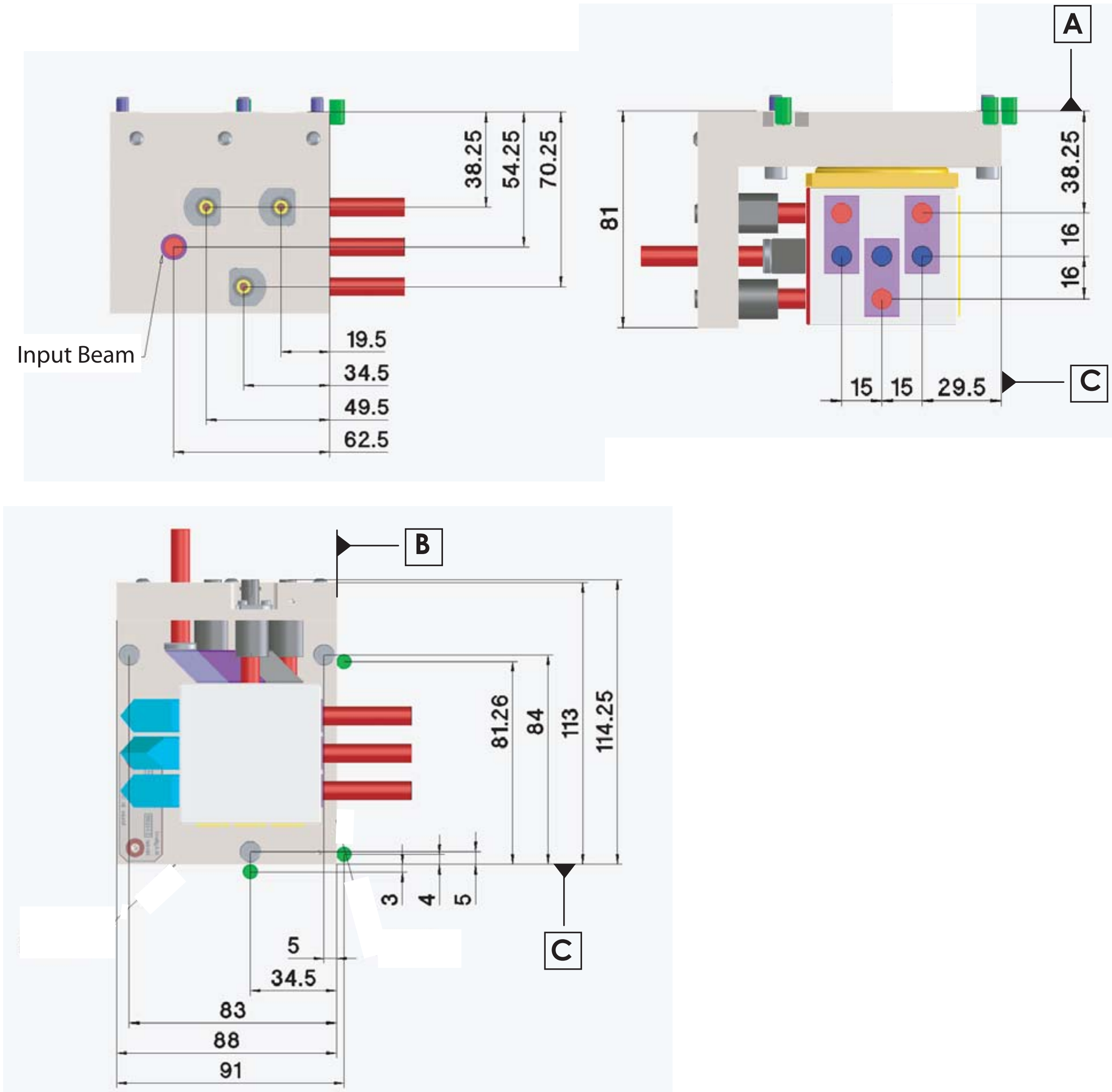


Figure 240 Agilent E1837A Three-Axis Interferometer — dimensions

Agilent E1837A glass dimensions

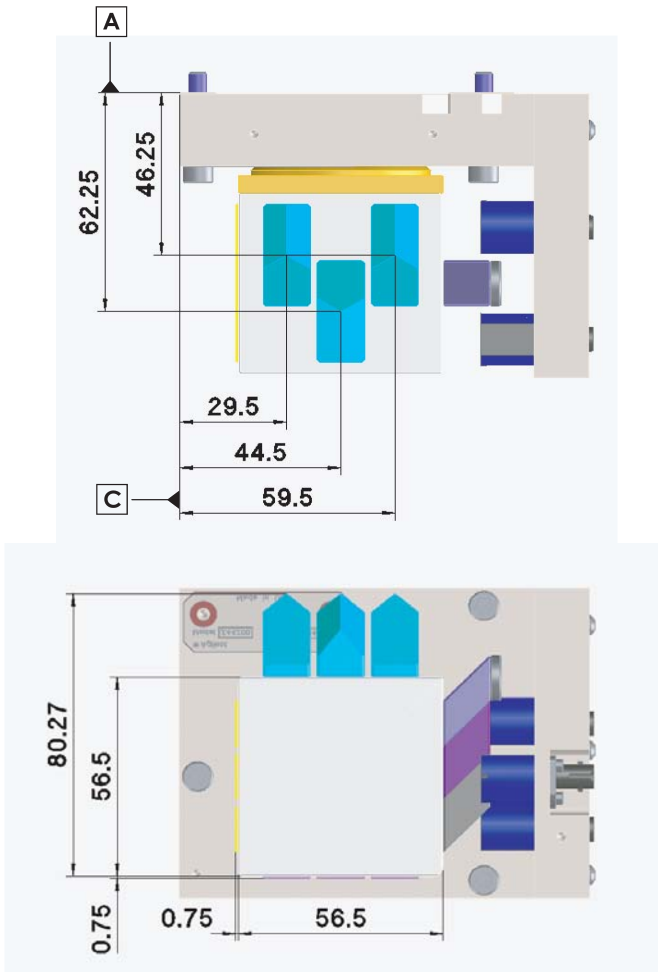


Figure 241 Agilent E1837A glass dimensions

Agilent Z4399A Three-Axis Interferometer

The Agilent Z4399A Three-Axis Interferometer (see figures 242 and 243) has integral remote sensors with ST connectors eliminating the need to mount separate remote sensors. Plastic or glass fiber optics with ST connectors are available. Multiple fiber lengths are available, contact Agilent for details.

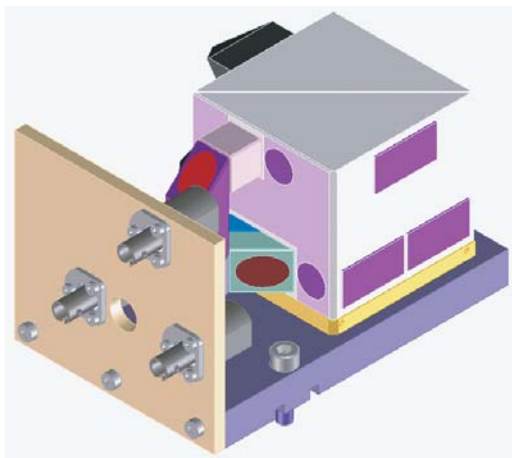


Figure 242 Agilent Z4399A Three-Axis Interferometer

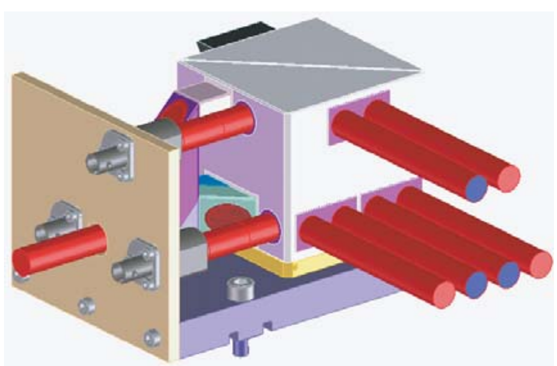


Figure 243 Agilent Z4399A Three-Axis Interferometer — beams shown

Agilent Z4399A beam pattern, spacing, and labels

Figure 244 shows the beam pattern and spacing of the Agilent Z4399A interferometer, viewing from the stage to the interferometer position.

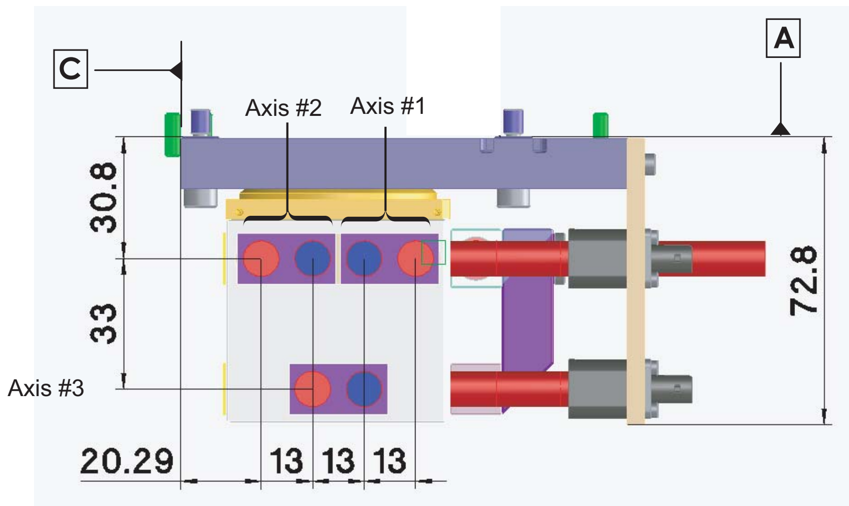


Figure 244 Agilent Z4399A beam labels and relative positions — shown with datums

Agilent Z4399A Three-Axis Interferometer specifications

Weight:	1.66 kg (3.65 lbs)
Dimensions:	See Figure 245 on page 667
Glass Dimensions:	See Figure 246 on page 668
Materials:	
Baseplate	Invar
Coefficient of Thermal Expansion	7.1 x 10^{-6} mm/mm/°C (BK-7), 1.5 x 10^{-6} mm/mm/°C (Invar)
Optics	BK-7
Natural Frequency	~ 700 Hz
Mounting Interface	
Fasteners	M5 x 0.8 Socket Head Captive Screw (SHCS)
Surface Profile	0.02 mm
Surface Finish	0.4 µm
Beam Diameter:	ϕ 9 mm, maximum (visible)
Resolution:	
Optical	$\lambda/4$
Linear[1]	0.62 nm (using 256 × resolution extension) 0.15 nm (using 1024 × resolution extension)
Angular (yaw or roll)[1]	
See "NGI Angular Resolution" section in Chapter 6, "NGI Measurement Optics (General Information)," in Volume I of this manual for explanation of angular resolution.	

Thermal Drift due to Glass Path Imbalance:	<10nm/°C
Non-linearity Error:	± 1 nm
Output Efficiency:	
Typical of all axes	18%
Worst case for all axes	12%
Measure Point Tolerance:	
Absolute	± 0.5 mm relative to nominal location
Input Beam Cone Angle (IBCA):	< 1 mrad
Beam Parallelism:	Figure 249 on page 670
Axis #1 - Axis #2	< 25 µrad
Axis #1 - Axis #3	< 25 µrad
Operating Temperature:	19 to 26 °C
Measurement and Reference Mirror Recommendations:	
Reflectivity	>92%
Flatness	$\lambda/20$

[1] Linear and angular resolutions are dependent on the electronics used. Optical resolution is dependent only on the interferometer, and can be used to determine linear and angular resolutions when the electronic resolution extension is known. The linear and angular specifications in this section are for interferometer use with the X256 resolution extension electronics (10897B/C, 10898A) or X1024 resolution extension electronics (N1231B, N1225A).

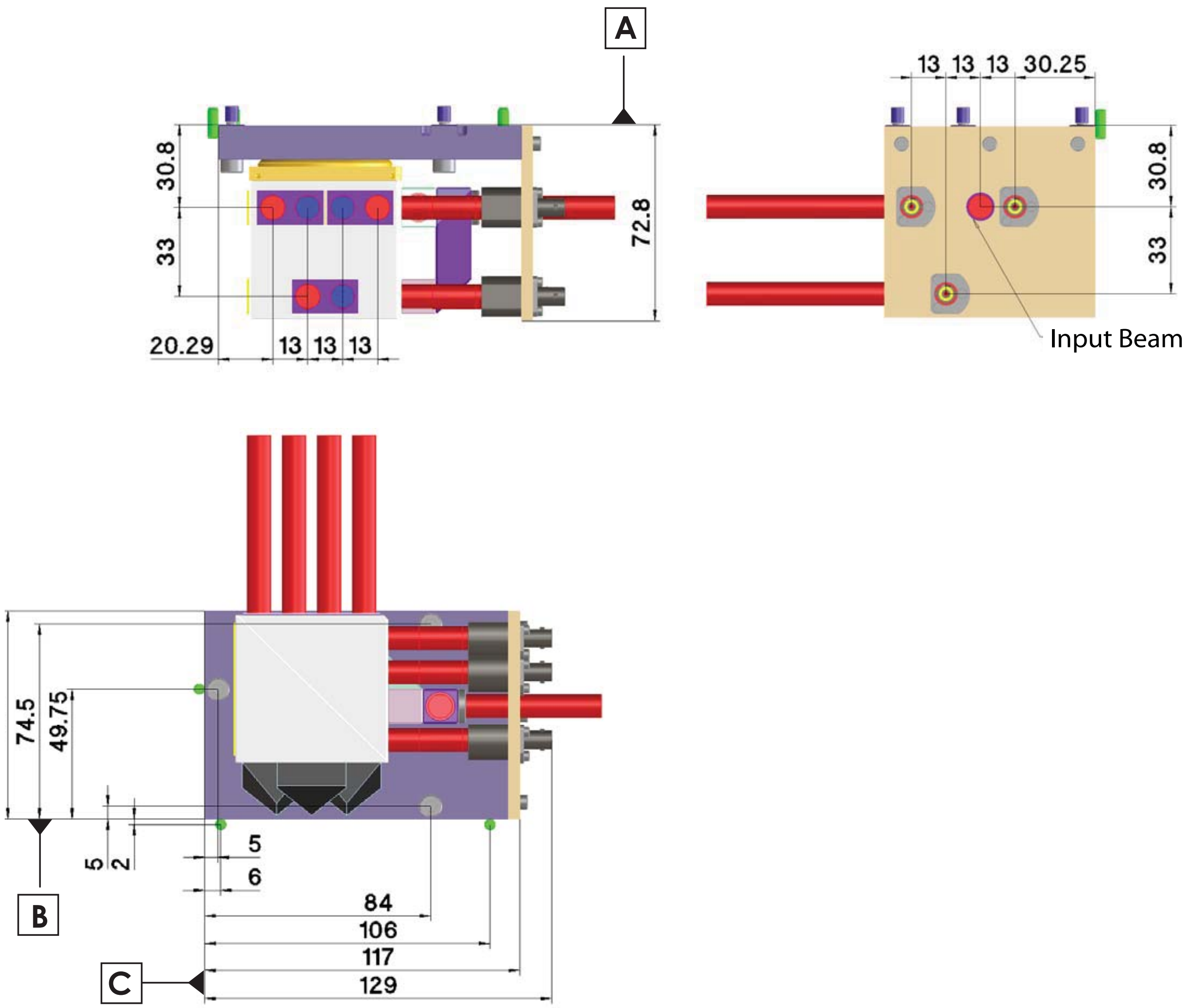


Figure 245 Agilent Z4399A Three-Axis Interferometer — dimensions

Agilent Z4399A glass dimensions

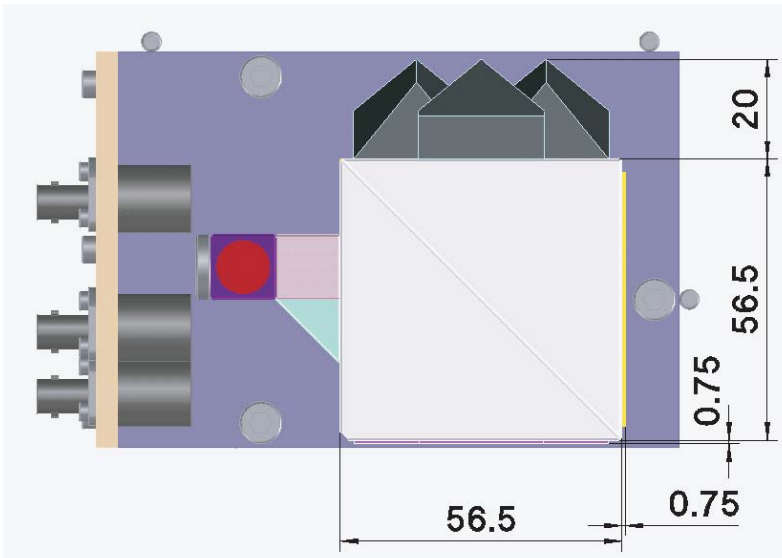


Figure 246 Z4399A glass dimensions

Agilent Z4422B Three-Axis Interferometer

The Agilent Z4422B Three-Axis Interferometer produces a three-axis set of beams used for measurements of translation along or rotation around an axis of motion (see figures 247 and 248).

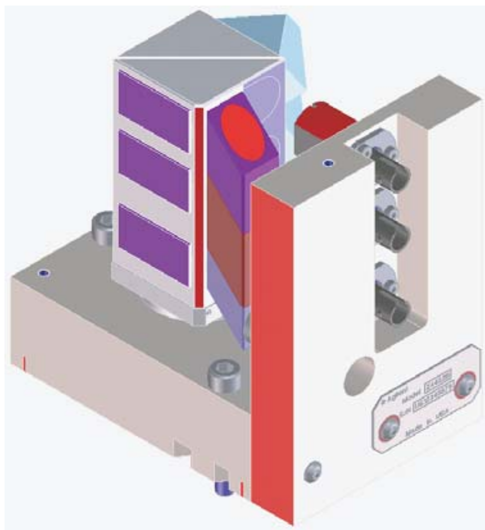


Figure 247 Agilent Z4422B Three-Axis Interferometer

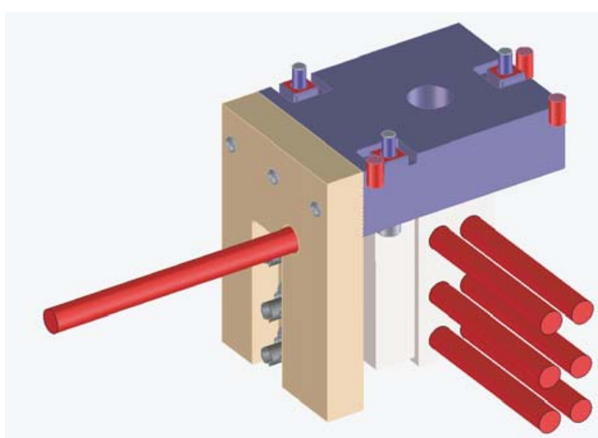


Figure 248 Agilent Z4422B Three-Axis Interferometer — beams shown

Agilent Z4422B beam pattern, spacing, and labels

Figure 249 shows the beam pattern and spacing of the Agilent Z4422B interferometer, viewing from the stage to the interferometer position.

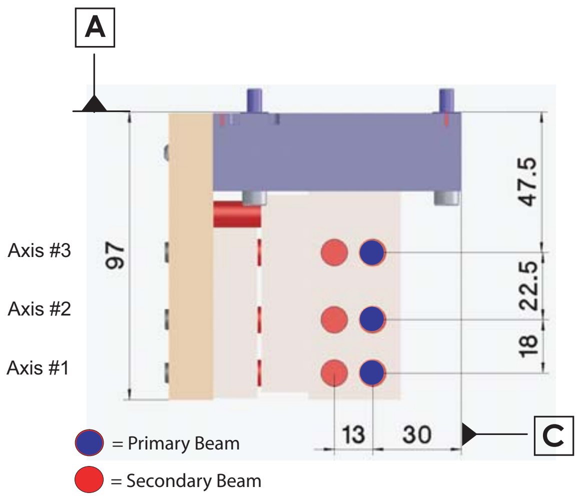


Figure 249 Agilent Z4422B beam labels and relative positions

Agilent Z4422B Three-Axis Interferometer specifications

Weight:	1.95 kg (4.3 lbs)
Dimensions:	See Figure 250 on page 672
Glass Dimensions:	See Figure 251 on page 673
Materials:	
Baseplate	Passivated 416 Stainless Steel
Coefficient of Thermal Expansion	9.9×10^{-6} /°C
Optics	BK-7
Natural Frequency	~ 1kHz
Mounting Interface	
Fasteners	M5 x 0.8 Socket Head Captive Screw (SHCS)
Surface Profile	0.02 mm
Surface Finish	0.4 µm
Beam Diameter:	ϕ 9 mm, maximum (visible)[1]
Resolution:	
Optical	λ/4
Linear[2]	0.62 nm (using 256 × resolution extension) 0.15 nm (using 1024 × resolution extension)
Angular (yaw or roll)[2]	
See “NGI Angular Resolution” section in Chapter 6, “NGI Measurement Optics (General Information),” in Volume I of this manual for explanation of angular resolution.	

Thermal Drift due to Glass Path Imbalance:	≤10nm/°C
Non-linearity Error:	± 1 nm
Measure Point Tolerance[3]	
Mean	± 0.15 mm
Deviation	± 0.05 mm
Input Beam Cone Angle (IBCA):	< 1 mrad
Beam Parallelism[4]	See Figure 249 on page 670
Axis #1 - Axis #2	< 25 µrad
Axis #2 - Axis #3	< 100 µrad
Optical Efficiency (input power/axis output power):	
Typical for Axis #3	13%
Worst Case for Axis #3	10%
Typical for all axes except Axis #3	18%
Worst Case for all axes except Axis #3	13%
Operating Temperature Range:	19 to 26 °C
Measurement and Reference Mirror Recommendations:	
Reflectivity	>92%
Flatness	λ/20

[1] Interferometer allows 7.5 mm ($1/e^2$)

[2] Linear and angular resolutions are dependent on the electronics used. Optical resolution is dependent only on the interferometer, and can be used to determine linear and angular resolutions when the electronic resolution extension is known. The linear and angular specifications in this section are for interferometer use with the X256 resolution extension electronics (10897B/C, 10898A) or X1024 resolution extension electronics (N1231B, N1225A).

[3] See “Measure Point Tolerance” in Chapter 6 in Volume I of this manual for a description of these tolerances.

[4] Beam Parallelism is specified between primary beams. See Figure 249.

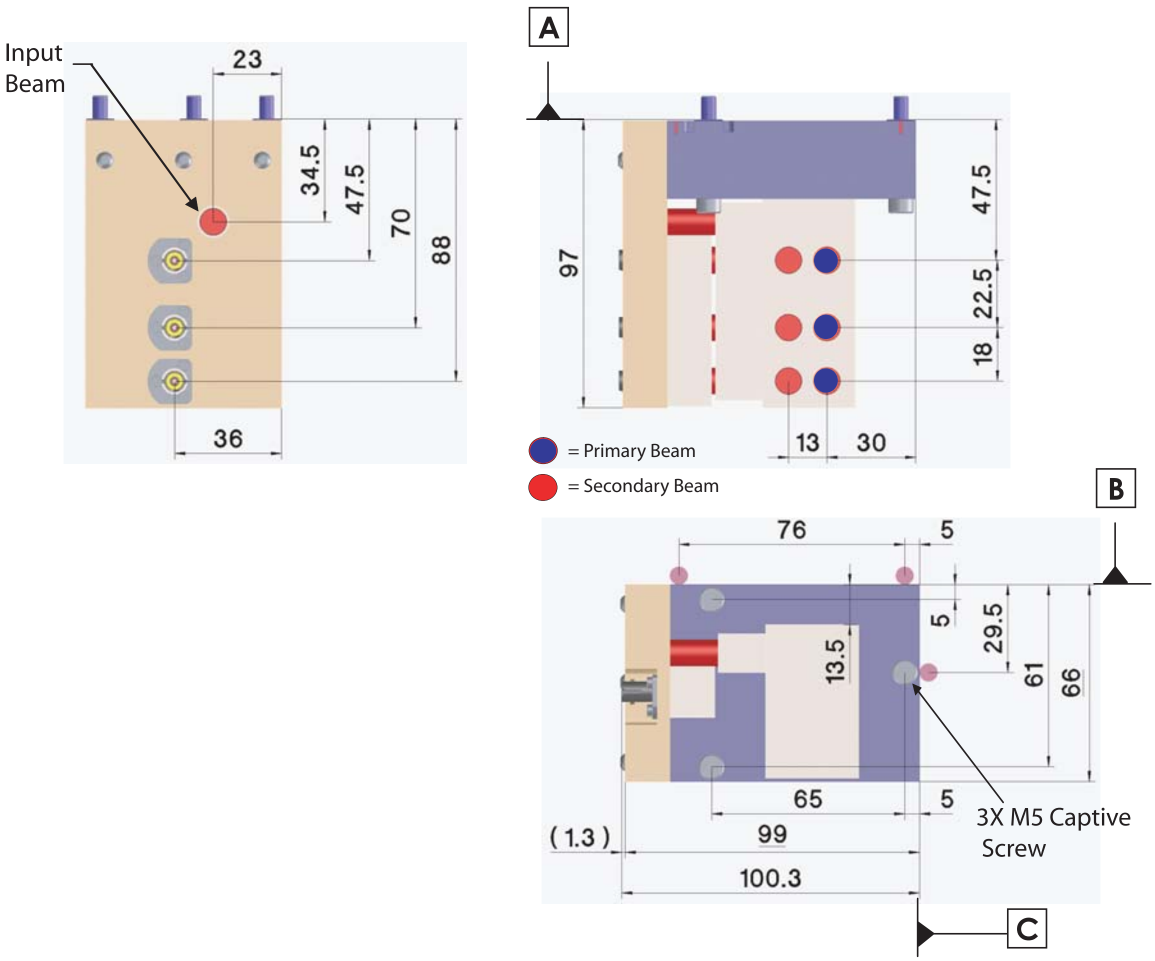


Figure 250 Agilent Z4422B Three-Axis Interferometer — dimensions

Agilent Z4422B glass dimensions

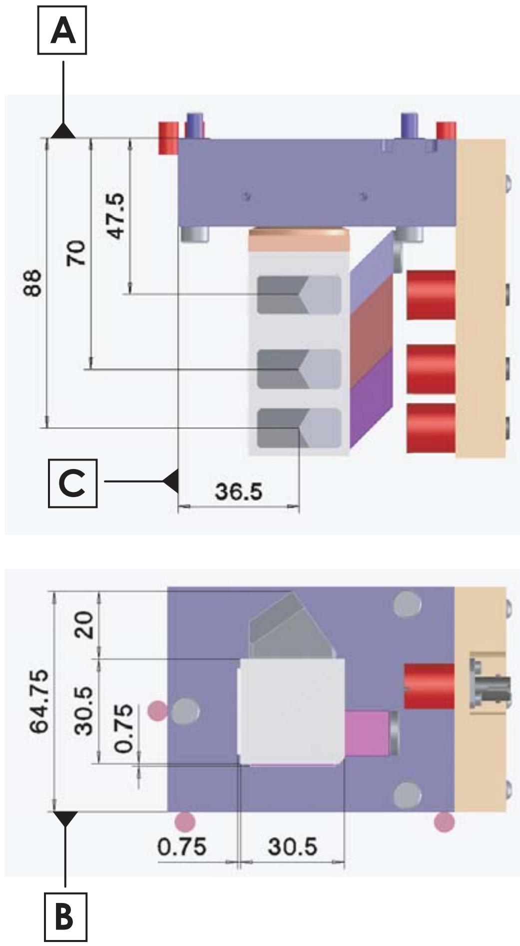


Figure 251 Agilent Z4422B glass dimensions

34
Agilent Z4420B and Agilent Z4421B Five-Axis Interferometers

Description

NOTE See Chapter 6, "NGI Measurement Optics (General Information)," in Volume I of this manual for general description, and alignment and mounting procedures.

The Agilent Z4420B and Agilent Z4421B Five-Axis interferometers are described in this chapter. The two interferometers use the compact monolithic interferometer (MIF) design. The outputs of these interferometers are coupled to a 400-micron fiber with an ST connector and NA of 0.39.

The Agilent Z4420B Five-Axis Interferometer has a right turn configuration design (see figures 252 and 253).

The Agilent Z4421B Five-Axis Interferometer has a left turn configuration design (see figures 257 and 258).

The Agilent Z4420B and Agilent Z4421B interferometers can be mounted using three screws in either the upright or hanging position.

Agilent Z4420B Five-Axis Interferometer

The Agilent Z4420B Five-Axis Interferometer produces a five-axis set of beams used for measurements of translation along or rotation around an axis of motion (see figures 252 and 253).

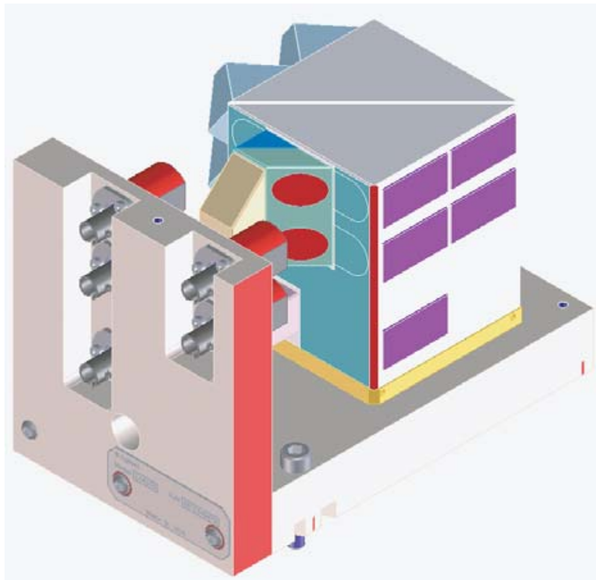


Figure 252 Agilent Z4420B Five-Axis Interferometer

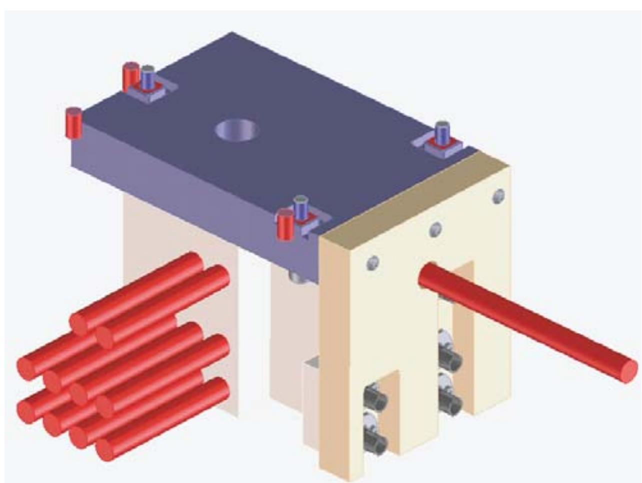


Figure 253 Agilent Z4420B Five-Axis Interferometer — beams shown

Agilent Z4420B beam pattern, spacing, and labels

Figure 254 shows the beam pattern and spacing of the Agilent Z4420B interferometer, viewing from the stage to the interferometer position.

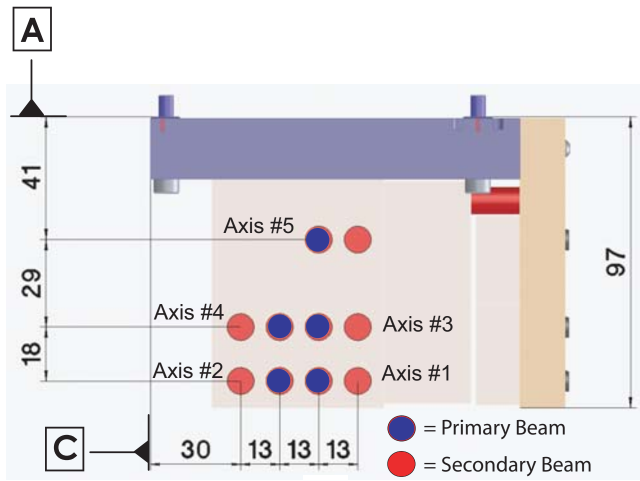


Figure 254 Agilent Z4420B beam labels and relative positions

Agilent Z4420B Five-Axis Interferometer specifications

Weight:	3.13 kg (6.9 lbs)	**Thermal Drift due to Glass Path Imbalance:**	≤10nm/°C
Dimensions:	See Figure 255 on page 680	**Non-linearity Error:**	± 1 nm
Glass Dimensions:	See Figure 256 on page 681	**Measure Point Tolerance[3]:**	
Materials:		Mean	± 0.15 mm
Baseplate	Passivated 416 Stainless Steel	Deviation	± 0.05 mm
Coefficient of Thermal Expansion	9.9 x 10^{-6} /°C	**Input Beam Cone Angle (IBCA):**	< 1 mrad
Optics	BK-7	**Beam Parallelism[4]:**	See Figure 254 on page 678
Natural Frequency	~ 1kHz	Axis #1 - Axis #2	< 25 µrad
Mounting Interface		Axis #2 - Axis #4	< 25 µrad
Fasteners	M5 x 0.8 Socket Head Captive Screw (SHCS)	Axis #1 - Axis #3	< 25 µrad
Surface Profile	0.02 mm	Axis #3 - Axis #4	< 25 µrad
Surface Finish	0.4 µm	Axis #3 - Axis #5	< 100 µrad
Beam Diameter:	ϕ 9 mm, maximum (visible)[1]	**Optical Efficiency (input power/axis output power):**	
Resolution:		Typical for Axis #5	7%
Optical	λ/4	Worst Case for Axis #5	5%
Linear[2]	0.62 nm (using 256 × resolution extension) 0.15 nm (using 1024 × resolution extension)	Typical for all axes except Axis #5	10%
Angular (yaw or roll)[2]		Worst Case for all axes except Axis #5	7%
See "NGI Angular Resolution" section in Chapter 6, "Next Generation Interferometers (General Information)," in Volume I of this manual for explanation of angular resolution.		**Operating Temperature Range:**	19 to 26 °C
		Measurement and Reference Mirror Recommendations:	
		Reflectivity	>92%
		Flatness	λ/20

1 Interferometer allows 7.5 mm (1/e^2)

2 Linear and angular resolutions are dependent on the electronics used. Optical resolution is dependent only on the interferometer, and can be used to determine linear and angular resolutions when the electronic resolution extension is known. The linear and angular specifications in this section are for interferometer use with the X256 resolution extension electronics (10897B/C, 10898A) or X1024 resolution extension electronics (N1231B, N1225A).

3 See "Measure Point Tolerance" in Chapter 6 in Volume I of this manual for a description of these tolerances.

4 Beam Parallelism is specified between primary beams. See Figure 254 on page 678.

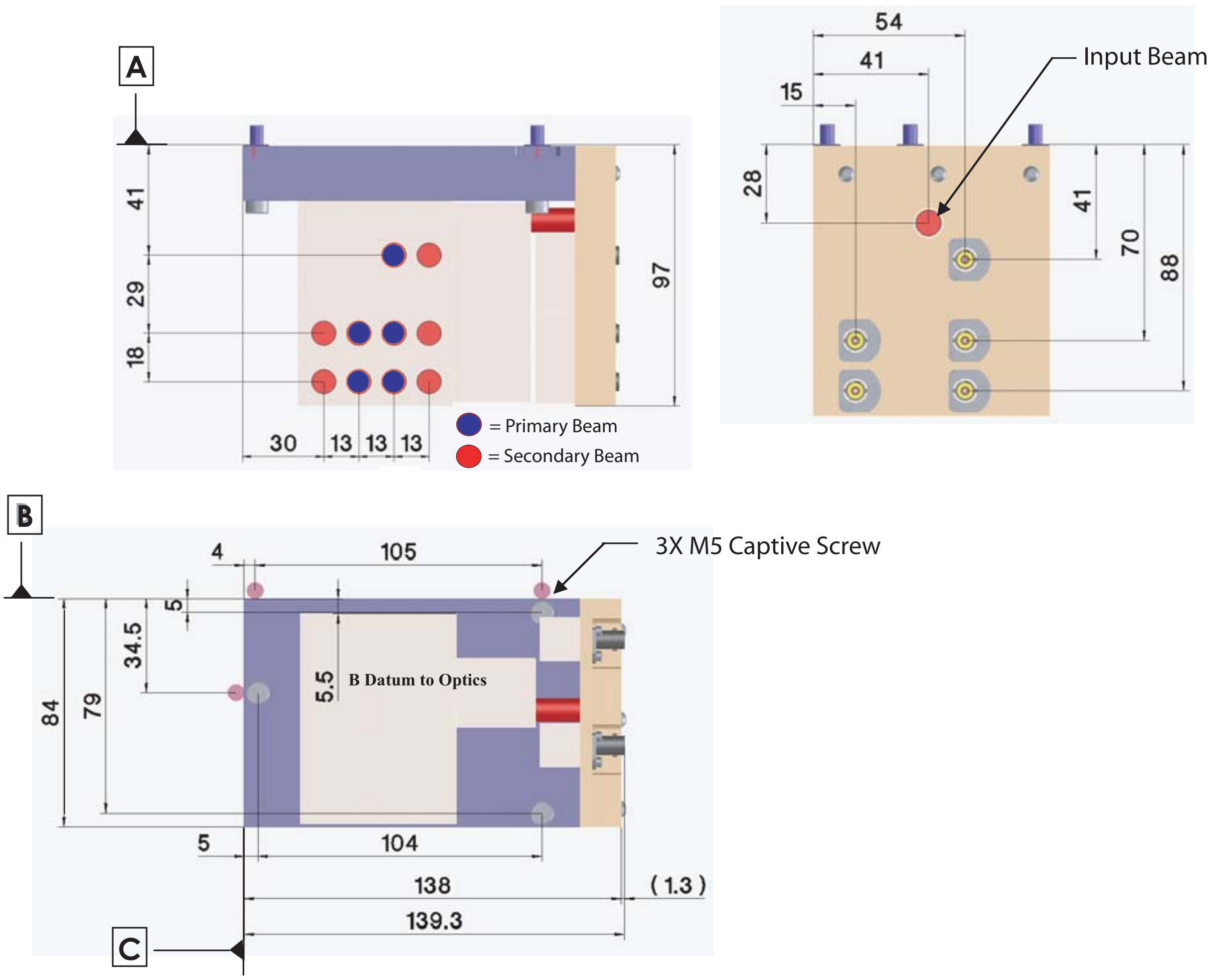


Figure 255 Agilent Z4420B Five-Axis Interferometer — dimensions

Agilent Z4420B glass dimensions

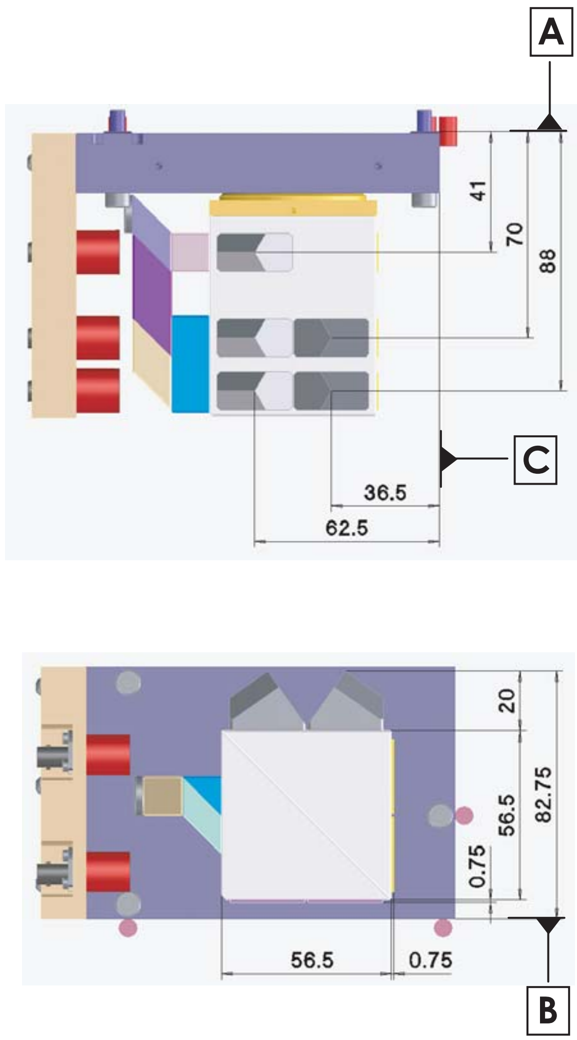


Figure 256 Agilent Z4420B glass dimensions

Agilent Z4421B Five-Axis Interferometer

The Agilent Z4421B Five-Axis Interferometer produces a five-axis set of beams used for measurements of translation along or rotation around an axis of motion (see figures 257 and 258). It differs from the Agilent Z4420B in that the beams closest to the base are *centered* horizontally in the beam pattern.

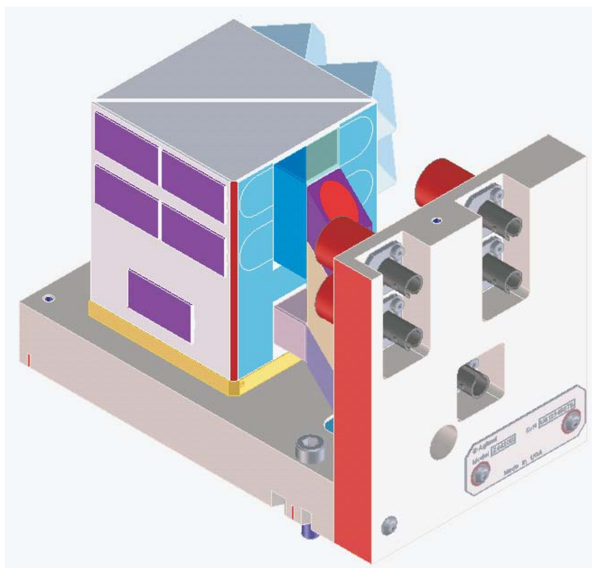


Figure 257 Agilent Z4421B Five-Axis Interferometer

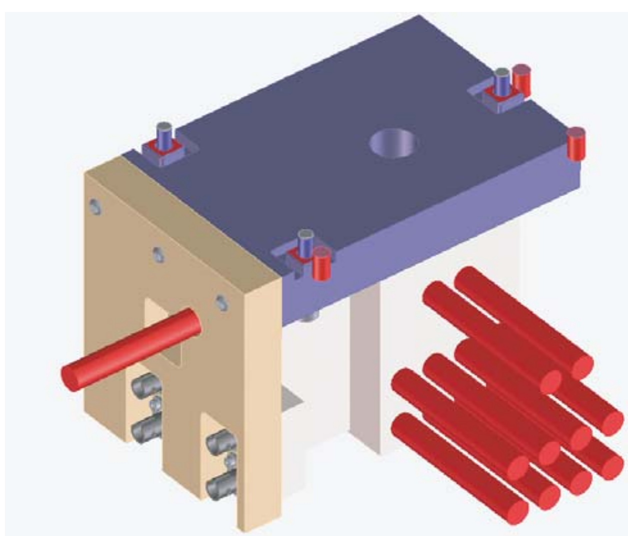


Figure 258 Agilent Z4421B Five-Axis Interferometer — beams shown

Agilent Z4421B beam pattern, spacing, and labels

Figure 259 shows the beam pattern and spacing of the Agilent Z4421B interferometer, viewing from the stage to the interferometer position.

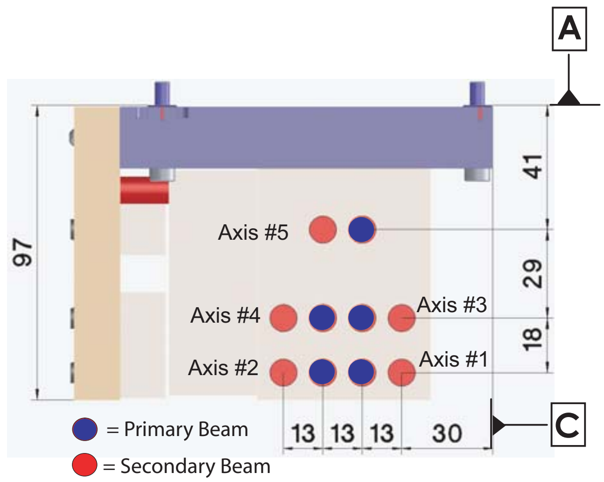


Figure 259 Agilent Z4421B beam labels and relative positions

Agilent Z4421B Five-Axis Interferometer specifications

Weight:	3.15 kg (7 lbs)	**Thermal Drift due to Glass Path Imbalance:**	≤10nm/°C
Dimensions:	See Figure 260 on page 685	**Non-linearity Error:**	± 1 nm
Glass Dimensions:	See Figure 261 on page 686	**Measure Point Tolerance**[3]**:**	
Materials:		Mean	± 0.15 mm
Baseplate	Passivated 416 Stainless Steel	Deviation	± 0.05 mm
Coefficient of Thermal Expansion	9.9×10^{-6} /°C	**Input Beam Cone Angle (IBCA):**	< 1 mrad
Optics	BK-7	**Beam Parallelism**[4]**:**	See Figure 259 on page 683
Natural Frequency	~ 1kHz	Axis #1 - Axis #2	< 25 µrad
Mounting Interface		Axis #2 - Axis #4	< 25 µrad
Fasteners	M5 x 0.8 Socket Head Captive Screw (SHCS)	Axis #1 - Axis #3	< 25 µrad
Surface Profile	0.02 mm	Axis #3 - Axis #4	< 25 µrad
Surface Finish	0.4 µm	Axis #3 - Axis #5	< 100 µrad
Beam Diameter:	ϕ9 mm, maximum (visible)[1]	**Optical Efficiency (input power/axis output power):**	
Resolution:		Typical for Axis #5	7%
Optical	λ/4	Worst Case for Axis #5	5%
Linear*	0.62 nm (using 256 × resolution extension) 0.15 nm (using 1024 × resolution extension)	Typical for all axes except Axis #5	10%
Angular (yaw or roll)[2]		Worst Case for all axes except Axis #5	7%
See "NGI Angular Resolution" section in Chapter 6, "Next Generation Interferometers (General Information)," in Volume I of this manual for explanation of angular resolution.		**Operating Temperature Range:**	19 to 26 °C
		Measurement and Reference Mirror Recommendations:	
		Reflectivity	>92%
		Flatness	λ/20

[1] Interferometer allows 7.5 mm (1/e2)

[2] Linear and angular resolutions are dependent on the electronics used. Optical resolution is dependent only on the interferometer, and can be used to determine linear and angular resolutions when the electronic resolution extension is known. The linear and angular specifications in this section are for interferometer use with the X256 resolution extension electronics (10897B/C, 10898A) or X1024 resolution extension electronics (N1231B, N1225A).

[3] See "Measure Point Tolerance" in Chapter 6 in Volume I of this manual for a description of these tolerances.

[4] Beam Parallelism is specified between primary beams. See Figure 259 on page 683.

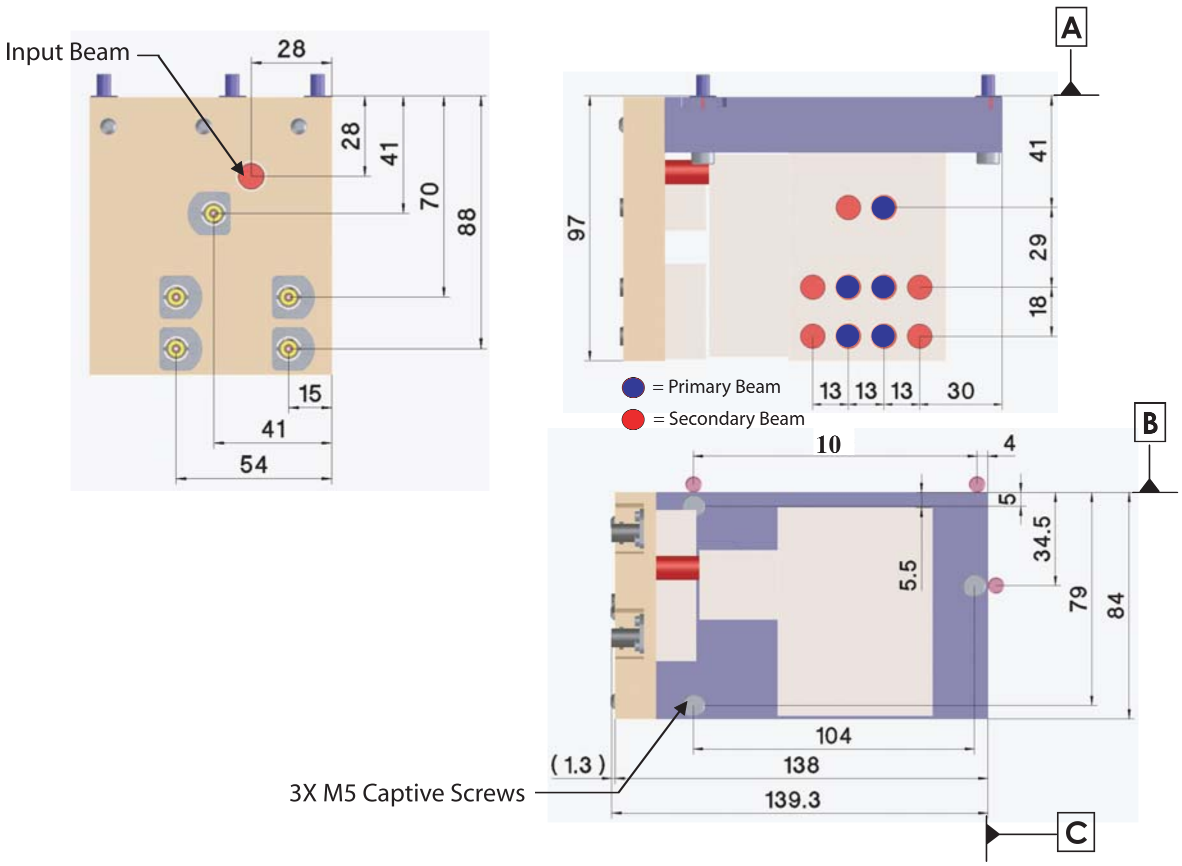
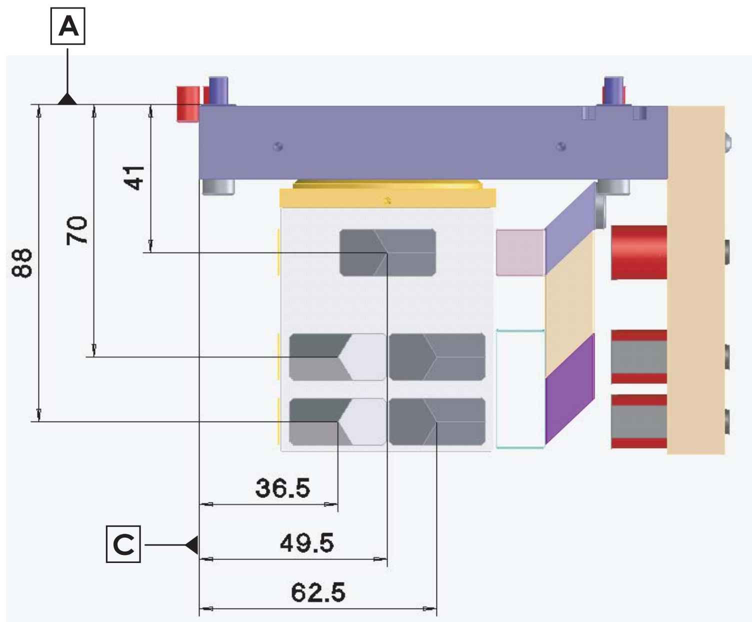


Figure 260 Agilent Z4421B Five-Axis Interferometer — dimensions

Agilent Z4421B glass dimensions



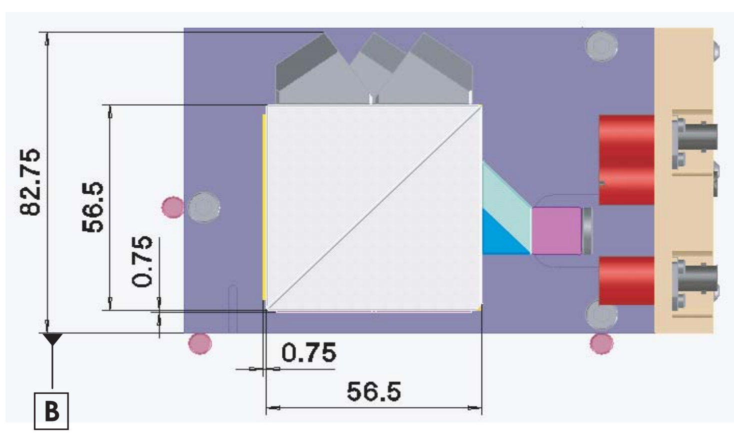


Figure 261 Agilent Z4421B glass dimensions

35
Receivers

General

One receiver is required for each measurement or wavelength tracker axis.

The receiver converts the Doppler component of the laser beam from an interferometer or wavelength tracker into an electrical signal for the measurement electronics.

This chapter describes the following receivers:

- Agilent 10780C Receiver,
- Agilent 10780F Remote Receiver,
- Agilent E1708A Remote Dynamic Receiver, and
- Agilent E1709A Remote High-Performance Receiver

The Agilent 5519A and 5519B laser heads, which are a component of the Agilent 5529A/55292A Dynamic Calibrator system, has a built-in receiver. This chapter includes a brief description of that receiver. However, the installation and alignment of that receiver occurs as part of the Agilent 5519A/B Laser Head installation and alignment procedures, given in the *Agilent 5519A Laser Head Service Manual.*

Receiver specifications are given later in this chapter.

Comparison of Agilent Laser Receiver Families

Table 77 summarizes the features, characteristics, and specifications the Agilent 10780C/F, Agilent E1708A, and Agilent E1709A receivers.

The Agilent E1708A receiver is functionally similar to the Agilent 10780F receiver. However, the E1708A is not a direct replacement for 10780F. Comparisons of the two laser receiver families are provided in Table 13.

.

Table 77 Comparison of Agilent Laser Receiver families

Characteristic	E1709A Receiver	E1708A Receiver	10780C, 10780F Receivers
Dynamic Range	25:1 to 6:1, depending on the AC/DC ratio	10:1	Not specified
Sensitivity	.20 -.80 μW (depending on the AC/DC ratio), with 2 meter plastic cable	2.2 μW (E1708A with 2-meter fiber optic cable) 5 μW (E1708A with 10-meter fiber optic cable)	1.5 μW (10780C) 2.2 μW (10780F with 2-meter fiber optic cable) 5 μW (10780F with 10-meter fiber optic cable)
Alignment Tolerance	For plastic fiber optic cable (Option 010) Roll: ±3° Pitch: ±1° Yaw: ±1° Agilent remote sensor is self-aligning with some interferometers.	For plastic fiber optic cable Roll: ±3° Pitch: ±1° Yaw: ±1° Agilent remote sensor is self-aligning with some interferometers.	Roll: ±3° Pitch: ±1° Yaw: ±1° 10780F is self-aligning with some interferometers.
Output Signal Frequency (Differential square wave at Doppler-shifted frequency)	100 kHz to 15.5 MHz (slew rates to 1 m/s with plane mirror optics)	100 kHz to 7.2 MHz (slew rate to 500 mm/s with plane mirror optics)	100 kHz to 7.2 MHz
Fixed Data Delay (typical)*	33.2 ns (typical) 0.01 ns/°C	86 ns	Not specified
Errors due to frequency variations at fixed temperature*	For 25:1 to 6:1 input amplitude variations and frequency range of 100 kHz to 15.5 MHz ≤ ±1.2 nm for linear optics ≤ ±0.6 nm for plane mirror optics ≤ ±0.3 nm for high resolution optics	For 3:1 input amplitude variations and frequency range of 100 kHz to 7.2 MHz ≤ ±1.2 nm for linear optics ≤ ±0.6 nm for plane mirror optics ≤ ±0.3 nm for high resolution optics	Not specified
Signal Strength Monitor	0 to 10 volts output, proportional to optical input signal power	0 to 8 volts output, proportional to optical input signal power	Range: 0 to 0.8 volts
Power Requirements	15 Vdc ±1V at less than 267 mA	15 Vdc ±1V at less than 250 mA	+15 Vdc at 136 mA
Heat Dissipation	0.0 W for remote sensor 4.0 W typical for receiver	0.0 W for remote sensor 3.8 W typical for receiver	0.0 W for remote sensor 2.0 W typical for receiver
Temperature Range	0 to 40° C operating	0 to 40° C operating	0 to 40° C operating

Table 77 Comparison of Agilent Laser Receiver families (continued)

Characteristic	E1709A Receiver	E1708A Receiver	10780C, 10780F Receivers
Fiber-Optic Cable Length	Option 010: 2m (plastic) Contact Agilent for longer fiber optic cables.	2 m standard (plastic) Contact Agilent for longer fiber optic cables.	2 m standard 10 m maximum
Weight	Receiver body:190 g Option 010: Remote sensor with 2 m cable: 26 g	Receiver body:170 g, Remote sensor with 2 m cable: 26 g	136 g, 10780C 126 g, 10780F body 26 g, remote sensor with 2 m cable
Dimensions	Height: 78.1 mm (3.075 in) Width: 115.6 mm (4.552 in Depth: 19.8 mm (0.780 in)	Height: 78.1 mm (3.075 in) Width: 115.6 mm (4.552 in Depth: 19.8 mm (0.780 in)	Height: 38.1 mm (1.50 in) Width: 114.8 mm (4.52 in) Depth: 19.8 mm (0.78 in)
Dimensions (receiver body, mounting area)	4 holes at corners of a rectangle 40.0 mm (1.575 in) high 108.0 mm (4.250 in) wide, centered on receiver body centerline	4 holes at corners of a rectangle 40.0 mm (1.575 in) high 108.0 mm (4.250 in) wide, centered on receiver body centerline	2 holes 107.8 mm (4.25 in) apart on receiver centerline

* For ac input signal power:
E1708A: <200 µW
E1709A: <50 µW

Agilent 10780C and Agilent 10780F Receivers

Description

General

The Agilent 10780C Receiver or Agilent 10780F Remote Receiver converts the Doppler-shifted laser light from an interferometer or the wavelength tracker into electrical signals that can be processed by the rest of the laser system.

Lens and polarizer

Light enters either receiver through a lens and polarizer.

The Agilent 10780C lens and polarizer are built into the same assembly that houses the receiver electronics (see Figure 262). Agilent 10780C receiver's lens focuses the laser light onto a silicon PIN photodiode. Between the lens and the diode is a small piece of polarizing material oriented at 45° to the horizontal and vertical axes of the receiver.

The Agilent 10780F Remote Receiver's lens and polarizer are contained in a small assembly that is connected to the electronics housing by a fiber optic cable (see Figure 262). The fiber optic cable allows the receiver module to be mounted away from the measurement area, removing a source of heat. The interference signal between the f1 and f2 polarizations is sent through the fiber optic cable to the electronics housing. The Agilent 10780F receiver's fiber optic sensor head may be mounted directly to certain interferometers (Agilent 10719A, Agilent 10721A, Agilent 10735A, Agilent 10736A).

Alignment pins are provided for easy installation and alignment. This eliminates the need for any other user-supplied mount for the sensor head.

When the receiver input is oriented properly, that is, with its vertical axis parallel or perpendicular to the axes of the laser head, the polarizer passes one-half the incident power from each of the two incoming orthogonally polarized components of the received laser beam.

Photodiode

The output from the polarizer assembly is an amplitude-modulated sine wave that is sent to a photodiode chip in the receiver's electronic housing. The frequency is the Doppler-shifted split frequency. The amplitude is proportional to the product of the incident powers of the two orthogonal components.

The photodiode generates an ac current, which is converted to an ac voltage at a frequency of 100 kHz to 6.0 MHz.

The detected signal voltage goes through an impedance transformation stage, two gain stages, and a level translation stage. The result, a TTL-level signal, goes to a TTL differential line driver, which is ac-coupled to the rest of the measurement electronics by a shielded twisted-pair cable.

The output is a differential square wave at the Doppler-shifted split frequency.

An available dc voltage output on the Agilent 10780C or Agilent 10780F receiver indicates incoming laser beam intensity.

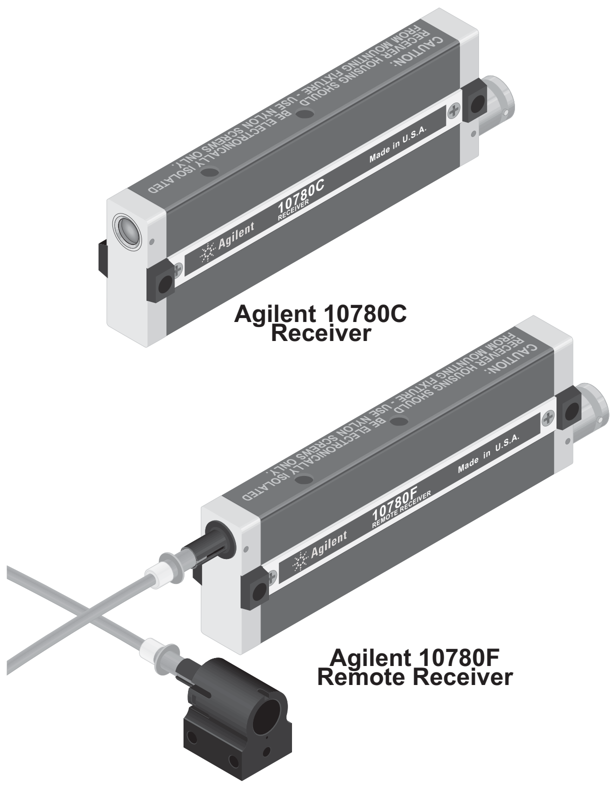


Figure 262 Agilent 10780C Receiver and Agilent 10780F Remote Receiver

Agilent 5519A/B Laser Head Receiver

The Agilent 5519A/B internal measurement receiver amplifies and converts the difference frequency of the laser beam (returned by the system optics) to TTL levels and supplies the signal to the measurement electronics.

During the measurement, the vertical and horizontal components pass through the turret and measurement optics and return to the measurement receiver. The difference between their frequencies will change whenever the measurement optics are moving.

The laser light returning from the measurement optics is directed through a polarizer and onto a photodiode. Because of the polarizer orientation, the beam power past the polarizer varies sinusoidally at the difference frequency of the two laser frequency components.

The beam power at the difference frequency is converted to TTL levels. The frequency of the TTL output is the measurement frequency.

Special considerations

Cables

General Each Agilent 10780C or Agilent 10780F receiver requires a cable to carry signals and power between it and the measurement electronics axis board with which it is to be used. One cable is required per measurement axis. The cable used depends on the axis board used, and the cable length required.

Cables are described in Chapter 36, “Accessories,” of this manual.

The Agilent 5519A/B Laser Head receiver connection is made via the cable that also provides power for the laser. The cable depends on the axis board used. Cables are described in Chapter 36, “Accessories,” of this manual.

Agilent 10790A/B/C cables An Agilent 10790A, Agilent 10790B, or Agilent 10790C Receiver Cable is used to connect the Agilent 10780C or Agilent 10780F receiver to the Agilent 10895A VME Axis Board, for both measurement and Wavelength Tracker axes.

Agilent 10880A/B/C cables An Agilent 10880A, Agilent 10880B, or Agilent 10880C Receiver Cable is used to connect an Agilent 10780C or Agilent 10780F receiver to an Agilent 10885A PC Axis Board, Agilent 10889B PC Servo Axis Board, Agilent 10896B VME Laser Compensation Board, Agilent 10897C VME High Resolution Laser Axis Board, Agilent 10898A VME High Resolution Dual Laser Axis Board, or Agilent N1231A PCI Three-Axis Board, for both measurement and Wavelength Tracker axes.

Effects of motion and orientation

Motion of the receiver or laser head along the beam path (X) has no effect on the measurement, since both f_1 and f_2 would exhibit Doppler shift.

Small motions of the laser head, receiver, interferometer, or retroreflector in a direction perpendicular to the beam path (Y or Z) have no effect on the measurement. The only restriction is that sufficient light returns to the receiver.

Although the Laser Head or the Receiver may be rotated in 90° increments about the beam axis (roll), other roll deviations from the four optimum positions degrade the measurement signal. If either the Laser Head or Receiver is rotated 45° about the beam axis, all position information will be lost because the receiver will not be able to distinguish between the two frequencies.

Angular motion of the receiver about the Y axis, the Z axis, or both, has no effect on the measurement, within certain alignment limits.

Mounting

Offset aperture

Offset aperture allows flexibility in mounting the Agilent 10780C or Agilent 10780F receiver (that is, the bulk of the receiver or sensor head can be mounted above, below, right, or left of the incoming laser beam).

Agilent 10780F Remote Receiver sensor head

The Agilent 10780F receiver’s fiber optic sensor head may be mounted directly to certain interferometers (Agilent 10719A, Agilent 10721A, Agilent 10735A, Agilent 10736A). Alignment pins are provided for easy installation and alignment. This eliminates the need for any other user-supplied mount for the sensor head.

Installation

When installing the receiver, keep the following points in mind:

At a 45° position (roll), the signal will go to zero.

Plastic mounting hardware electrically isolates the Agilent 10780C or Agilent 10780F receiver from the machine and reduces problems with heat conduction.

The receiver typically dissipates 2.0 watts, with a maximum dissipation of 2.7 watts. Plastic pads keep an air gap around the receiver and act as thermal and electrical isolators.

CAUTION Use Nylon screws only (Agilent 2360-0369). The receiver housing must be electrically isolated from the mounting fixture.

- The remote sensor in the Agilent 10780F Remote Receiver does not dissipate any power. The remote sensor does not require a nylon screw.
- Allow a 5 cm space at the rear of each receiver housing for each cable connection.
- Maintain a bend radius of at least 35 mm (1.4 inches) to prevent signal attenuation in the Agilent 10780F receiver’s fiber optic cable.

Cable connection

Agilent 10790A/B/C Receiver Cable This cable’s connectors are identical on either end as shown in Figure 282 of Chapter 36, “Accessories. The connectors on the cable and on the receiver and Agilent 10895A axis board are “keyed” to go together only one way. The connectors on the cable each have a locking ring, which takes a 1/4-turn clockwise to secure the cable to its mating connector.

CAUTION Each connector on an Agilent 10790A, Agilent 10790B, or Agilent 10790C cable has both a male and female half. Before making a connection, be sure the male half of the cable connector is properly aligned with the female half of the mating connector. Failure to align the pins prior to mating the connectors may result in damaged pins.

Agilent 10880A/B/C Receiver Cable The connectors at each end are different as shown in Figure 284 of Chapter 36, “Accessories.

One connector is a bayonet connector that inserts into the Agilent 10885A, 10889B, 10896B, 10897C, 10898A, or N1231A axis board. The connectors lock together. To unlock the connectors, slide the cable connector sleeve away from the Agilent axis board’s panel until the connectors separate.

CAUTION Any attempt to twist the cable connector when it is connected to the Agilent 10885A panel connector may cause damage.

The other connector fits the connector on the receiver; this connector is “keyed” to go together only one way. This connector has a locking ring, which takes a 1/4-turn clockwise to secure the cable to its mating connector on the receiver.

Fasteners

The supplied nylon screws must be used to assure that the receiver housing is electrically isolated from the mounting fixture.

Clearance for laser beam

Figure 263 shows: 1) the clearance requirement for the laser beam passing the receiver or sensor head on its way to the interferometer or wavelength tracker, and 2) how the receiver alignment target can be used to be sure the receiver is positioned correctly with respect to this beam. Laser beam clearance is also shown in the receiver specification drawings at the end of this chapter.

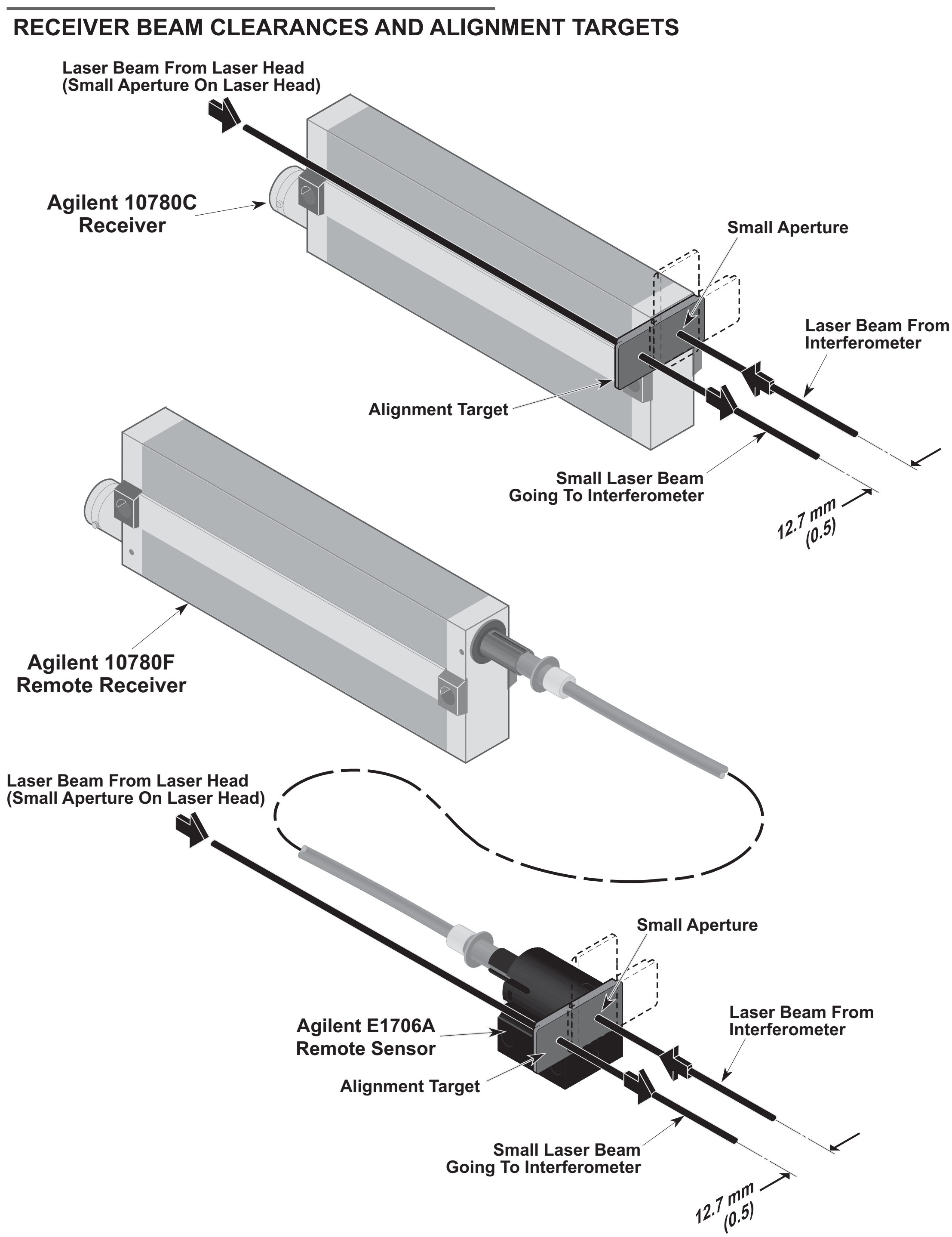


Figure 263 Agilent 10780C and Agilent 10780F Receiver beam clearances and alignment targets

Alignment

General

Each Agilent 10780C or Agilent 10780F Receiver in the measurement system requires an alignment relative to its input beam to maximize its measurement signal strength.

This alignment is typically done by positioning the receiver so the two polarization vectors from the laser head are parallel or perpendicular to the plane defined by the centerlines of the two mounting holes (within ± 3°).

Also, the beams should be centered on the receiver's input lens.

Alignment target

The Agilent 10780C or Agilent 10780F receiver is supplied with a snap-on beam target to ease coarse alignment. The alignment targets are shown in Figure 294 of Chapter 36, “Accessories,” in this manual.

The alignment target attaches at the receiver lens and helps align the receiver to the center of the incident beam. It is also used to adjust the spacing between the beam going to the interferometer and the return beam incident on the receiver.

The Agilent Part Number for the standard Alignment Target for the Agilent 10780C Receiver is 10780-40003.

The alignment target for use with an Agilent 10780F Remote Receiver having a 9 mm lens is Agilent Part Number 10780-40009.

Principle

The receiver is aligned by moving it and rotating it relative to the beam axis.

Receiver alignment is performed during the optical system alignment. The receiver is moved to center the incident beam on its input lens.

The receiver photodetector only measures the overlapping portion of the laser beams.

For maximum signal strength, the interferometer and retroreflector are aligned so the reference beam from the interferometer and the measurement beam from the retroreflector exactly overlap upon recombination. These recombined laser beams then enter the receiver at the center of its input lens. From Figure 264, it is clear that if the recombined laser beams entering the receiver are not centered on the photodetector, measurement signal loss will occur. If the interferometer or the retroreflector is misaligned (Figure 264), the reference and measurement beams no longer completely overlap, resulting in signal loss. Typically, a lateral offset of 1/4 of the beam diameter between the beams is allowable for an adequate measurement signal. However, you must make every effort to optimize the laser beam overlap for maximum performance.

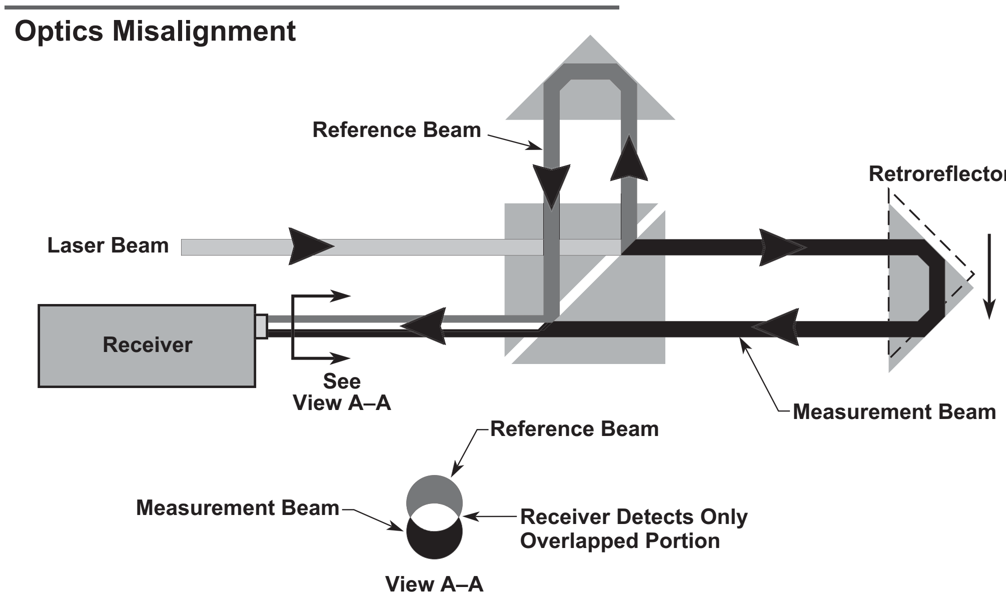


Figure 264 Effect of optics misalignment

If the measurement beam is not aligned parallel to the direction of retroreflector travel, there are two effects.

- First, a cosine error is generated of a magnitude directly related to the angle of misalignment. For a complete description of cosine error, refer to Chapter 12, “Accuracy and Repeatability,” in Volume I of this manual.
- Second, when movement occurs between the optics, the angular misalignment also causes a lateral displacement of the measurement beam with respect to the reference beam at recombination, resulting in additional signal loss. Figure 265 illustrates the result of angular misalignment.

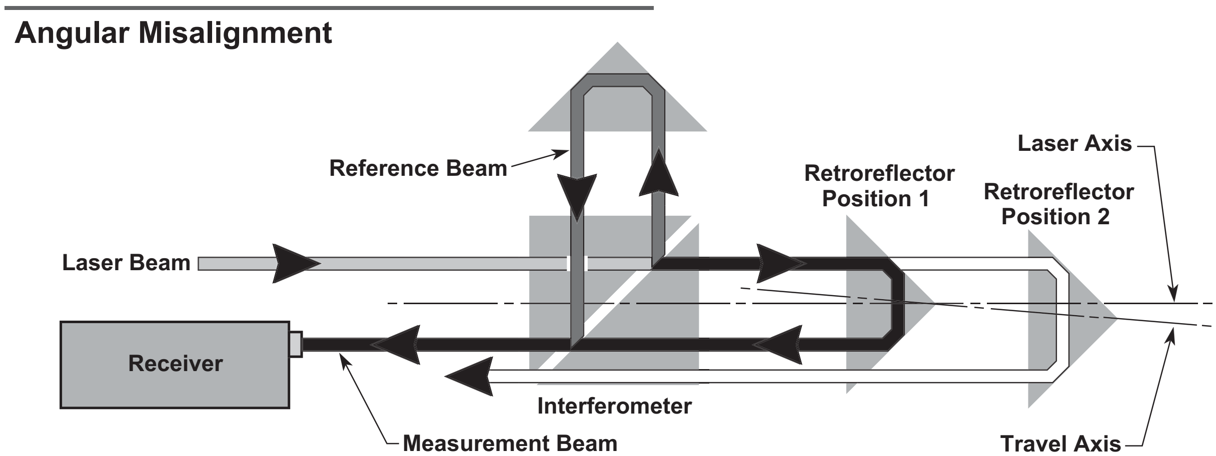


Figure 265 Effects of Angular Misalignment to the Direction of Travel

NOTE The presence of measurement signal through the total length of travel does not guarantee that the measurement axis is aligned for minimum cosine error. Also, any angular misalignment of the laser beam to the direction of travel causes a decrease in the measurement signal strength.

Receiver alignment and gain adjustment procedure

The procedures presented here are common to most of the alignment procedures or techniques presented in Chapter 4, “System Installation and Alignment,” and Chapter 5, “Measurement Optics (General Information),” in Volume I of this manual. Usually, aligning the receiver and adjusting its gain will be done after all other optics alignment has been done.

To align and adjust the Agilent 10780C or Agilent 10780F receiver:

1 Align the optics on the machine in the desired configuration. See the alignment procedures or techniques applicable to the interferometer(s) or wavelength tracker installed in your system. Use alignment targets, alignment aids, or both, to establish proper beam spacing and positioning.
2 Run the system stage out to its limit such that the retroreflector or plane mirror for one axis is at its furthest position from the interferometer.
3 Mount the Agilent 10780C or Agilent 10780F receiver on that axis, if this has not already been done.
4 Connect a digital voltmeter (DVM) or oscilloscope to the test point on the back of the receiver.
5 Align the receiver for a maximum positive voltage at the test point. You may have to adjust the gain potentiometer to keep the test point voltage out of saturation and in the linear region (0.1 to 0.8V).

NOTE

A simple way to align the receiver is to use a gage block to autoreflect the beam. Remember that the objective is to position the receiver or sensor head such that the beam enters the input aperture perpendicular to its front face and centered in the aperture. Hold the gage block against the front face and adjust the receiver or sensor head position and angular orientation so that the beam is autoreflected, that is, coincident upon itself at the laser head.

This will provide excellent alignment of the receiver in pitch and yaw, but not roll, relative to the beam axis. Roll must be aligned so the two polarization vectors from the laser head are parallel to or perpendicular to the plane defined by the centerlines of the two mounting holes, within ±3°.

6 Turn the GAIN potentiometer fully clockwise.
7 Block the measurement beam (the beam between the interferometer and the measurement reflector).
8 Adjust the GAIN potentiometer counter-clockwise until the test point voltage drops below 0.1V.
9 Unblock the measurement beam. The test point voltage should be at least 0.7V.

NOTE

Record the voltage reading at the beam monitor test point as an axis reference for future troubleshooting.

Operation

The Agilent 10780C Receiver or Agilent 10780F Remote Receiver normally receives its operating power from the measurement electronics to which it is connected. When the measurement electronics are turned on, the receiver will turn on.

An LED on the Agilent 10780C or Agilent 10780F receiver signals beam capture.

An available dc voltage output on the Agilent 10780C or Agilent 10780F receiver indicates incoming laser beam intensity.

Specifications and characteristics

Specifications describe the device’s warranted performance. Supplemental characteristics (indicated by TYPICAL or NOMINAL) are intended to provide non-warranted performance information useful in applying the device.

Specifications for the Agilent 10780C Receiver and Agilent 10780F Remote Receiver are given below.

Specifications for the Agilent 5519A/B Laser Head’s internal receiver are given in Chapter 16, “Laser Heads,” of this manual.

Sensitivity

The maximum sensitivity of the Agilent 10780C is 1.5 μW (factory-set at 5 μW) and can be adjusted via an externally accessible potentiometer. The adjustment procedure is given earlier in this chapter.

Maximum sensitivity of the Agilent 10780F Remote Receiver is 2.2 μW with its standard 2 m cable (a 10 m cable reduces the sensitivity to 5.0 μW).

The difference between the Agilent 10780C and the discontinued Agilent 10780A and Agilent 10780B models is the increased bandwidth and sensitivity of the Agilent 10780C to laser light.

Agilent 10780C Receiver Specifications

Weight: 136 grams (4.8 ounces)

Dimensions: see figure below

Typical Power Requirements: +15 volts at 136 mA

Heat Dissipation: 2.0 W typical

Alignment Tolerances:

Roll: ±3 degrees

Pitch: ±1 degree

Yaw: ±1 degree

Maximum Sensitivity: 1.5 µW

Factory adjusted to 5.0 µW; can be adjusted to maximum sensitivity using procedures in the Agilent 10780C/F Operating and Service Manual.

Output Signal:

Differential square wave at Doppler-shifted split frequency (100 kHz to 7.2 MHz)

Electrical Cables:

Agilent 10790A: 5 m (15.2 ft)

Agilent 10790B: 10 m (30.5 ft)

Agilent 10790C: 20m (61 ft)

Electrical cables for Agilent 10885A, 10889B, 10896B, 10897C, 10898A, or N1231A/B axis board:

Agilent 10880A, 5 m (15.2 ft)

Agilent 10880B, 10 m (30.5 ft)

Agilent 10880C, 20m (61 ft)

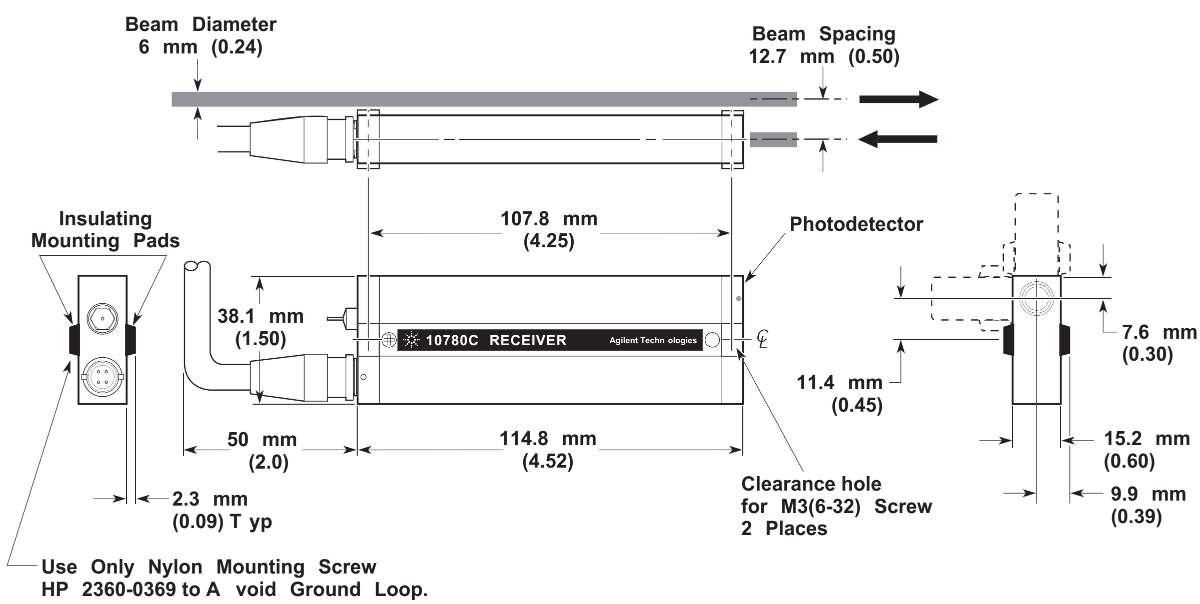


Figure 266 Agilent 10780C Receiver — dimensions

Agilent 10780F Remote Receiver Specifications

Weight: 126 grams (4.5 ounces) for Agilent 10780F receiver
26 grams (0.9 ounce) for remote sensor with a 2 meter cable

Dimensions: see figure below

Typical Power Requirements: +15 volts at 136 mA

Heat Dissipation: 2.0 W typical for receiver
0 W for remote sensor

Alignment Tolerances:

Roll: ±3 degrees

Pitch: ±1 degree

Yaw: ±1 degree

Maximum Sensitivity: 2.2 µW (with 2-meter cable)

Factory adjusted to 5.0 µW; can be adjusted to maximum sensitivity using procedures in the Agilent 10780C/F Operating and Service Manual. (Becomes 5.0 *W with a 10-meter fiber cable.)

Output Signal:

Differential square wave at Doppler-shifted split frequency (100 kHz to 7.2 MHz)

Electrical Cables:

Agilent 10790A: 5 m (15.2 ft)

Agilent 10790B: 10 m (30.5 ft)

Agilent 10790C: 20m (61 ft)

Electrical cables for Agilent 10885A, 10889B, 10896B, 10897C, 10898A, or N1231A/B axis board:

Agilent 10880A, 5 m (15.2 ft)

Agilent 10880B, 10 m (30.5 ft)

Agilent 10880C, 20m (61 ft)

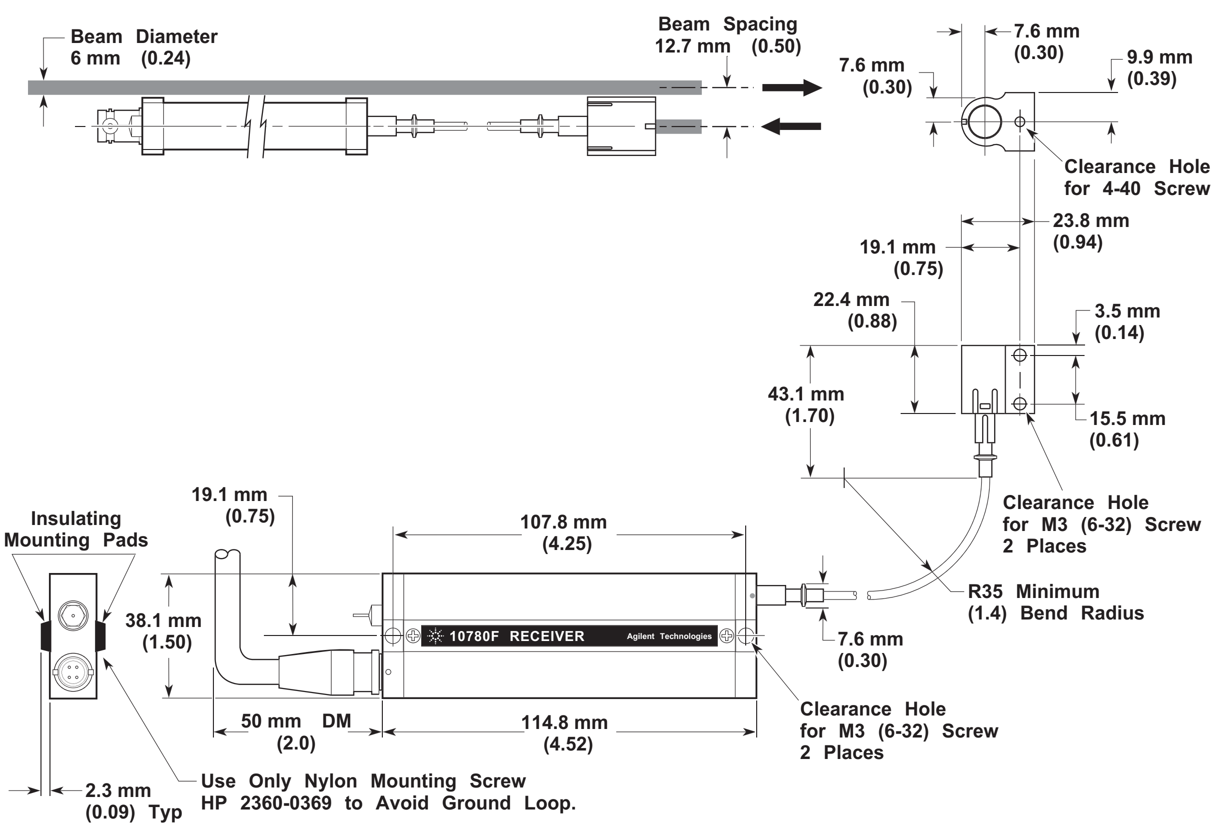


Figure 267 Agilent 10780F Remote Receiver — dimensions

Agilent E1708A Remote Dynamic Receiver

Description

The Agilent E1708A Remote Dynamic Receiver, shown in Figure 268, is intended for use in applications requiring sub-nanometer resolutions of systems in motion. It extends the performance of systems that use the Agilent 10897C High Resolution Laser Axis board for VMEbus by providing performance consistent with the high resolution and low variable data age of that board. As the Doppler shift caused by motion of the system stage changes the measurement frequency, the Agilent E1708A receiver ensures minimal phase processing errors. The E1708A also provide immunity to errors induced by changes in measurement signal (laser input) power level.

One receiver package is required for each measurement axis in the Laser Transducer system being installed.

The Agilent E1708A receives the laser beam via a remote sensor (Agilent E1706A) containing a lens and polarizer. A fiber-optic cable (Agilent E1705A) carries the beam from the remote sensor to the electronics in the receiver body. The fiber-optic cable length is 2.0 meters to allow for considerable mounting flexibility and ease of use. This arrangement provides several benefits:

- it allows the receiver body to be located well away from the point of beam intercept so receiver heat is not dissipated near the measurement area.
- it makes easier access to the attenuator and squelch adjustments possible, and
- there is a much smaller package size in the measurement area.

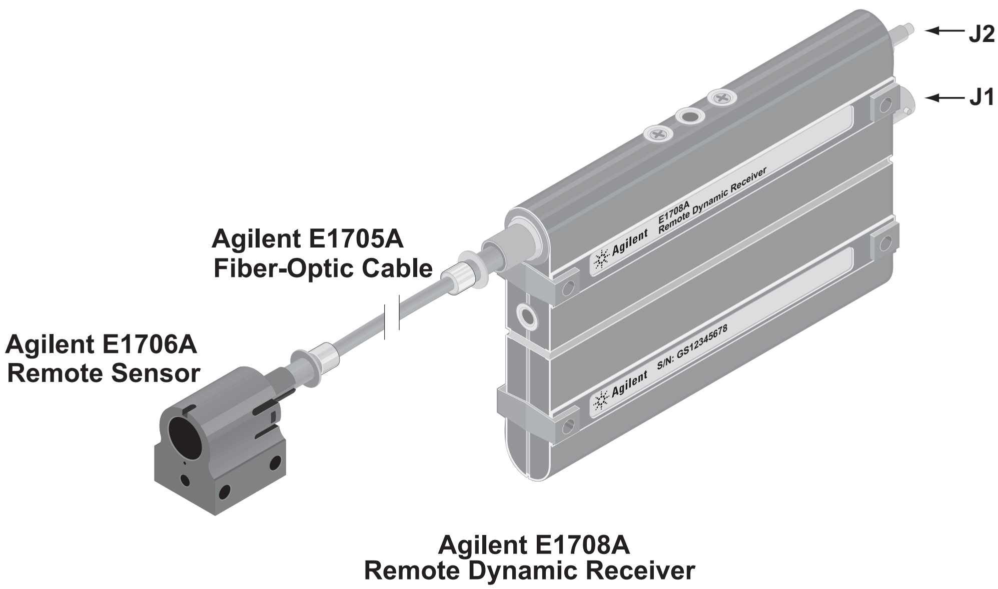


Figure 268 Agilent E1708A Remote Dynamic Receiver

Principles of operation

The Agilent E1708A receiver's body contains the photodetector, preamplifiers, and a detector circuit designed to convert the laser beam returning from an interferometer into a differential square wave at the Doppler frequency (100 kHz to 7.2 MHz). The Doppler frequency contains the measured displacement information (MEAS signal), representing the relative motion between an interferometer and its associated reflector. A squelch circuit allows the receiver's signal output to be turned off automatically if the input signal is not strong enough. A secondary output from the receiver is a dc level that is proportional to the input signal strength. LED indicators on the receiver light when any input signal is detected. For a block diagram, see Figure 268.

1 Photodetector, amplifier
2 Attenuator adjustment
3 Amplifier
4 LEDs
5 Squelch adjustment
6 Signal level detector circuit
7 Sinewave-to-squarewave converter
8 Signal strength connector (J2, see Figure 268)
9 Output signal/input power connector (J1, see Figure 268)

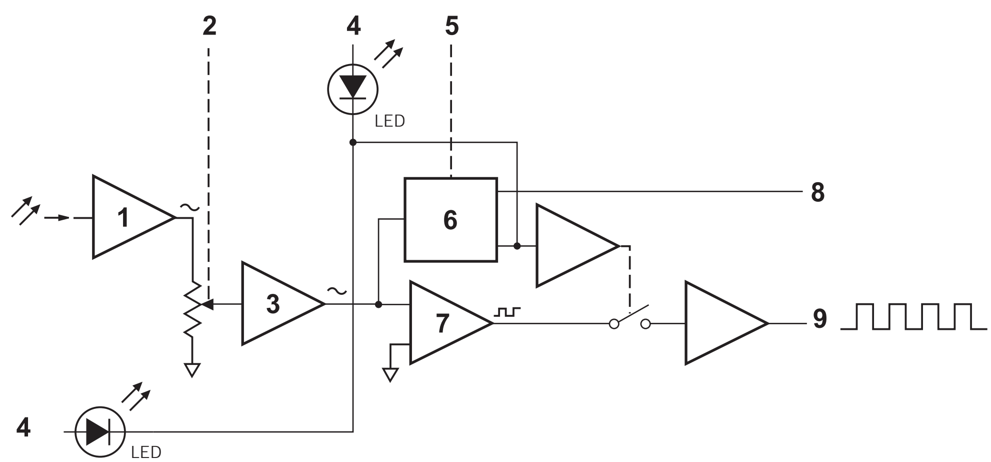


Figure 269 Agilent E1708A Receiver—block diagram

Installation

Refer to Agilent 10780C/F Receiver's placement, mounting, installation examples, and procedures for alignment to the laser beam. For more specific mounting, installation, and alignment and adjustment procedures, see the *Agilent E1707A Dynamic Receiver and Agilent E1708A Remote Dynamic Receiver Operating Manual.*

Cables for electronics

The receiver cable to be used depends on the electronics (system) to be used. Table 78 lists the available cables. Refer to the manual for your system for more cabling information.

Table 78 Cables for use with an E1708A receiver

For use with these electronics	Use one of these Receiver Cables	Description
Agilent 10885A PC Axis Board Agilent 10889B PC Servo-Axis Board Agilent 10896B Laser Compensation Board for VMEbus (with Agilent 10717A Wavelength Tracker)	5 meters: Agilent 10880A 10 meters: Agilent 10880B For cable lengths longer than 10 meters, use high-performance cables. Contact Agilent for information about high-performance cables.	These cables have a 4-pin BNC connector on one end and a 4-pin LEMO connector on the other.
Agilent 10897C High Resolution VMEbus Laser Axis Board Agilent 10898A VME High Resolution Dual Laser Axis Board Agilent N1231A/B PCI Three-Axis Board	Use high-performance cables (5 meters: Agilent N1250A; 10 meters: Agilent N1250B). Contact Agilent for additional information.	These cables have a 4-pin BNC connector on one end and a 4-pin LEMO connector on the other. Use high performance cables for both the receiver and the laser head.
Agilent 10895A Laser Axis Board for VMEbus	5 meters: Agilent 10790A 10 meters: Agilent 10790B	These cables have a 4-pin BNC connector on each end.

Each of these receivers has a polarizer as part of its input lens assembly. The E1708A receiver's lens assembly is in the remote sensor assembly.

When mounting either receiver, remember the following points:

- For maximum input signal strength, align the polarizer so its polarization vectors are the same as those of the incoming laser beam. At a 45-degree roll position, the signal goes to zero.
- For either receiver body, power dissipation is typically 3.8 watts. The receiver's mounting feet keep an air gap around the receiver and also act as thermal and electrical isolators.
- Leave enough clearance for the signal cable that connects to the receiver's 4-pin signal and power connector. (See dimensional drawing in Figure 271.)
- The receiver housing must be electrically isolated from the equipment it is mounted on. The clearance holes in the receiver's insulating mounting feet let you use either 6-32 or M3.5 screws.

CAUTION

When installing or removing the fiber optic cable from the receiver body or sensor head, DO NOT PULL ON THE CABLE PROPER, GRIP THE CONNECTOR AND PULL IT STRAIGHT OUT (see Figure 270).

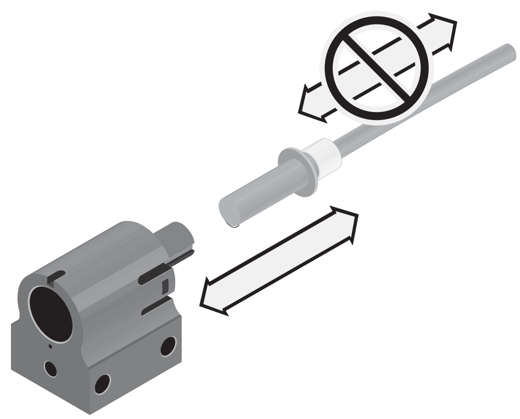


Figure 270 Grip and fiber-optic cable connector

Agilent E1705A Fiber-Optic Cable considerations

The Agilent E1705A Fiber-Optic Cable supplied with the Agilent E1708A receiver is 2.0 meters long (The Agilent E1705A cable comes in different lengths and is made of plastic or glass. Contact Agilent Call Center to order a fiber optic cable of your preference; telephone numbers of various call centers are listed on the "Service and Support" page at the back of this manual). The radius of any bend should be 35 mm (1.4 inches) or more. When coiled to take up excess cable slack, the coil diameter should not be less than 150 mm (6 inches). Details of coiling are given below.

See Figure 79 for fiber optic cable characteristics that require special handling and consideration for installation and operation.

Table 79 Fiber optic cable considerations

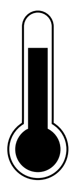
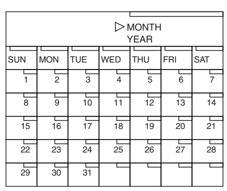
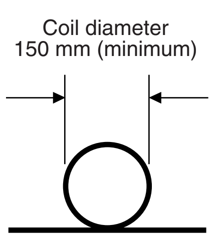
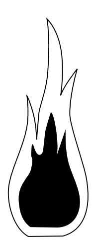
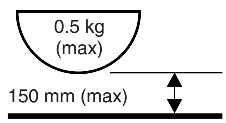
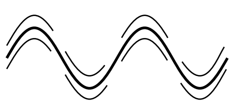
Attribute	Description, comment, etc.
Attenuation	Normal cable attenuation is covered by the Sensitivity section of the Specifications in Appendix A. Attenuation due to environmental changes is covered in the information below.
Temperature Sensitivity 	The fiber optic cable is relatively insensitive to temperature changes. The only characteristic that is affected is the cable attenuation, which changes only 2 to 3 percent from 0 to 50 degrees C. Note that measurement accuracy is unaffected by amplitude variations.
Lifetime 	When the cable is flexed continuously around a small radius, the cable will develop permanent attenuation. The attenuation increases as the flexing continues. Using a larger bend radius allows a considerable increase in lifetime. The lifetime specification is 1000 cycles with a 90-degree bend around a 10-millimeter (0.4-inch) radius. In tests using a 75-millimeter (3.0-inch) bend radius, the cables survived more than 260,000 cycles of bending with no increase of signal attenuation. Cables in permanent installations should not have bends less than 35 millimeters (1.4 inches) radius. If the cable must flex repeatedly, the bend radius should not be less than 100 millimeters (4 inches).
Coiling Excess Cable 	The cable coil diameter should be 150 millimeters (6 inches) or larger, to avoid any increase in attenuation.
Environmental Considerations 	The fiber optic cables are UL-recognized components that pass UL VW-1 flame retardancy specifications. In most instances, the use of conduit is probably not necessary, since the cable has excellent safety properties in flammable environments. Also, the cable is electrically non-conductive, so it requires no shielding.

Table 79 Fiber optic cable considerations (continued)

Attribute	Description, comment, etc.
	The cable's polyethylene jacket provides protection against abrasion and chemicals. Avoid placing the cable directly in organic or alkaline solvents for extended periods of time (hundreds of hours), since these chemicals can penetrate the polyethylene jacket and degrade the optical properties of the fiber.
	The fiber cable is specified to withstand a 0.5 kilogram weight shaped in the form of a half-cylinder that is dropped from a height of 150 millimeters.
Cable Bending and Movement 	Shaking, bending and vibration of the cable will not result in measurement errors, but can cause signal attenuation. If the movement is periodic and continuous, amplitude modulation can occur, with the amplitude depending on the bend radius. Amplitude modulation can cause signal attenuation but not measurement errors.

Alignment and adjustments

To aid in aligning the laser beam, three features are available:

- Initial receiver positioning and coarse beam alignment are achieved with a snap-on beam target fixture (Agilent part number 10780-40009) which is supplied with the receiver. The target is for beam alignment only, and should be removed before operating the receiver.
- LEDs on the top and front of the receiver light to provide visual indication that the receiver photo detector has received both frequency components of the laser beam.
- A dc voltage, which is a function of the incoming laser signal level, is made available for assistance in fine-tuning the laser beam alignment.

The remote sensor allows the receiver's body to be located well away from the point of beam intercept. Some Agilent interferometers allow for direct mounting of the remote sensor.

Operation

Two LEDs light to indicate that the receiver's photodetector has received the laser beam. If the LEDs do not light during operation, try adjusting the attenuator and squelch controls, as described in the "Alignment and Adjustments" of the *Agilent E1707A Dynamic Receiver and Agilent E1708A Remote Dynamic Receiver Operating Manual*

Specifications and characteristics

Specifications describe the device's warranted performance. Supplemental characteristics (indicated by TYPICAL or NOMINAL) are intended to provide non-warranted performance information useful in applying the device.

Specifications for the Agilent E1708A Remote Dynamic Receiver are provided in the following subsection.

Agilent E1708A Remote Dynamic Receiver Specifications

Weight: 170 grams (6.0 ounces)

26 g (0.9 ounces) for remote sensor with 2-m cable

Dimensions: see figure below

Typical Power Requirements: +15 volts ±1V at 250 mA maximum

Heat Dissipation: 3.8 W typical for receiver

0.0 W for remote sensor

Alignment Tolerances:

Roll: ±3 degrees

Pitch: ±1 degree

Yaw: ±1 degree

Maximum Sensitivity: 2.2 µW (E1708A with 2-m cable)

5.0 µW (E1708A with 10-m cable)

Output Signal:

Differential square wave at Doppler-shifted split frequency (100 kHz to 7.2 MHz). (Designed to operate with Agilent laser boards.)

Signal Strength Monitor: 0-8 volts proportional to optical input signal

Electrical Cables:

Agilent 10790A, 5 m (16.4 ft)

Agilent 10790B, 10 m (32.8 ft)

Agilent 10790C, 20 m (65.6 ft)

Electrical cables for Agilent 10885A, 10889B, 10896B, 10897C, 10898A, or N1231A/B axis board:

Agilent 10880A: 5 m (16.4 ft)

Agilent 10880B: 10 m (32.8 ft)

Agilent 10880C: 20m (65.6 ft)

or high performance electrical cables:

Agilent N1250A 5 m (16.4 ft)

Agilent N1250B 10 m (32.8 ft)

Fiber-Optic Cables Length:

2 m standard

10 m maximum

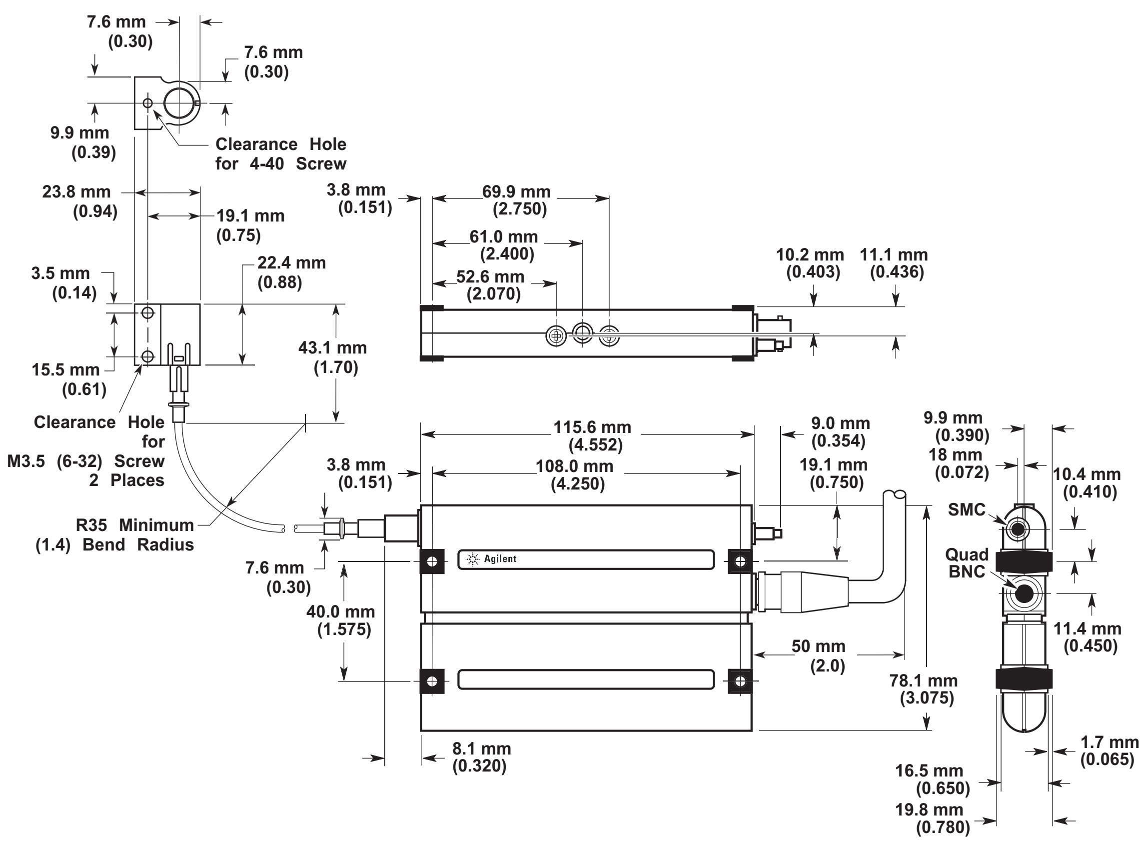


Figure 271 Agilent E1708A receiver — dimensions

Agilent E1709A Remote High-Performance Receiver

Description

The Agilent E1709A Remote High-Performance Receiver (see Figure 272) is an important component of the measurement electronics for an Agilent Laser Interferometer Measurement System. The Agilent E1709A converts light from the remote sensor to electrical signals that can be processed by the system electronics (See Figure 275). The Agilent E1709A is for use in the most demanding applications requiring sub-nanometer resolutions of systems in motion. As the Doppler shift caused by motion of the system stage changes the measurement frequency, the Agilent E1709A receiver ensures minimal phase (position) processing errors. The E1709A also provides immunity to errors induced by changes in measurement signal power level.

One receiver is required for each measurement axis in the Laser Transducer system being installed. See the *Agilent E1709A Remote High-Performance Receiver Operating Manual* for compatible cable information, as well as signal and connector information.

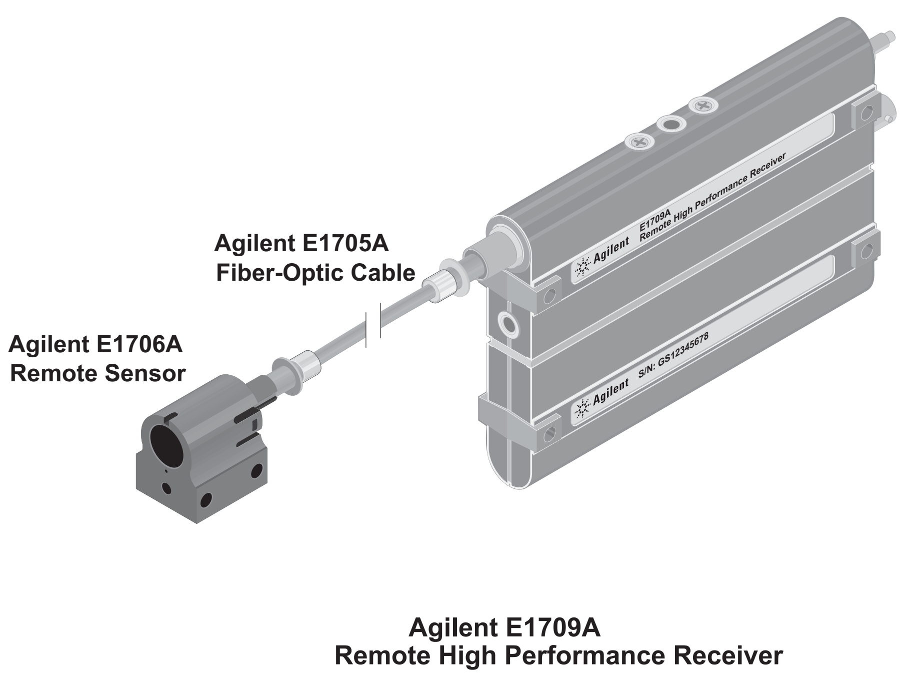
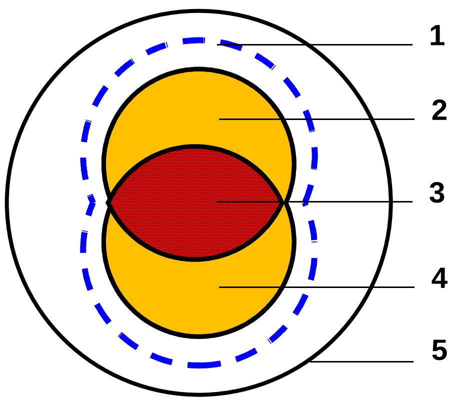


Figure 272 Agilent E1709A Remote High-Performance Receiver

Key definitions and concepts

Sensitivity dependencies are explained in terms of AC/DC ratio. It is important to understand this concept and how its measurement relates to the resultant electrical output of the Agilent E1709A receiver. Understanding the following terms will also clarify the differences between the Agilent E1708A and the Agilent E1709A, which are discussed and listed later in "Agilent E1709A relationship to Agilent E1708A" subsection in this chapter. The definitions include references to connectors (J2 and J3), shown in Figure 273. Detailed descriptions of the Agilent E1709A connectors and signal outputs are covered in *Agilent E1709A Remote High-Performance Receiver Operating Manual.*

Figure 273 illustrates the ac and dc light power relationship.



1 DC Light Power
Sum of both beams including overlap area (J3)

2 Measurement Beam

3 AC Light Power (beam overlap of 50%)
Only the overlapping portion of the beam (J3 and J2)

4 Reference Beam

5 Remote Sensor Clear Aperture

Figure 273 AC/DC light power relationship

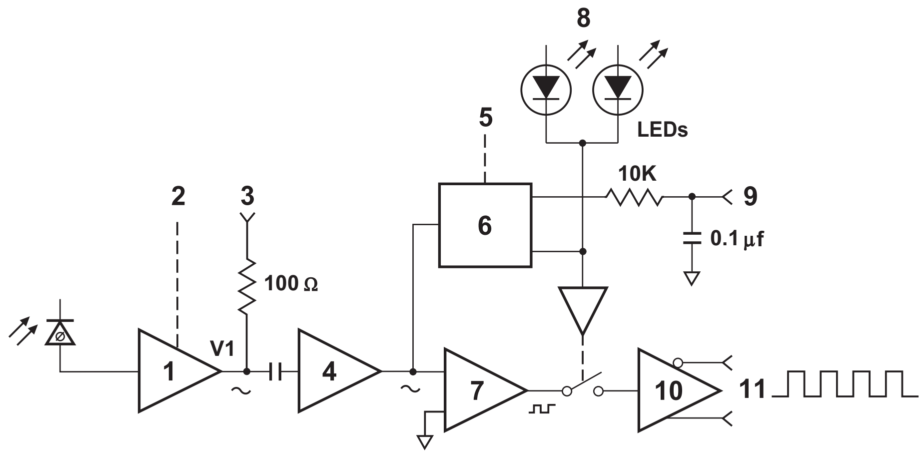
DC Light Power In the Agilent laser measurement system, the receiver captures the light power (intensity) from the two beams, the Measurement Beam and the Reference Beam, which are at slightly different frequencies. The sum of the light power in each beam is the dc component of the light power (assuming both beams are within the sensor clear aperture area).

NOTE For the Agilent E1708A, the dc portion of the laser beam has little impact on the specification. However, with the Agilent E1709A, the amplitude of the dc light signal directly affects the receiver sensitivity. Therefore, it is important to measure both the ac and the dc components at the First Stage Output.

AC Light Power When the two beams overlap, this produces a *difference frequency* (split frequency), which is detected by the receiver as the ac component of the light power. It is the ac light power that is converted to an electrical signal, which becomes the *measurement frequency*.

AC/DC Ratio This is the proportion of ac light power to the total dc light power. For example, Figure 273 shows the AC/DC ratio as approximately 50%. The importance of the AC/DC ratio is discussed in detail in Chapter 3 of the *Agilent E1709A Remote High-Performance Receiver Operating Manual*. The alignment procedure described in Chapter 4 of the Operating Manual involves calculating the AC/DC ratio and comparing the values to the Agilent E1709A specifications.

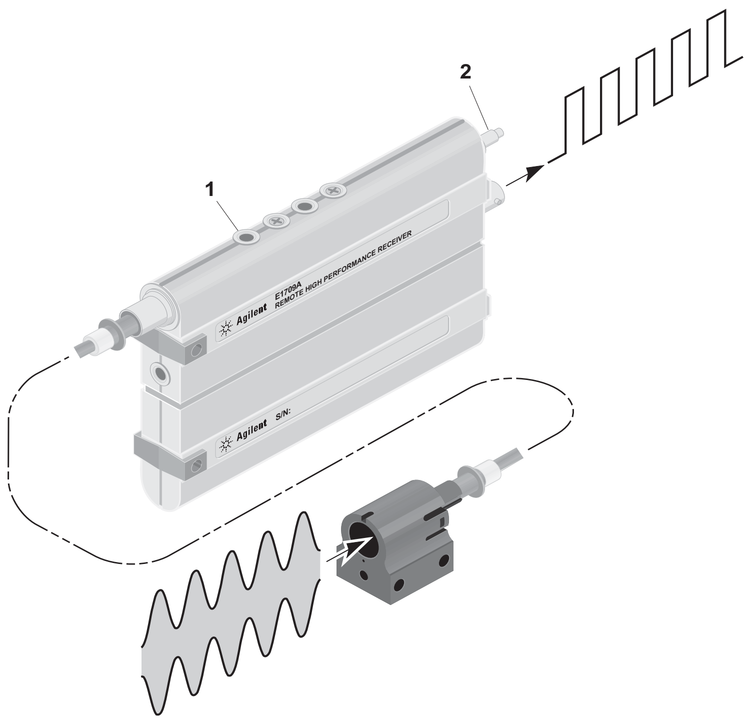
First Stage vs. Second Stage In the first stage of the Agilent E1709A electronics, both the dc and the ac signals are present. In the second stage, the dc is stripped away and only the ac signal is used to create the receiver output signal. The first and second stages are shown in Figure 274.



1 Photodetector, first stage amplifier
2 Attenuator adjustment
3 First Stage Output (J3 connector)
4 Second stage amplifier
5 Squelch adjustment
6 Signal strenght detector circuit
7 Sinewave-to-squarewave converter
8 LEDs
9 Signal strength voltage (J2 connector)
10 Cable driver
11 Output signal/input power (J1 connector)

Figure 274 Agilent E1709A Receiver block diagram

Figure 275 illustrates the location and signal characteristics of J2 and J3.



	Reference	Description
1	J3 First Stage Output	Indicates ac and dc portions of the light signal.
2	J2 Signal Strength Voltage	indicates only the ac portion of light signal as a dc voltage. This is an SMC connector. An SMC (f) to BNC (f) Adapter (Agilent part number 1250-0832) is available.

Figure 275 Agilent E1709A with fiber and lens assembly

First Stage Output Voltage (J3) This is the actual output voltage of the Agilent E1709A's first electrical stage. It contains both the dc and ac portions of the incoming light signal and hence is used to determine the AC/DC ratio. This signal **is** affected by adjustments of the Agilent E1709A attenuator.

Signal Strength Voltage (J2) This is a dc voltage that is proportional to the ac component of the signal at the output of the second electrical stage. This signal **is** affected by any adjustments of the Agilent E1709A attenuator. This dc voltage should not be confused with the dc light signal component.

Features

Agilent E1706A Remote Sensor

The Agilent E1709A requires an Agilent E1706A Remote Sensor containing a lens, polarizer, and Agilent E1705A Fiber-Optic Cable that can be purchased separately or as an option to the Agilent E1709A. Glass or plastic fiber cables are available. Contact Agilent call center for details. The fiber-optic cable carries the beam from the remote sensor to the electronics in the receiver body. The fiber optic cable length is 2.0 meters to allow for considerable mounting flexibility and ease of use (if you require some length other than the standard 2.0 meters, contact Agilent call center). This arrangement provides several benefits:

- It allows the receiver body to be located well away from the point of beam intercept so receiver heat is not dissipated near the measurement area.
- It provides easier access to the attenuator and squelch adjustments.
- It provides a much smaller package size in the measurement area.

Application characteristics

The Agilent E1709A:

- Has high sensitivity of .20 µ to 0.80 µW depending on ac signal strength with a 2-meter cable.
- Accommodates a high Doppler frequency shift to allow greater speed in stage velocity with slew rates to 1m/s with plane mirror optics.
- Has a wide operating temperature range of 0-40° C.
- Has a wide Dynamic Range of 25:1 to 6:1, depending on ac signal strength.

Agilent E1709A relationship to Agilent E1708A

There are several additional features provided by the Agilent E1709A that are not provided by earlier model receivers such as the Agilent E1708A Remote Dynamic Receiver. For detailed comparison of Agilent E1708A and Agilent E1709A, see Figure 77.

Technical enhancements

The Agilent E1709A, compared to the Agilent E1708A:

- has 3 to 11 times greater sensitivity, enabling the measurement system to function with weaker beam signal. This allows a much longer distance between receiver and sensor or more axes per laser head.
- accommodates a higher Doppler frequency shift to allow greater speed in stage velocity (slew rate). The Agilent E1709A can tolerate approximately two times the slew rate limit of the Agilent E1708A.
- has approximately 10 times greater immunity to temperature variations.
- allows approximately 5 times more dynamic range (optical power change).

Adjustment and additional alignment requirements

The Agilent E1709A has much greater sensitivity specifications than the Agilent E1708A. In order to obtain the optimum sensitivity performance for the Agilent E1709A, additional measurements and alignment procedures are required to maximize the ratio of ac light signal to dc light signal at the receiver input. Figure 273, illustrates ac light and dc light at the receiver input.

The Agilent E1709A features an oscilloscope probe connection to measure the AC/DC ratio.

Retrofit issues

The Agilent E1709A can be used in most applications where the Agilent 10780F or Agilent E1708A is used. In most respects, the Agilent E1709A has better specifications than these other receivers, and will perform as well or better. However, several specifications should be checked.

- Size is the same as the Agilent E1708A and larger than the Agilent 10780F.
- Maximum AC Optical Signal Intensity specification is 50µW for the Agilent E1709A, which is 4 times less than for the Agilent E1708A. The maximum optical signal can be larger if larger position error is acceptable.
- AC/DC ratio is more important for the Agilent E1709A than for other Agilent laser system receivers.

- DC power consumption is considerably larger than the Agilent 10780F and slightly larger than the Agilent E1708A.
- Agilent recommends the use of a scope probe to align the Agilent E1709A. Approximately 130 mm (5 in.) of space above the top of the receiver is needed to allow the scope probe to be plugged in to the J3 connector. The Agilent E1708A (which is almost identical to the Agilent E1709A) does not have a scope probe connector and does not have this space requirement. Therefore, when retrofitting the Agilent E1709A into an Agilent E1708A application, make sure there are provisions for this scope probe access.
- For maximum slew rate, the Agilent 10898A Dual Laser Axis Board and high-performance cables are required.
- When replacing an Agilent 10780C/F with either an Agilent E1708A or Agilent E1709A, metal mounting screws can be used. (Plastic screws are recommended for the Agilent 10780C/F.)

Specifications and characteristics

Specifications describe the device’s warranted performance. Supplemental characteristics (indicated by TYPICAL or NOMINAL) are intended to provide non-warranted performance information useful in applying the device.

Specifications for the Agilent E1709A Remote High-Performance Receiver are provided in the following subsection.

Agilent E1709A Remote High-Performance Receiver Specifications

Weight: For Agilent E1709A —190 grams (6.7 ounces)
For remote sensor with 2m cable: 26g (0.9 oz)

Dimensions: see Figure on next page

Typical Power Requirements:
+15 volts ±1V at 267 mA maximum

Heat Dissipation: 4.0 W typical for receiver
0.0 W for remote sensor

Temperature Range: 0-40 °C operating

Warm-up Time: 45 minutes typical for still air
15 minutes typical for 60 m/min (200 ft/min) moving air

Optical Input:
Dynamic Range ratio: 25:1 to 6:1, depending on the AC/DC ratio.
Maximum input: 50 µW ac, 150 µW dc

Output Signal:

Differential square wave at Doppler-shifted split frequency (100 kHz to 15.5 MHz). (Slew rates to 1 m/s with plane mirror optics, 2 m/s with linear optics.)

Fixed Data Delay: 33.2 ns (typical)

Fixed Delay Temperature Coefficient: 0.015 ns/°C

Errors due to Doppler frequency variations and amplitude variations (within the Dynamic Range ratio specification):
±1.2 nm for linear optics
±0.6 nm plane mirror optics
±0.3 nm for high resolution optics
For overdrive condition, errors are two times these values.

Signal Strength Voltage: 0-10 volts proportional to ac optical input signal

Alignment and Sensitivity: see table below.

Recommended Electrical Cables for Agilent 10885A, 10889B, 10896B, 10897C, 10898A, or N1231A/B axis board:
Agilent N1250A High Performance Receiver Cable (5 m)
Agilent N1250B High Performance Receiver Cable (10 m)
Agilent N1251A Matching High Performance Laser Head Cable (3 m)
Agilent N1251B Matching High Performance Laser Head Cable (7 m)

.

Fiber Optic Cable Type	Remote Sensor Alignment Tolerance	Sensitivity*			
		AC/DC ratio			
		90%	50%	20%	10%
2 m plastic	Roll: ±3° Pitch: ±1° Yaw: ±1°	0.20 µW	0.26 µW	0.46 µW	.80 µW

*See the *Agilent E1709A Remote High-Performance Receiver Operating Manual* (Agilent Part Number E1709-90006, English or E1709-90007, Japanese) for more details on sensitivity.

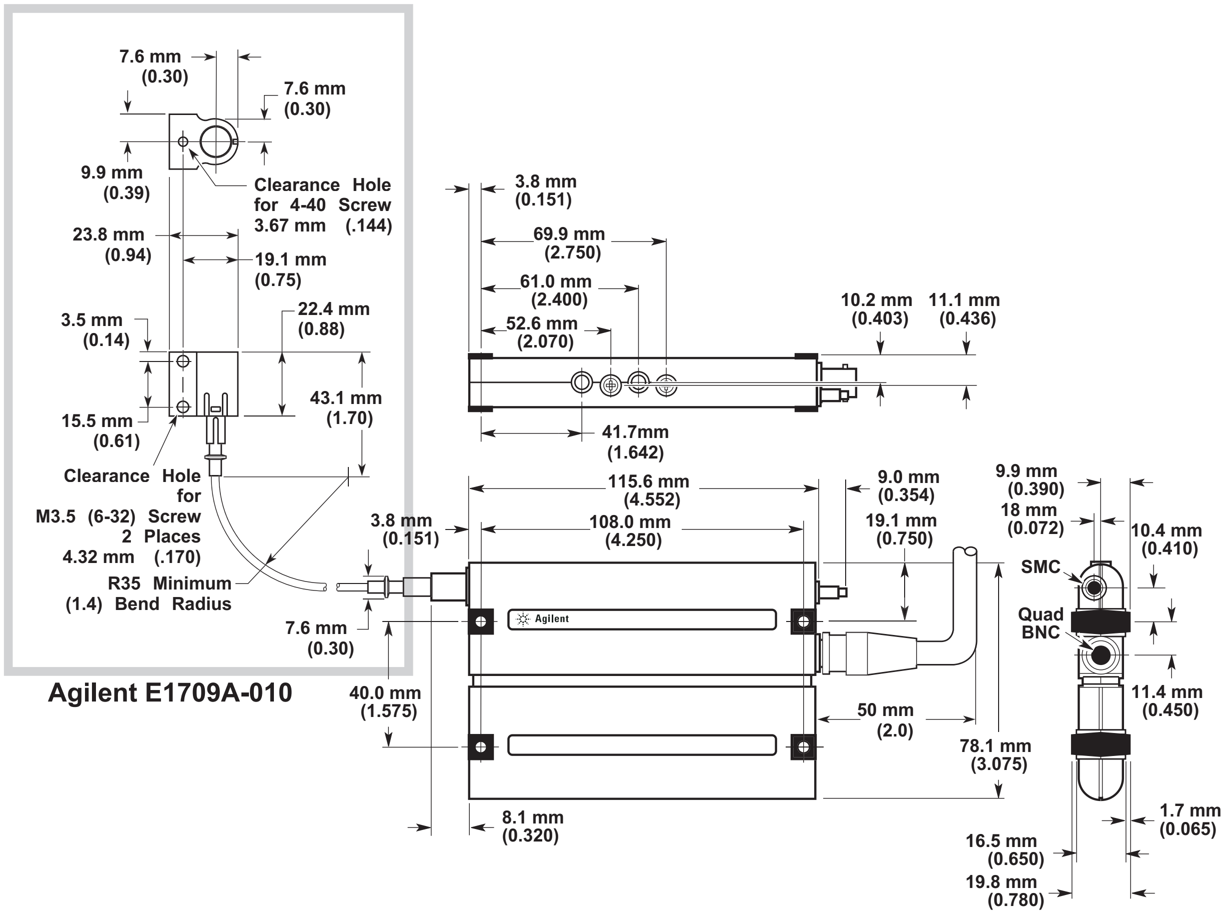


Figure 276 Agilent E1709A receiver — dimensions

36
Accessories

General

This chapter lists and describes Agilent Technologies optic mounts and cables, alignment aids, and other devices available for Agilent Laser measurement systems.

Adjustable Mounting Hardware

Table 80 Adjustable mounting hardware

Component	Comment(s)
Adjustable Mounts	**Adjustable mounts simplify installation and alignment of the optics listed below:**
Agilent 10710B	Use with Agilent 10700A, 10701A, 10705A, 10707A
Agilent 10711A	Use with Agilent 10702A, 10706A, 10706B, 10715A, 10716A
Height Adjuster and Post	**The Height Adjuster and Post simplifies installation and alignment of the optics listed below:**
Agilent 10785A	Agilent 10767A, 10770A, 10771A, 10774A, 10775A, 10776A
	The Height Adjuster and Post may be used with the Agilent 10784A Base
Straightness Accessory Kit	**The Straightness Accessory Kit simplifies installation and alignment of the optics listed below:**
Agilent 10776A	Agilent 10774A, 10775A

Adjustable mounts

The optical elements inside many of the Agilent Laser Transducer System optics are not precisely referenced to their housings. In most applications involving these optics, a few simple alignments during system installation will usually provide equal or better alignment than referencing the optics to their housings. Therefore, slight positioning adjustments of the unreferenced interferometers, beam splitters, and beam benders are needed for proper system alignment. In general, it will be necessary to adjust most, or all, of the optical components.

In general, when aligning Agilent optics, it will be necessary to adjust most or all of the optical components. Most optics are not referenced to their housings, some simple adjustments by the user can provide optimum alignment. The Agilent 10710B and Agilent 10711A Adjustable mounts should be used to provide the adjustment capability for most optical components.

In general, the alignment procedures are performed with all optical components in place. Your measurement system design should allow for adjustment of the laser, optics, and receivers during alignment.

For optics that are not referenced to their housings, use of an Agilent 10710B or Agilent 10711A adjustable mount is recommended. These mounts provide a convenient means for mounting, aligning, and securely locking measurement optics into position.

Both mounts allow angular adjustment in two directions (tilt and yaw).

The Agilent 10710B allows ±8° in tilt and yaw adjustment.

The Agilent 10711A allows ±5° in tilt and yaw adjustment.

The mounts also allow a component to be rotated about its optical centerline (roll) providing simple, time-saving installations.

Any optical component that fits an adjustable mount is supplied with a Hardware Kit (5061-6021 kit for the Agilent 10710B; 5061-6022 kit for the Agilent 10711A) to mount it on the appropriate adjustable mount.

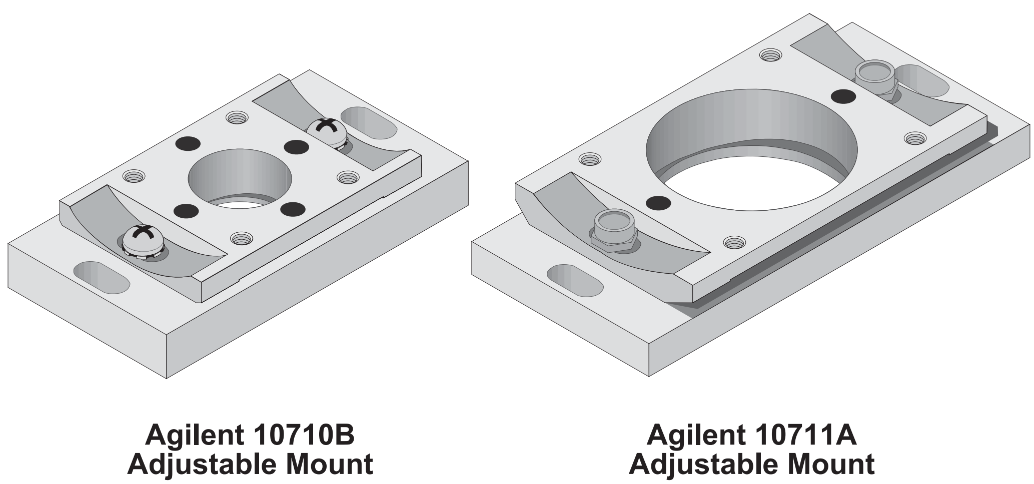


Figure 277 Agilent 10710B and Agilent 10711A adjustable mounts

Height adjuster and post, and base

Some of the optics described in this manual, primarily those intended for use in an Agilent Laser Calibrator System, are designed for use with the Agilent 10785A Height Adjuster and Post. In many cases, the Agilent 10785A can be installed in an existing tapped hole in the device being measured; where this is not possible, it may be possible to use the Agilent 10784A Base as a mounting surface.

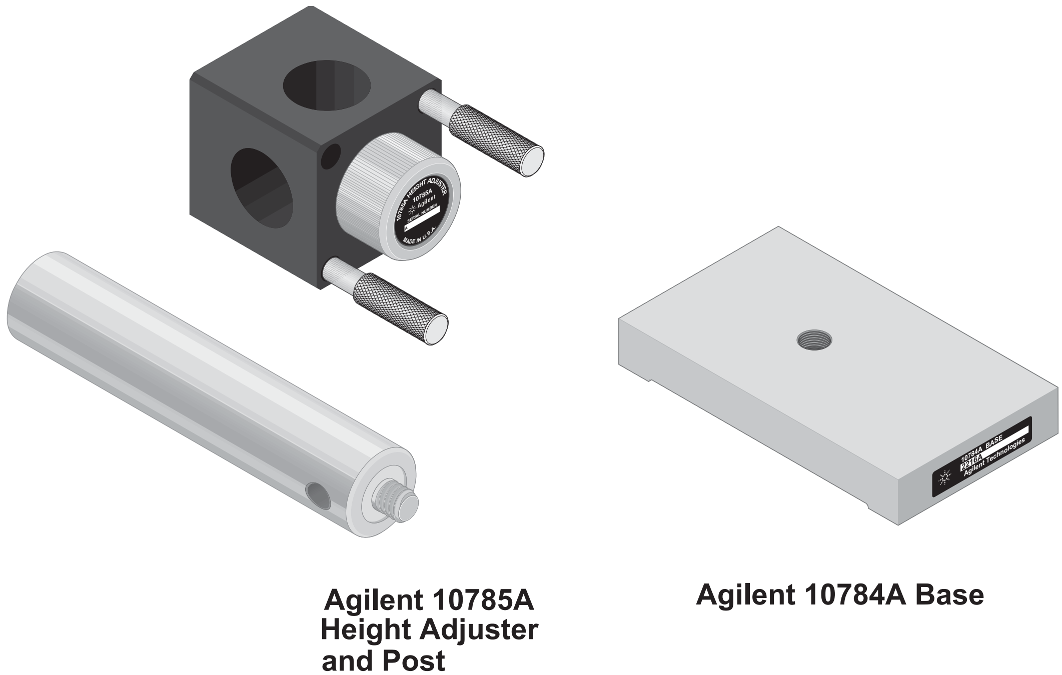


Figure 278 Agilent 10785A Height Adjuster and Post and Agilent 10784A Base

Specifications

Specifications describe the device's warranted performance. Supplemental characteristics (indicated by TYPICAL or NOMINAL) are intended to provide non-warranted performance information useful in applying the device.

Agilent 10710B/10711A Adjustable Mount Specifications

Figures 279 and 280 show the specifications for the Agilent 10710B and Agilent 10711A adjustable mounts.

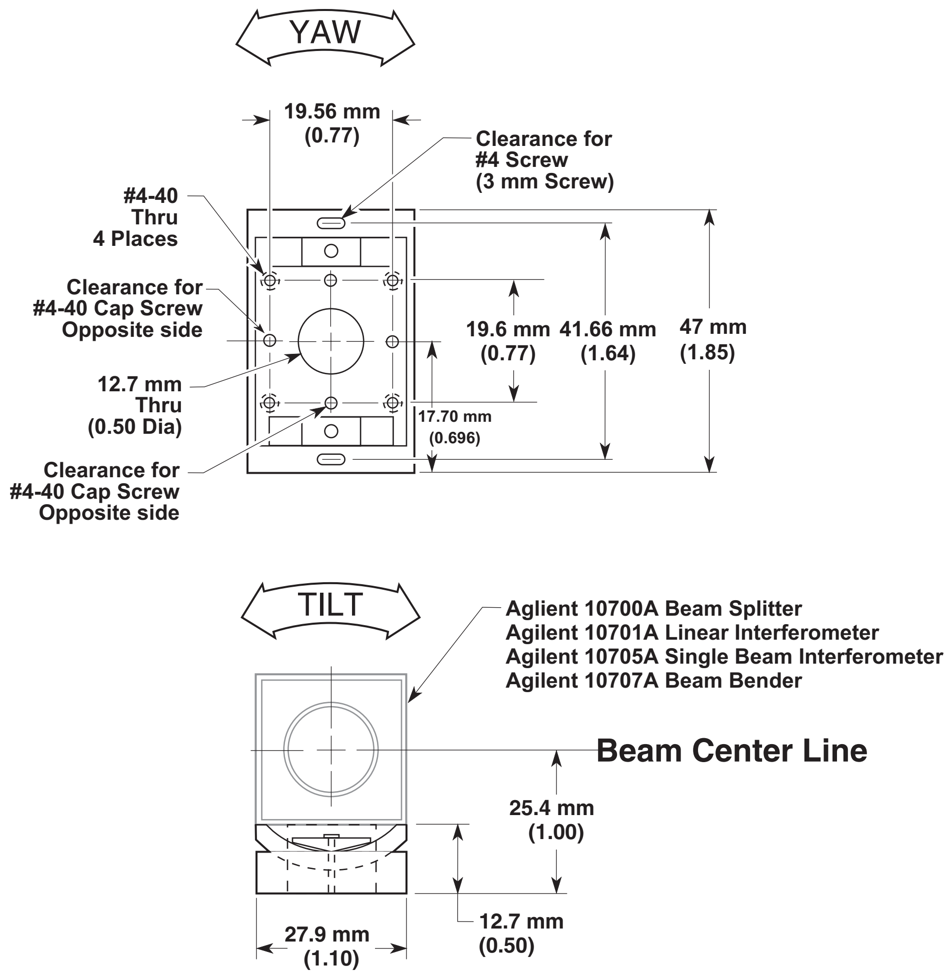


Figure 279 Agilent 10710B Adjustable Mount — dimensions

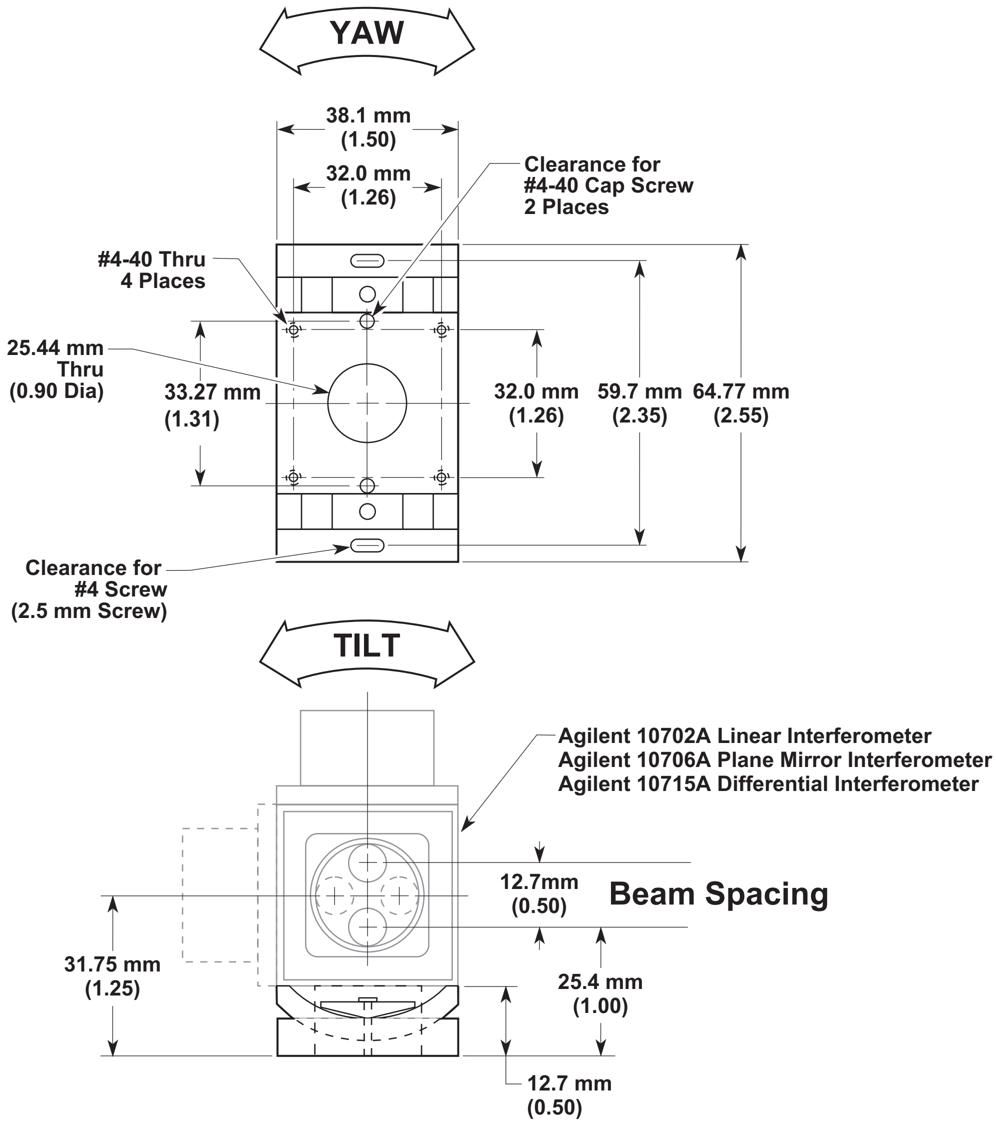


Figure 280 Agilent 10711A Adjustable Mount — dimensions

Agilent 10785A Height Adjuster/Post and the Agilent 10784A Base Specifications

Figure 281 shows the specifications for the Agilent 10785A Height Adjuster and Post and the Agilent 10784A Base.

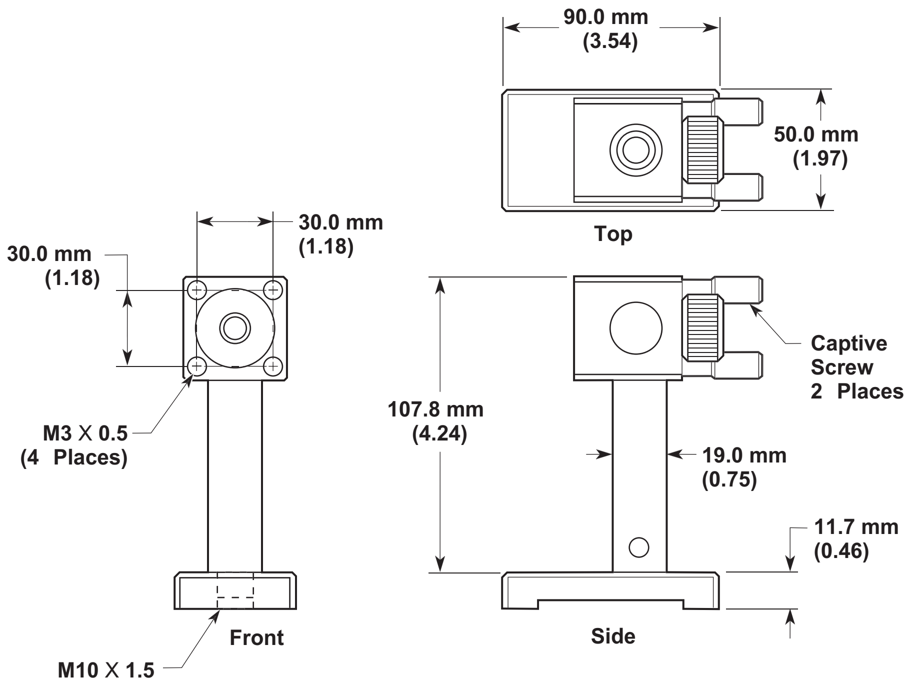


Figure 281 Agilent 10785A Height Adjuster and Post and Agilent 10784A Base — dimensions

Cables

Cables for transmission of power, reference, and measurement signals are available from Agilent.

A typical laser measurement system requires cables as listed in Table 82.

NOTE If you use the Agilent 5519A/B Laser Head's internal receiver, a receiver cable is not necessary.

Table 81 is a summary listing of the Agilent cables that are available for connecting the laser head and receiver(s) in a measurement system to the system control electronics. Note that cable numbers shown in Table 81 identify a "family" of cables, available in different lengths. Table 82 provides additional cable information..

Table 81 Summary of available laser system cables

Device	PC		VME	
	10887	10885[1], 10889, N1231	10896, 10897, 10898	10895[1]
Agilent 5517A Laser Head	10883[2]	10881, N1251		10791
Agilent 5517B Laser Head	10883[2]	10881, N1251		10791
Agilent 5517BL Laser Head	10883[2]	10881, N1251		10791
Agilent 5517C Laser Head	10883[2]	10881, N1251		10791
Agilent 5517D Laser Head	10883[2]	10881, N1251		—
Agilent 5517DL Laser Head	—	10881, N1251		—
Agilent 5517FL Laser Head	—	10881, N1251		—
Agilent 5519A Laser Head	10882	10882[2]		10882[2]
Agilent 5519B Laser Head	10882	10882[2]		—
Agilent 10780C Receiver	10880[2]	10880,1250		10790
Agilent 10780F Remote Receiver	10880[2]	10880,1250		10790
Agilent E1708A Remote Dynamic Receiver	10880[2]	10880,1250		10790
Agilent E1709A Remote High-Performance Receiver	10880[2]	10880,1250		10790

[1] These axis boards do not have sufficient bandwidth to work with these laser heads. Do not use them together in a system.

[2] Specific options must be ordered for these cables to get the correct connectors and cable configuration for proper system interconnect. Contact Agilent for configuration assistance.

Table 82 Cables

Component	Comment(s)
Receiver Cable connects the measurement signal from the Agilent 10780C/F Receiver to the Agilent 10895A VME Axis Board—one cable required per receiver.	
Agilent 10790A	5 meters (16.4 feet)
Agilent 10790B	10 meters (32.8 feet)
Agilent 10790C	20 meters (65.6 feet)
Receiver Cable connects the measurement signal from the Agilent 10780C/F Receiver to an Agilent 10885A PC Axis Board, Agilent 10889B PC Servo Axis Board, Agilent 10896B VME Laser Compensation Board, Agilent 10897C VME High Resolution Laser Axis Board, Agilent 10898A VME High Resolution Dual Laser Axis Board, or Agilent N1231A PCI Three-Axis Board—one required per receiver.	
Agilent 10880A	5 meters (16.4 feet)
Agilent 10880B	10 meters (32.8 feet)
Agilent 10880C	20 meters (65.6 feet)
Agilent 10791A/B/C Laser Head Cable connects the Agilent 5517x series Laser Head to an Agilent 10895A VME axis board. *It has spade lugs for connection to a power supply to provide power to the laser head*—one required per system.	
Agilent 10791A	5 meters (16.4 feet)
Agilent 10791B	10 meters (32.8 feet)
Agilent 10791C	20 meters (65.6 feet)
Agilent 10881A/B/C Laser Head Cable connects the Agilent 5517x series Laser Head to an Agilent 10885A, 10889B, 10896B, 10897C, 10898A, or N1231A/B axis board. *It has a DIN connector for connecting to the Agilent 10884B Power Supply to provide power to the laser head*—one required per system.	
Agilent 10881A	3 meters (9.8 feet)
Agilent 10881B	7 meters (23.0 feet)
Agilent 10881C	20 meters (65.6 feet)
Agilent 10881D/E/F Laser Head Cable connects the Agilent 5517x series Laser Head to an Agilent 10885A, 10889B, 10896B, 10897C, 10898A, or N1231A axis board. *It has spade lugs for connection to a power supply to provide power to the laser head*—one required per system.	
Agilent 10881D	3 meters (9.8 feet)
Agilent 10881E	7 meters (23.0 feet)
Agilent 10881F	20 meters (65.6 feet)

Table 82 Cables (continued)

Component	Comment(s)
Laser Head Cable connects the Agilent 5519A/B Laser Head to the Agilent 10887P Programmable PC Calibrator Board in the Agilent 5529A system.	
Agilent 10882A	3 meters (9.8 feet)
Agilent 10882B	7 meters (23.0 feet)
Agilent 10882C	20 meters (65.6 feet)
High Performance Receiver Cable connects the measurement signal from the Agilent E1708A or Agilent E1709A Receiver to an Agilent 10897C, 10898A, or N1231A/B axis board—one required per receiver.	
Agilent N1250A	5 meters (16.4 feet)
Agilent N1250B	10 meters (32.8 feet)
High Performance Laser Head Cable connects the Agilent 5517A/B/C/D Laser Head to an Agilent 10897C, 10898A, or N1231A/B axis board—one required per system.	
Agilent N1251B	7 meters (23.0 feet)

Fiber optic cables

If you are replacing Agilent 10897/8 VME High Resolution Laser Axis Board (s) with the Agilent N1225A Four-Channel High Resolution Laser Axis Board for VME, the fiber optic cables may need to be replaced with cables that have ST connectors. Refer to these Agilent product numbers:

- E1705B-XXX Plastic Vpin to ST fiber
- E1705E-XXX Glass Vpin to ST fiber
- E1705F-XXX Glass ST to ST fiber

Where XXX is the option number of the product and designates the nominal fiber length.

Table 83 lists the standard fiber lengths available.

Table 83 Standard fiber cable lengths

Option (XXX)	Fiber Length
004	0.2 m +5 mm –0 mm
020	1 m +10 mm –0 mm
025	1.25 m +10 mm –0 mm
040	2 m +20 mm –0 mm
050	2.5 m +20 mm –0 mm

Table 83 Standard fiber cable lengths (continued)

Option (XXX)	Fiber Length
060	3 m +20 mm –0 mm
080	4 m +20 mm –0 mm
100	5 m +20 mm –0 mm
120	6 m +20 mm –0 mm
140	7 m +20 mm –0mm
160	8 m +20 mm –0 mm
180	9 m +100 mm –0 mm
200	10 m +100 mm –0 mm

Laser head cables (for power only)

Table 84 lists the laser head cables with no reference leg, that carry power only. The are available under the part numbers listed in the table. The cables are shown in figures 290 through 293.

Table 84 Power only laser head cables

Part Number	Description
E1847A-060	Laser Head Power only cable, 3 m +0.15 m, –0 m; #6 spade lugs
E1847A-140	Laser Head Power only cable, 7 m +0.15 m, –0 m; #6 spade lugs
E1847A-200	Laser Head Power only cable, 10 m +0.15 m, –0 m; #6 spade lugs
E1847A-300	Laser Head Power only cable, 15 m +0.25 m, –0 m; #6 spade lugs
E1847A-400	Laser Head Power only cable, 20 m +0.25 m, –0 m; #6 spade lugs
E1848A-300	Laser Head Power only cable, 15 m +0.1m, –0 m male DIN connector
E1848B-060	Laser Head Power only cable, 3 m +0.15 m, –0 m; female DIN connector
E1848B-140	Laser Head Power only cable, 7 m +0.15 m, –0 m; female DIN connector
E1848B-200	Laser Head Power only cable, 10 m +0.1 5m, –0 m; female DIN connector
E1848B-300	Laser Head Power only cable, 15 m +0.25 m, –0 m; female DIN connector
E1848B-400	Laser Head Power only cable, 20 m +0.25 m, –0 m; female DIN connector

Agilent 10790A/B/C Receiver Cable

The Agilent 10790A/B/C Receiver Cable, shown in Figure 282, is used to connect the measurement signal from any Agilent receiver to the Agilent 10895A VME Axis Board.

Figure 282 Agilent 10790A/B/C Cable

Agilent 10791A/B/C Laser Head Cable

The Agilent 10790A/B/C Laser Head Cable, shown in Figure 283, is used to connect an Agilent 5517A/B/BL/C/D/DL/FL Laser Head to an Agilent 10895A VME Laser Axis Board. *It has **spade lugs** for connecting the laser head to a customer-supplied power supply.*

Figure 283 Agilent 10791A/B/C Cable

Agilent 10880A/B/C Receiver Cable

The Agilent 10880A/B/C Receiver Cable, shown in Figure 284, is used to connect the measurement signal from any Agilent receiver to the Agilent 10885A PC Axis Board, Agilent 10889B PC Servo Axis Board, Agilent 10896B VME Laser Compensation Board, Agilent 10897C VME High Resolution Laser Axis Board, Agilent 10898A VME High Resolution Dual Laser Axis Board, or Agilent N1231A/B PCI Three-Axis Board.

Figure 284 Agilent 10880A/B/C Cable

Agilent 10881A/B/C Laser Head Cable

The Agilent 10881A/B/C Laser Head Cable, shown in Figure 285, is used to connect an Agilent 5517A/B/BL/C/D/DL/FL Laser Head to an Agilent 10885A PC Axis Board, Agilent 10889B PC Servo Axis Board, Agilent 10896B VME Laser Compensation Board, Agilent 10897C VME High Resolution Laser Axis Board, Agilent 10898A VME High Resolution Dual Laser Axis Board, or Agilent N1231A/B PCI Three-Axis Board. *It has a **DIN** connector for connecting the laser head to the Agilent 10884B Power Supply.*

Figure 285 Agilent 10881A/B/C Laser Head Cable

Agilent 10881D/E/F Laser Head Cable

The Agilent 10881D/E/F Laser Head Cable, shown in Figure 286, is used to connect an Agilent 5517A/B/BL/C/D/DL/FL Laser Head to an Agilent 10885A PC Axis Board, Agilent 10889B PC Servo Axis Board, Agilent 10896B VME Laser Compensation Board, Agilent 10897C VME High Resolution Laser Axis Board, Agilent 10898A VME High Resolution Dual Laser Axis Board, or Agilent N1231A/B PCI Three-Axis Board. *It has **spade lugs** for connecting the laser head to a customer-supplied power supply.*

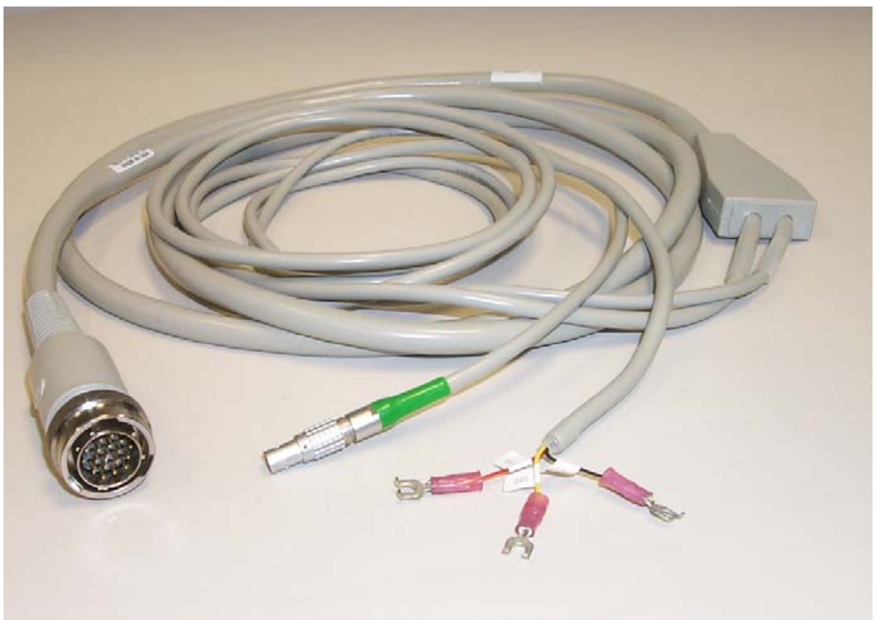


Figure 286 Agilent 10881D/E/F Laser Head Cable

Agilent 10882A/B/C Laser Head Cable

Agilent 10882A/B/C Laser Head Cable, shown in Figure 287, is used to connect the Agilent 5519A/B Laser Head to the Agilent 10887P Programmable PC Calibrator Board.

Figure 287 Agilent 10882A/B/C Laser Head Cable

Agilent N1250A/B High Performance Receiver Cable

The Agilent N1250A/B Receiver Cable, shown in Figure 288, is used to connect the measurement signal from an Agilent E1708A Receiver or Agilent E1709A Receiver to an Agilent 10889B PC Servo-Axis Board, Agilent 10897C VME High Resolution Laser Axis Board, Agilent 10898A VME High Resolution Dual Laser Axis Board, or Agilent N1231A/B PCI Three-Axis Laser Board.

Figure 288 Agilent N1250A/B High Performance Receiver Cable

Agilent N1251B High Performance Laser Head Cable

The Agilent N1251B Laser Head Cable, shown in Figure 289, is used to connect an Agilent 5517A/B/BL/C/D/DL/FL Laser Head to an Agilent 10897C VME High Resolution Laser Axis Board, Agilent 10898A VME High Resolution Dual Laser Axis Board, or Agilent N1231A/B PCI Three-Axis Laser Board. *It has a **DIN** connector for connecting the laser head to the Agilent 10884B Power Supply.*

Figure 289 Agilent N1251B High Performance Laser Head Cable

Agilent E1847A Laser Head Cable

The Agilent E1847A Laser Head Cable, shown in Figure 290, is used to connect a customer-supplied ±15V power supply to an Agilent 5517B/BL/C/D/DL/FL Laser Head. *It has* ***spade lugs*** *(#6) for connecting the laser head to a* customer-supplied *power supply.*

Figure 290 Agilent E1847A Laser Head Cable

Agilent E1848A Laser Head Cable

The Agilent E1848A Laser Head Cable, shown in Figure 291, is used to connect a customer-supplied ±15V power supply to an Agilent 5517B/BL/C/D/DL/FL Laser Head. *It has a 5-pin **male DIN** connector for connecting the laser head to a* customer-supplied *power supply.*

Figure 291 Agilent E1848A Laser Head Cable

Figure 292 shows the pinouts of 5-pin male DIN connector that connected to the Agilent E1848A Laser Head Cable.

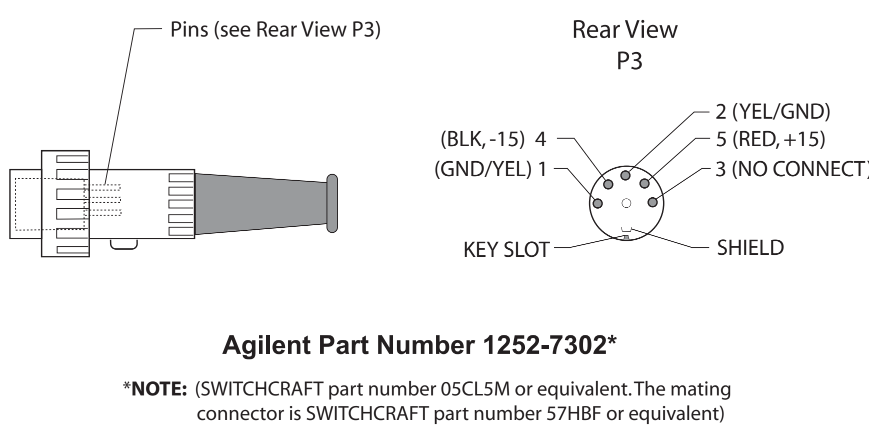


Figure 292 Male DIN Connector Pinout

Agilent E1848B Laser Head Cable

The Agilent E1848B Laser Head Cable, shown in Figure 293, is used to connect the Agilent 10884B Power Supply to an Agilent 5517B/BL/C/D/DL/FL Laser Head. *It has a 5-pin* ***female DIN*** *connector for connecting the laser head to the Agilent 10884B Power Supply.*

Figure 293 Agilent E1848B Laser Head Cable

Alignment Targets and Aids

Alignment targets and alignment aids, shown in Figure 294, can ease the job of aligning optical components of the laser measurement system. Table 85 lists the alignment targets and aids.

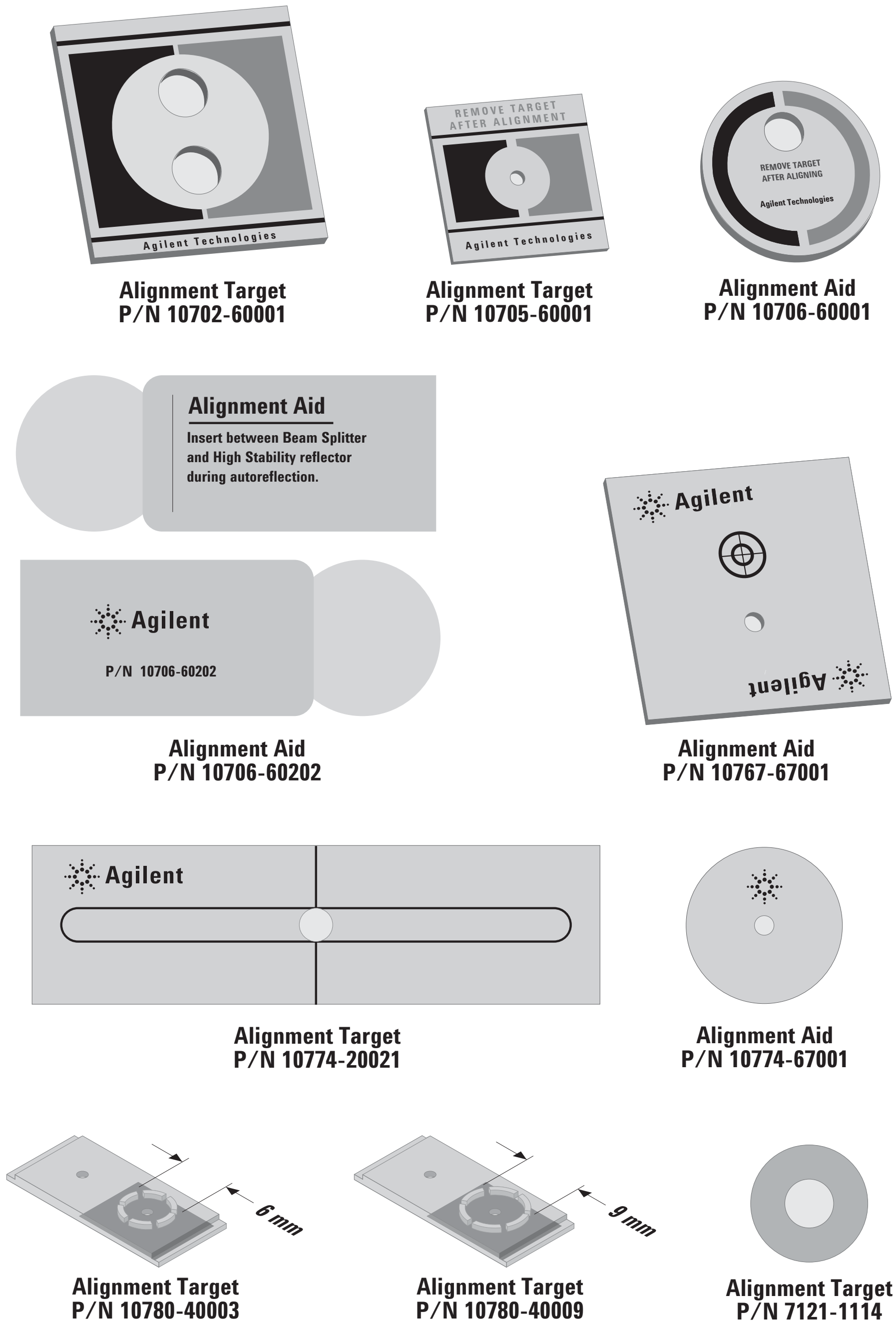


Figure 294 Alignment targets and aids

Table 85 Alignment targets and aids

Interferometer, other optic, or Receiver	Alignment Target	Alignment Aid
Agilent 10702A or Agilent 10702A-001	10702-60001	none
Agilent 10705A	10705-60001	none
Agilent 10706A	10702-60001	10706-60001
Agilent 10706B	10702-60001	10706-60001 10706-60202
Agilent 10715A	none	10706-60001
Agilent 10716A	none	10706-60001 10706-60202
Agilent 10717A	none	10706-60001
Agilent 10719A	none	10706-60202
Agilent 10721A	none	10706-60202
Agilent 10722A	none	10706-60001
Agilent 10735A	none	10706-60001
Agilent 10736A or Agilent 10736B-001	none	10706-60001
Agilent 10766A	none	10767-67001
Agilent 10767A	none	10767-67001
Agilent 10770A	none	10767-67001
Agilent 10774A	10774-20021	10774-67001
Agilent 10775A	10774-20021	10774-67001
Agilent 10780C	10780-40003	none
Agilent 10780F with 9 mm beam sensor head	10780-40009	none

Agilent 10753B Laser Tripod

The Agilent 10753B Laser Tripod is intended primarily for use with the Agilent 5519A/B Laser Head in an Agilent 5529A/55292A Dynamic Calibrator system. Information about the Agilent 10753B Laser Tripod is presented in the *Agilent 5529A/55292A Dynamic Calibrator Getting Started Guide* (Agilent manual part number 10747-90047).

Agilent 10759A Footspacing Kit

The Agilent 10759A Footspacing Kit is intended primarily for use when making Flatness Measurements with the Agilent 5529A/55292A Dynamic Calibrator system.

Information about the Agilent 10759A Footspacing Kit is presented in the *Agilent 5529A/55292A Dynamic Calibrator Measurement Reference Guide* (Agilent manual part number 10747-90051).

Optics

The optics listed here are those that are 1) not interferometers, and 2) not usually referred to as “beam-directing optics”.

Table 86 provides summary descriptions of the optics. More complete descriptions follow the table.

Specification drawings of the optics described in this chapter are provided as part of the descriptions.

Available Agilent Technologies measurement optics are described in Chapter 5, “Measurement Optics (General Information),” in Volume I of this manual.

Available Agilent Technologies beam-directing optics are described in Chapter 17, “Beam-Directing Optics,” in Volume I of this manual.

Table 86 Optics

Component	Comment(s)
Order as required to manipulate beam path for your application.	
Agilent 10724A	Plane Mirror Reflector
Agilent 10728A	Plane Mirror (requires user-supplied mounting hardware)
Agilent 10772A	Turning Mirror
Agilent 10773A	Flatness Mirror
Agilent 10776A	Straightness Accessory Kit
Agilent 10777A	Optical Square

All Agilent laser systems can use the same Agilent 107XX series of optics.

Vacuum applications

Many of the optical components of the laser measurement system have vacuum options, which are compatible with vacuum environments. Contact Agilent Call Center for information (telephone numbers of various call centers are listed on the "Service and Support" page at the back of this manual). Typically, these components have housings made of stainless steel and optical elements attached to the housings using a lower volatility (vacuum-grade) adhesive. See the specifications for a list of materials used in the optics.

For those optics (such as the Agilent 10728A mirror) which require a user-created mount arrangement, it is the user's responsibility to create a vacuum-compatible mounting, if one is required.

Agilent 10724A Plane Mirror Reflector

For linear applications requiring a plane mirror reflector, the Agilent 10724A Plane Mirror Reflector (see Figure 295) is recommended. It can be used with the Agilent 10706A, Agilent 10706B, Agilent 10715A, or Agilent 10716A plane mirror interferometers. The Agilent 10724A can only be used for single-axis linear measurements; for multiaxis applications that involve compound motions (such as X-Y stages), custom mirrors must be supplied by the user.

Figure 295 Agilent 10724A Plane Mirror Reflector

Agilent 10724A Plane Mirror Reflector Mounting

These instructions give the details for mounting and installing the Agilent 10724A Plane Mirror Reflector. The Agilent 10724A is shipped with the 5061-6009 Hardware Kit.

The Agilent 10724A is designed to be mounted into a hole or pocket on the stage (moving object). The mounting surface for the Agilent 10724A should be closely perpendicular to the axis of machine travel. Figure 296 shows the mounting hole details. Provision is made to lift the flange slightly off the mounting surface, thereby allowing pitch and yaw corrections to be made to align the Agilent 10724A exactly to the axis of machine travel.

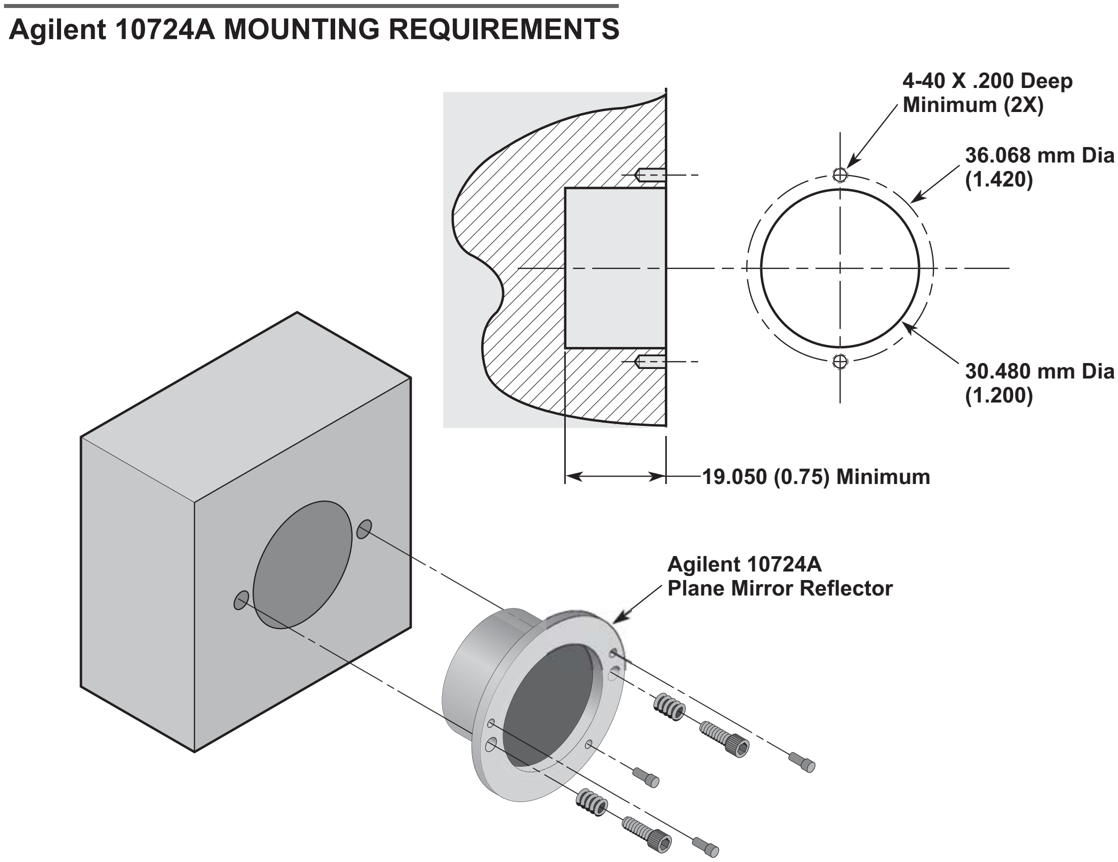


Figure 296 Agilent 10724A Plane Mirror Reflector — mounting requirements and installation

To install the Agilent 10724A:

1 Install three #2-56 cap screws into the flange from the mirror side, but do not let the screws protrude through the flange.

2 Insert the labeled end (non-flanged end) of the Agilent 10724A into the mounting hole or pocket. Start the two #4-40 cap screws through the compression springs and the clearance holes in the flange and then into the mounting surface (See Figure 296).

3 Tighten the #4-40 screws so they contact, but do not compress, the springs.

CAUTION

In steps 4 through 7 below, take care not to distort the mirror by over compressing the springs. The springs should never be tightened down solid; leave at least 0.001 clearance between the coils at all times. This may be checked by passing a piece of paper (about 0.001 inch thickness) through the coils.

4 Tighten each of the #4-40 screws one and a half turns. The springs are now initially compressed.

5 Advance the three #2-56 screws until they just contact the mounting surface. Then tighten each by one and a half turns to lift the housing off the mounting surface and further compress the springs.

6 Adjust the mirror in the pitch and yaw planes until it is perpendicular to the machine axis of travel by unscrewing the #2-56 cap screws. An auto-collimator or pre-aligned laser beam may be used for this purpose.

7 Again confirm that the springs have not been compressed solid by passing a piece of paper (about 0.001 inch thickness) through the coils.

Agilent 10724A Plane Mirror Reflector Specifications

Dimensions: see figure below

Weight: 50 grams (1.8 ounces)

Housing Material: 416 Stainless Steel

Reflectivity: 98% at 633 nanometers at normal incidence

Flatness: λ /10 (at 633 nanometers)

Installed Angular Adjustment Range: Pitch/Yaw: 1° Configurations

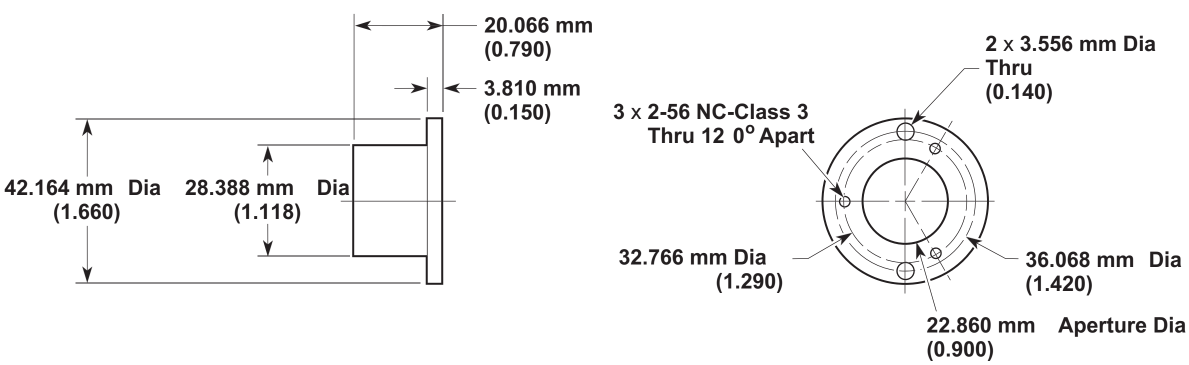


Figure 297 Agilent 10724A Plane Mirror — dimensions

Agilent 10728A Plane Mirror

This mirror is intended for use in a laser measurement system that uses a 9 mm (nominal) diameter or smaller laser beam. The 9-mm beam diameter requires use of this mirror, rather than a mirror that can only handle a beam up to 6 mm in diameter. A typical use of the Agilent 10728A Plane Mirror would be in a system that includes one or more of the following interferometers: Agilent 10735A, Agilent 10736A, Agilent 10736A-001. This mirror can also be used with smaller-diameter laser beams.

The Agilent 10728A Plane Mirror can be used with the Measurement Axis #2 beam paths from the Agilent 10736A-001 Three-axis Interferometer with Beam Bender. The Agilent 10728A is supplied without a housing.

Agilent Technologies does not provide mounting hardware for the Agilent 10728A mirror. This optic is intended for use in user-designed mounts. The user is responsible for devising a mounting method that does not cause stresses in the optical devices that will result in distortion of the reflected laser wavefronts.

Use of the Agilent 10728A mirror in a vacuum application depends on the materials used in the user-created mounting arrangement. Contact Agilent call center for information on a vacuum option Agilent 10728A.

Agilent 10728A Plane Mirror Specifications

Dimensions: see figure below

Weight: 21 grams (0.74 ounce)

Reflectivity: 98% at 633 nanometers at normal incidence

Flatness: λ /10 (at 633 nanometers)

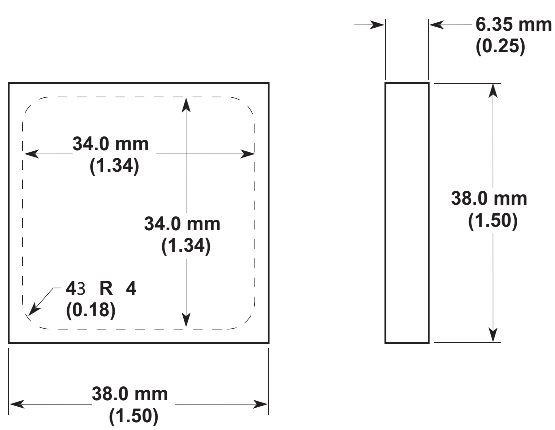


Figure 298 Agilent 10728A Plane Mirror — specifications

Agilent 10772A Turning Mirror

The Agilent 10772A Turning Mirror (see Figure 299) is a 100% reflectance mirror which turns the direction of an incoming laser beam 90 degrees. It can be used in place of the Agilent 10707A Beam Bender, if a larger aperture is needed, such as for use with a 9-mm diameter laser beam. The primary use of the Agilent 10772A Turning Mirror is in the laser calibration systems for machine tools.

The Agilent 10772A mounting screws have metric threads.

The same mirror is used in both the Agilent 10772A Turning Mirror and the Agilent 10773A Flatness Mirror; only the mounting is different.

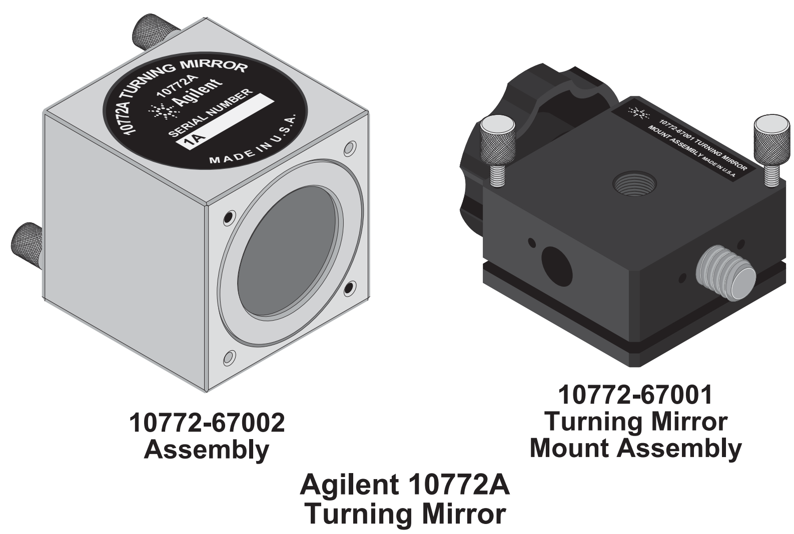


Figure 299 Agilent 10772A Turning Mirror

Agilent 10772A Turning Mirror Specifications

Dimensions: see figure below

Weight: 510 grams (18 ounce)

Materials Used:

Housing: Stainless Steel (416)
Apertures: Plastic (Nylon)
Optics: Optical Grade Glass
Adhesives: Low Volatility (Vacuum Grade)

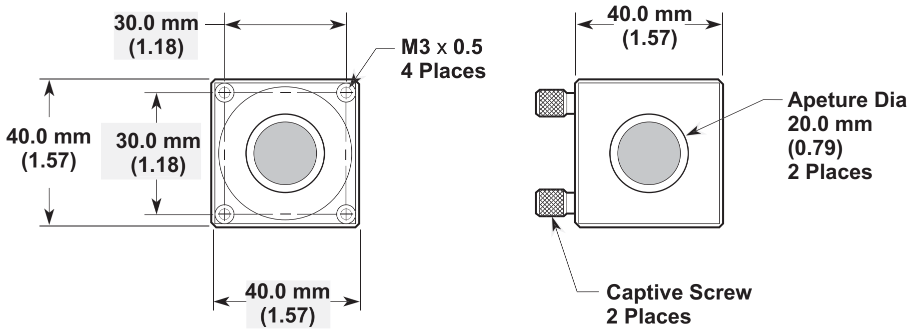


Figure 300 Agilent 10772A Turning Mirror — dimensions

Agilent 10773A Flatness Mirror

The Agilent 10773A Flatness Mirror (see Figure 301) is a 100% reflectance mirror which turns the direction of an incoming laser beam 90 degrees. The same mirror is used in both the Agilent 10772A and Agilent 10773A, only the mounting is different. The Agilent 10773A can be used in place of the Agilent 10707A Beam Bender, if a larger aperture is needed.

The Agilent 10773A Flatness Mirror is used mostly in laser calibrator systems for machine tools. Its mounting is via a swivel-attached baseplate having no other tapped holes for alternate mounting.

The Agilent 10773A is shipped with the 5061-6019 Hardware Kit.

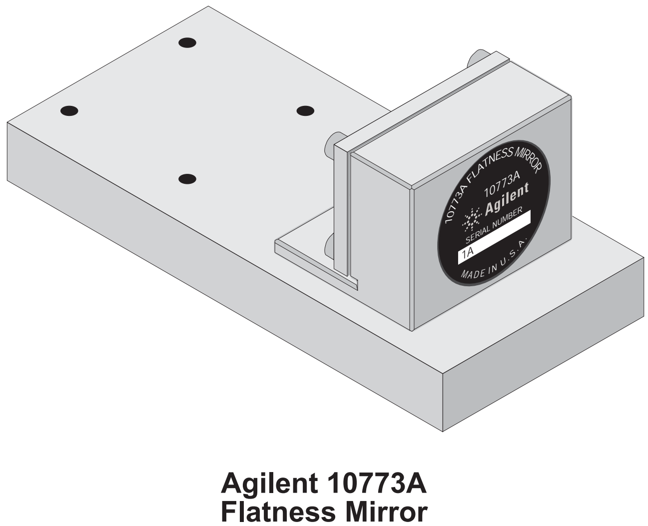


Figure 301 Agilent 10773A Flatness Mirror

Agilent 10773A Flatness Mirror Specifications

Dimensions: see figure below

Weight: 661 grams (23.3 ounce)

Materials Used:

Housing: Stainless Steel
Optics: Optical Grade Glass
Adhesives: Low Volatility (Vacuum Grade)

Optical Efficiency: Typical — 99%, Worst Case — 98%

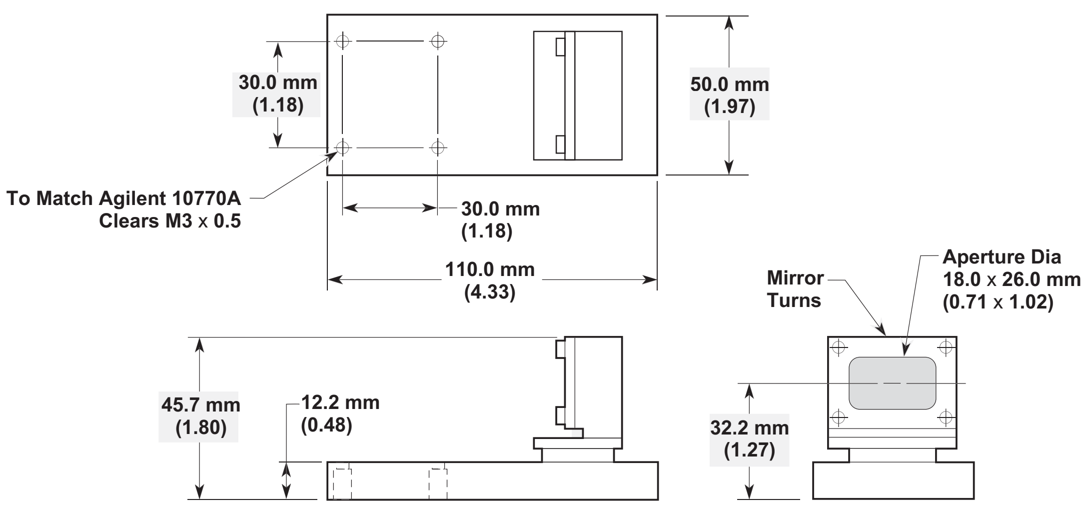


Figure 302 Agilent 10773A Flatness Mirror — dimensions

Agilent 10776A Straightness Accessory Kit

The Agilent 10776A Straightness Accessory Kit (see Figure 303) consists of a large retroreflector (Agilent part number 10776-67001) and mounting accessories. Its purpose is to facilitate vertical straightness measurements in calibrator applications. Refer to the *Agilent 5529A/55292A Dynamic Calibrator Measurement Reference Guide* (Agilent manual p/n 10747-90051) for application information.

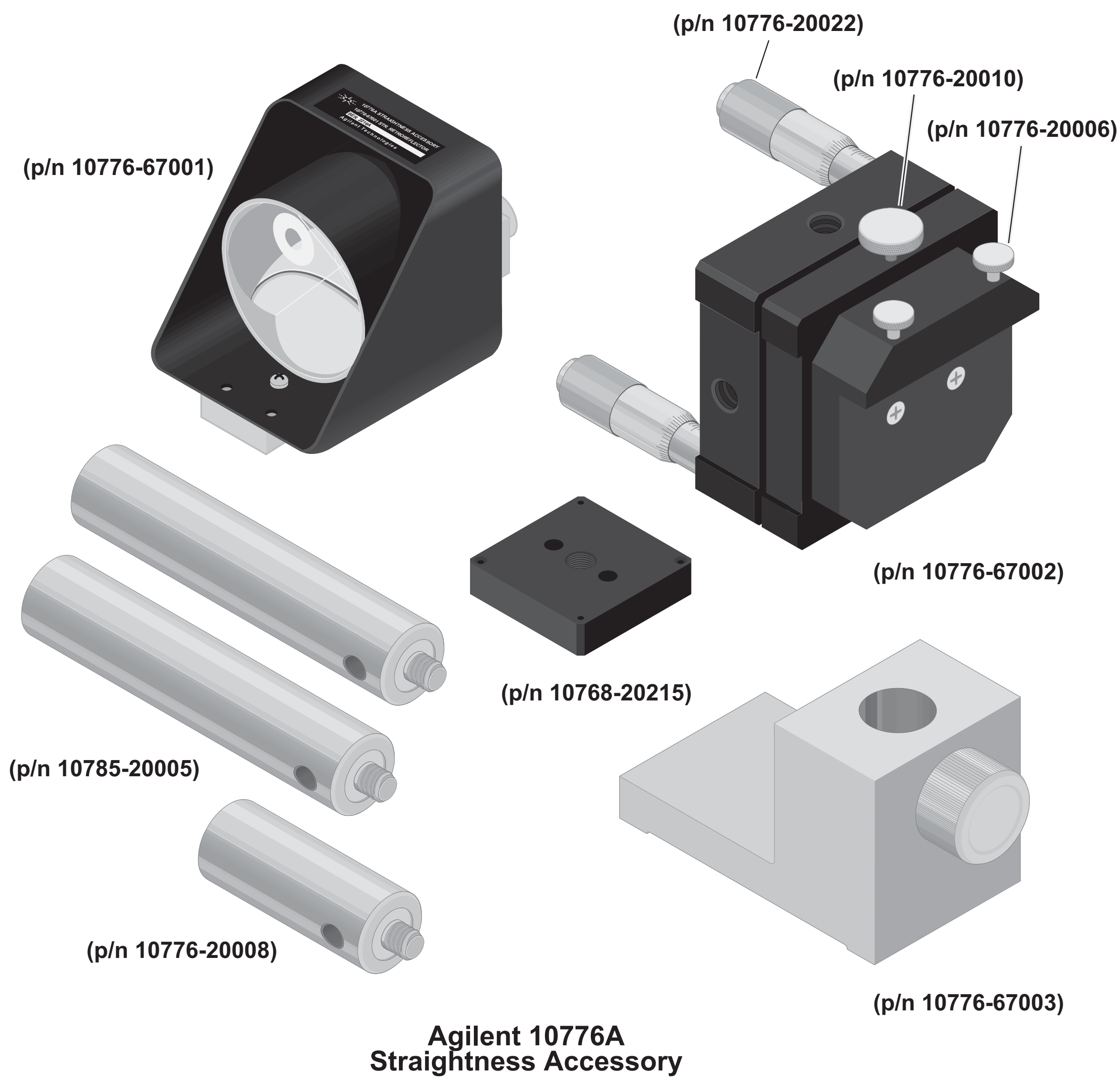


Figure 303 Agilent 10776A Straightness Accessory Kit

Agilent 10776-67001 Straightness Retroreflector Specifications

Dimensions: see figure below

Weight: 374 grams (13.2 ounces)

Materials Used:

Housing: Aluminum
Optics: Optical Grade Glass

Optical Efficiency: 80% (Worst Case)

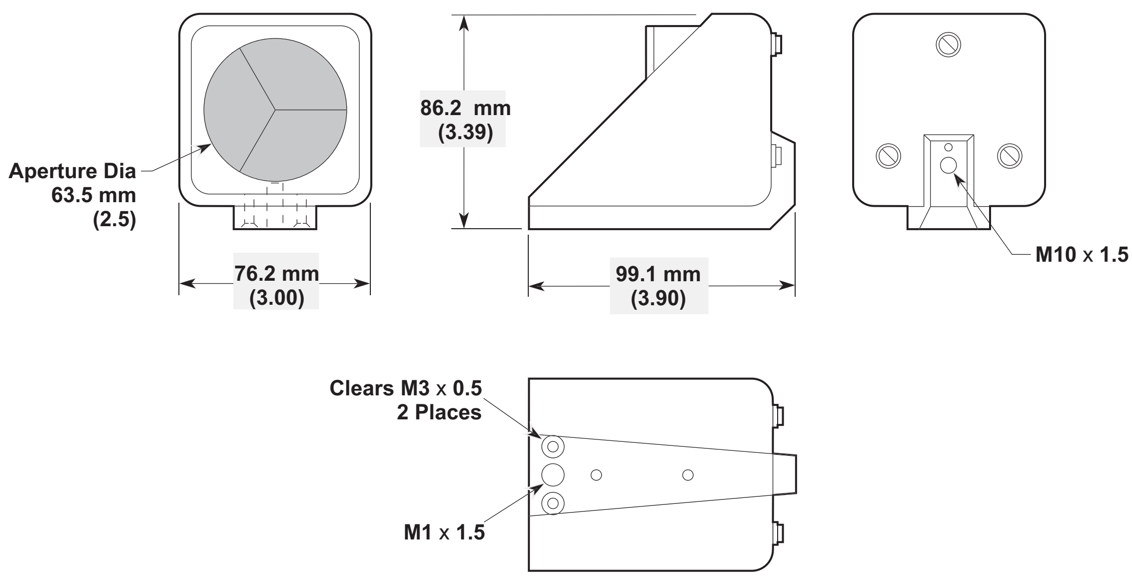


Figure 304 Agilent 10776-67001 Straightness Retroreflector — dimensions

Agilent 10777A Optical Square

The Agilent 10777A Optical Square (see Figure 305) directs an output beam at precisely 90 degrees to an input beam. It is used to measure the squareness of axes during laser calibration of a machine tool.

The Agilent 10777A Optical Square is used in specialized applications where the input beam must be turned at exactly 90 degrees. It contains two accurately aligned mirrors in a special housing. The optical square is a "constant-deviation" device because the 90-degree bend is constant even if there is an angular rotation between optical square and the input beam.

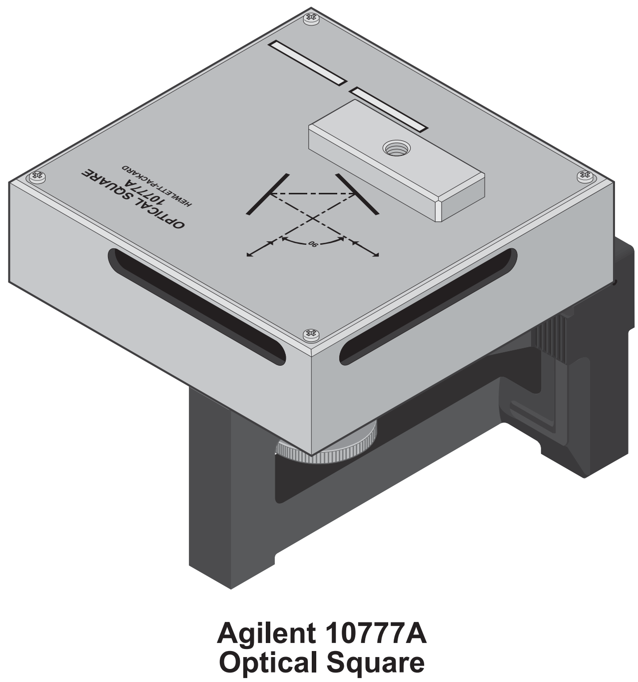


Figure 305 Agilent 10777A Optical Square

Agilent 10777A Optical Square Specifications

Dimensions: see figure below

Weight: 4.0 kilograms (8.8 pounds)

Materials Used:

Housing: Aluminum
Optics: Optical Grade Glass

Optical Efficiency: 92% (Worst Case)

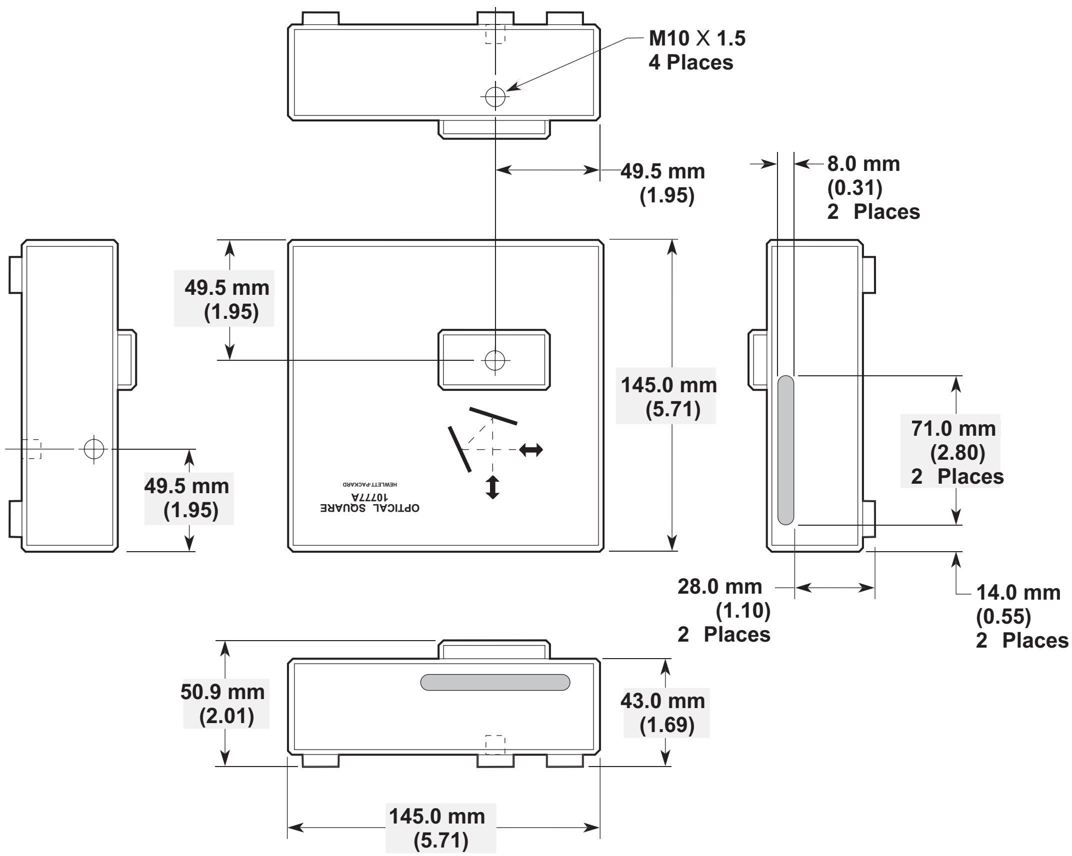


Figure 306 Agilent 10777A Optical Square — dimensions

Agilent N1203C/04C/07C Beam Manipulator Accessories

Adjustment tools

Adjustment tool kit (Agilent N1206T)

This kit contains a set of adjustment levers and an adapter that are designed to make user-desired beam alignment (by rotating the ball/mirror inside the manipulator) accessible from many different positions.

The tools, shown in Figure 307, contained in the kit are:

- Agilent N1206A Ball Adjustment Lever – long (176 mm)
- Agilent N1206B Adjustment Lever Adapter
- Agilent N1206F Ball Adjustment Lever – short (123 mm)
- Agilent N1206G Ball Adjustment Lever – bent (173 mm with 45° angle)

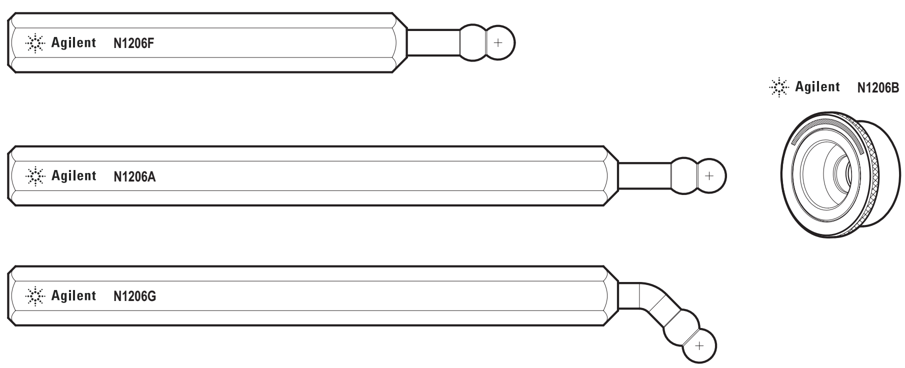


Figure 307 Agilent N1206T Adjustment Tool Kit

Customer-supplied hardware

A 5 mm Hex-key (customer-supplied) is needed to adjust the Agilent N1203C Precision Beam Translator Bender from the top or bottom, depending on how the translator is mounted.

Agilent 10884B Power Supply

The Agilent 10884B Power Supply converts ac power into ±15 V to power a single Agilent laser head and the multiple Agilent receivers that make up the Agilent laser transducer or laser calibrator system.

The Agilent 10884B can be used with the following products:

- Agilent 5517A/B/BL/C/DL/FL laser heads
- Agilent 10780C/F receivers, E1708A and E1709A remote receivers
- Agilent 10881A/B/C or N1251B laser head cable

Agilent 10881A/B/C, or N1251B laser head cables

The 10884B was designed to be used with 10881A/B/C or N1251B

laser head cables. These cables connect the power supply to the rear- panel connector of an Agilent laser head and also connect the reference frequency from the laser head to most Agilent laser axis boards. See Figure 308.

General information on laser head cables:

10881A	3 m laser head cable
10881B	7 m laser head cable
10881C	20 m laser head cable
N1251B	7 m high performance laser head cable

NOTE Overall length is from the 18-pin laser head connector to the 4-pin LEMO axis card connector.

NOTE A different cable is required for operation with an Agilent 10887 A PC calibrator board. Contact your Agilent representative for assistance with this application.

Installation

Installing the 10884B and 10881A/B/C and N1251B

1. Connect the 18-pin connector cable on the 10881A/B/C or Nl251B to the laser head.
2. Connect the LEMO connector on the 10881A/B/C or Nl251B to the reference connector on the laser axis board.
3. Connect the DIN connector on the 10881A/B/C or Nl251B to the end of the output cable of the 10884B.
4. Connect all receivers to the axis boards.
5. Connect any multi- axis Interconnect cables between axis boards.

   See the individual manuals for additional information.
6. Connect the AC line cord to the input connector of the 10884B.
7. Plug the ac line cord into an operating AC line outlet.

NOTE The Agilent 10884B Power Supply has no power switch. As soon as it is plugged in, it will provide output power and the LED indicator will light.

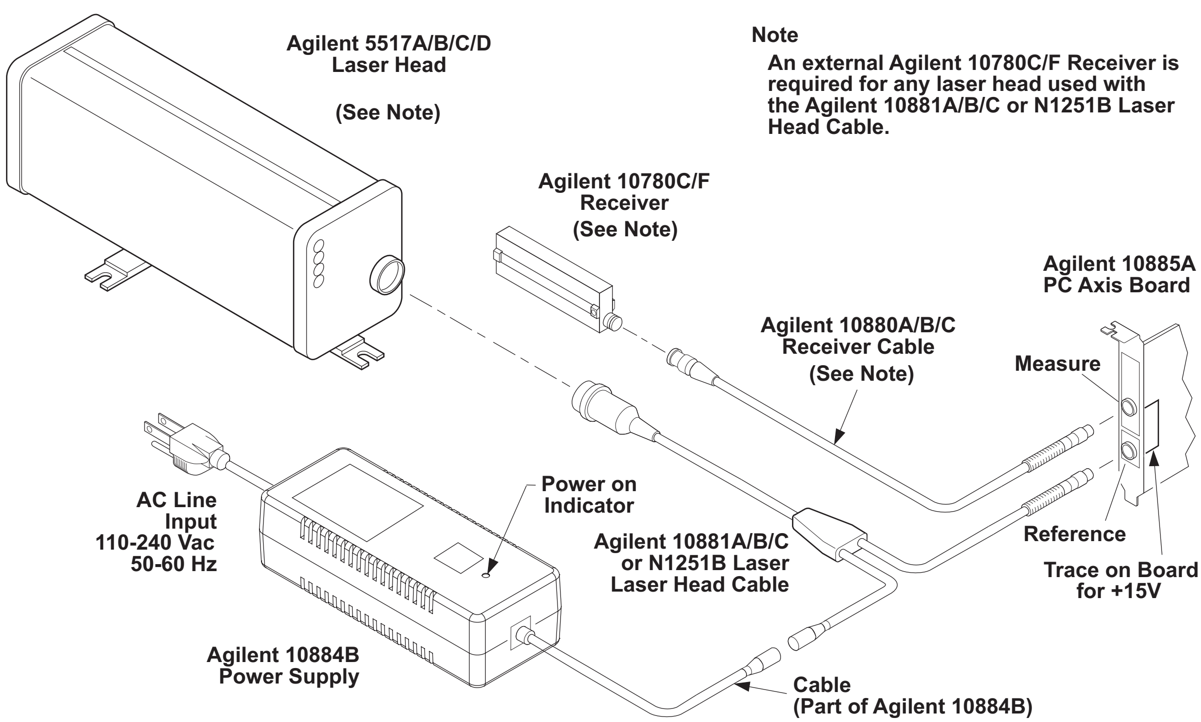


Figure 308 Connection the 10884B and 10881A/B/C and N1251B

Agilent I0883A/B/C upgrade kit

The Agilent 10884B is part of the 10883A/B/C upgrade kit which enables the laser head and environment sensors from an Agilent 5528A laser measurement system to be converted to an Agilent 5529A dynamic calibrator system. See Figure 309.

Table 87 lists the upgrade kit components for a typical system configuration.

Table 87 Upgrade Kit Components

Name	Quantity	Agilent Part Number	Description
10883A Upgrade Kit			
	1	10884B	Power Supply
	1	05508-60212	Remote Cable Adaptor
	1	10751-60209	Cable Adaptor
	1	10751-60306	Cable Adaptor
	1	10883-60201	3 m Laser Head Cable
10883B Upgrade Kit			
		Same as 10883A	
	1	10883-60202	7 m Laser Head Cable
10883C Upgrade Kit			
		Same as 10883A	
	1	10883-60203	20 m Laser Head Cable

Agilent 10884B and 10883A/B/C installation and use

NOTE The Agilent 10884B has no power switch. As soon as it is plugged in, it will provide output power and the LED indicator will light. When making the connections shown in Figure 2, the last connection you should make is plugging the line cord from the power supply into the power line.

1 Connect the equipment as shown in Figure 309.
2 Plug the ac line cord into an operating ac line outlet.

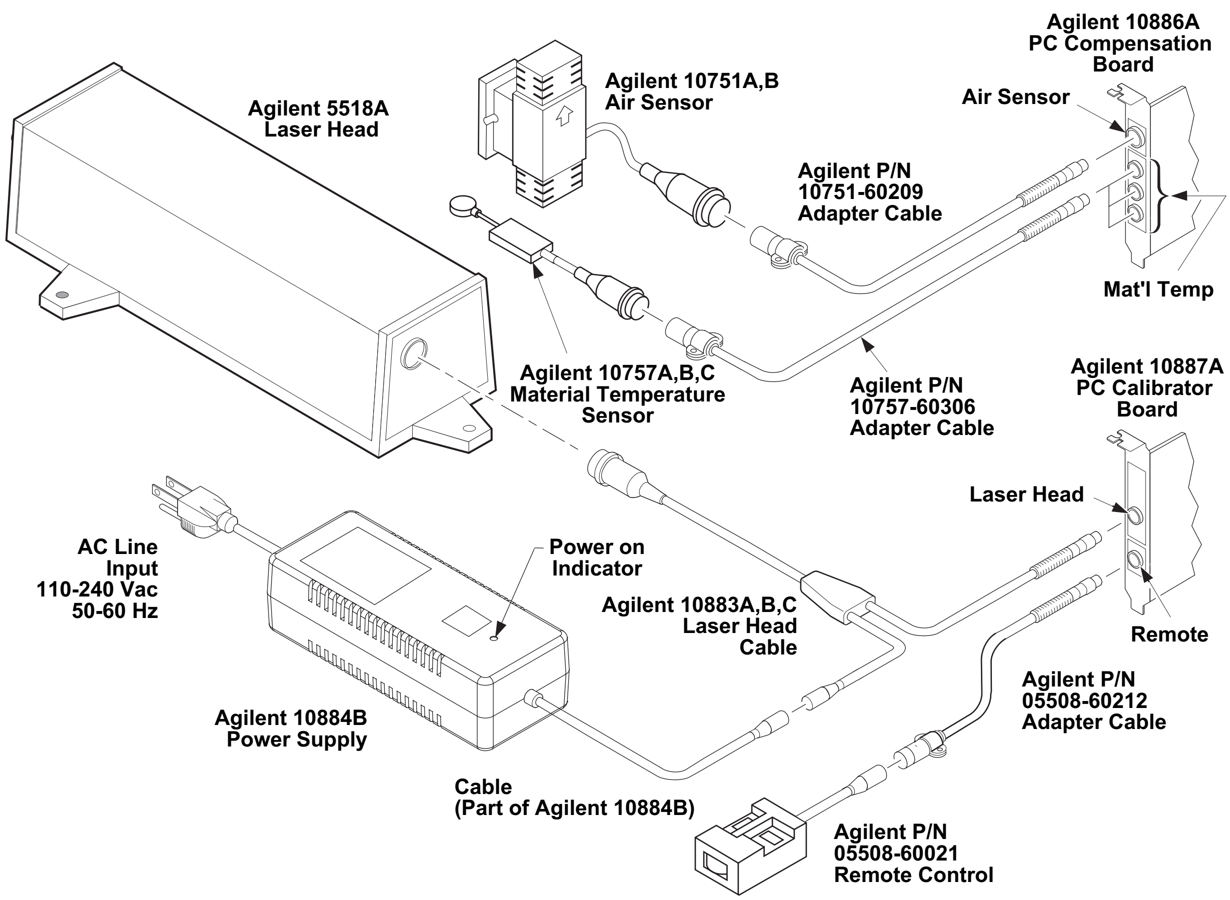


Figure 309 Installing the 10884B and 10883A/B/C

Agilent 10884B Power Supply Specifications and Characteristics

Dimensions: see figure below

Input: 110-240 Vac, 47-63 Hz 1.9A

Output: 65W max

Voltage Output: +15 Vdc at 3 A

-15 Vdc at 0.8 A

+5 Vdc at 6 A (not used)

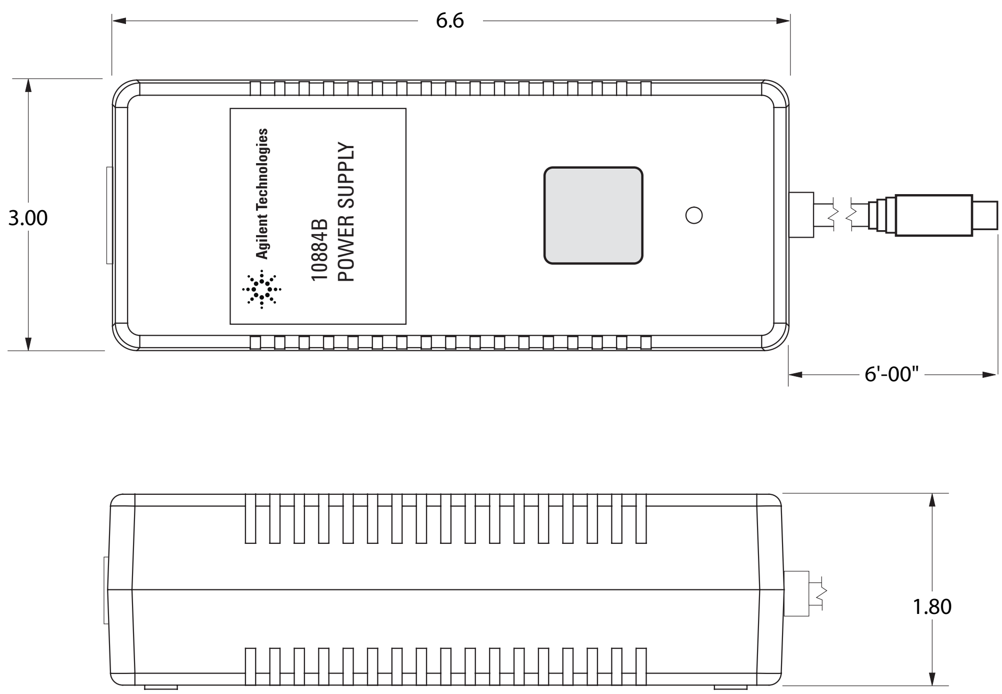


Figure 310 Agilent 10884B Power Supply — dimensions

Number of receivers in a system

The Agilent 10884B provides +15V 3.0A. This +15V is used to power the laser head and the receivers. Table 88 lists recommended cable and the number of receivers that can be used with the Agilent 10880A/B/C cable.

Table 88 Recommended Receiver cables

Product	Cable	Number of Receivers
10880A	5 m (16.4 ft)	Up to six 10780C/F or up to four E1708/09A
10880B	10m (32.8 ft)	Up to four 10780C/F or up to two E1708/09A
10880C	20 m (65.5 ft)	Up to two 10780C/F or one E1708/09A

Powering multiple receivers

The receiver is connected to the measurement connector on the Agilent measurement board. Receiver power is provided by a trace on the board. A multiple-receiver setup will use multiple Agilent axis boards. The +15V receiver power will be carried from one board to the next by a ribbon cable between measurement boards. As the number of receivers being used increases, the +15V current demand on the 10884B will increase up to the maximum +15V specification of the power supply. No additional receivers should be connected. If more receivers are needed, a second 10884B power supply should be added to the system and used to power the additional receivers.

Index

Numerics

A

B

C

D

E

F

G

H

I

K

L

M

T

V

W

Z

Agilent Technologies

Service and Support

Contacting Agilent Technologies:

For more information about Agilent test and measurement products, applications, and services, visit our web site at http://www.agilent.com/services/English/index.html.

Agilent's Test Measurement Fax Service for United States and Canada:

Technical information for test and measurement products and services is available 24 hours a day, 7 days a week, by calling 1-800-829-4444.

Technical Support:

If you need technical assistance with an Agilent test and measurement product or application, you can find a list of local service representatives on the web site listed above. If you do not have access to the Internet, one of the following centers can direct you to your nearest representative:

Asia Pacific:
Hong Kong SAR

Tel: (852) 2599-7777
Fax: (852) 2506-9284

Australia/New Zealand:
Blackburn, Victoria, Australia

Tel: 61 3 9210 5555

Canada:
Mississauga, ON, Canada

Tel: 877-894-4414
Fax: (905) 206-4700

Europe:
European Marketing Organization
The Netherlands

Tel: +31 20 547 2000
Fax: +31 20 547 7799

Japan:
Measurement Assistance Center
Tokyo, Japan

Tel: 81-426-56-7832
Fax: 81-426-60-8747

United States:
Test & Measurement Call Center
Englewood, CO, U.S.A.

Tel: (800) 829-4444 (Toll free in US)

Printed in U.S.A
Data subject to change
Rev 12/06

Continued from front matter. . .

Warranty (contd)

Agilent does not warrant that the operation of Agilent products will be uninterrupted or error free. If Agilent is unable, within a reasonable time, to repair or replace any product to a condition as warranted, customer will be entitled to a refund of the purchase price upon prompt return of the product.

Agilent products may contain remanufactured parts equivalent to new in performance or may have been subjected to incidental use.

The warranty period begins on the date of delivery or on the date of installation if installed by Agilent. If customer schedules or delays Agilent installation more than 30 days after delivery, warranty begins on the 31st day from delivery.

Warranty does not apply to defects resulting from (a) improper or inadequate maintenance or calibration, (b) software, interfacing, parts or supplies not supplied by Agilent, (c) unauthorized modification or misuse, (d) operation outside of the published environmental specifications for the product, or (e) improper site preparation or maintenance.

TO THE EXTENT ALLOWED BY LOCAL LAW, THE ABOVE WARRANTIES ARE EXCLUSIVE AND NO OTHER WARRANTY OR CONDITION, WHETHER WRITTEN OR ORAL, IS EXPRESSED OR IMPLIED AND AGILENT SPECIFICALLY DISCLAIMS ANY IMPLIED WARRANTIES OR CONDITIONS OF MERCHANTABILITY, SATISFACTORY QUALITY, AND FITNESS FOR A PARTICULAR PURPOSE.

Agilent will be liable for damage to tangible property per incident up to the greater of $300,000 or the actual amount paid for the product that is the subject of the claim, and for damages for bodily injury or death, to the extent that all such damages are determined by a court of competent jurisdiction to have been directly caused by a defective Agilent product.

TO THE EXTENT ALLOWED BY LOCAL LAW, THE REMEDIES IN THIS WARRANTY STATEMENT ARE CUSTOMER'S SOLE AND EXCLUSIVE REMEDIES. EXCEPT AS INDICATED ABOVE, IN NO EVENT WILL AGILENT OR ITS SUPPLIERS BE LIABLE FOR LOSS OF DATA OR FOR DIRECT, SPECIAL, INCIDENTAL, CONSEQUENTIAL (INCLUDING LOST PROFIT OR DATA), OR OTHER DAMAGE, WHETHER BASED IN CONTRACT, TORT, OR OTHERWISE.

For consumer transactions in Australia and New Zealand: the warranty terms contained in this statement, except to the extent lawfully permitted, do not exclude, restrict or modify and are in addition to the mandatory statutory rights applicable to the sale of this product to you.

Assistance

Product maintenance agreements and other customer assistance agreements are available for Agilent products.

For any assistance, contact your nearest Agilent Sales and Service Office.

Agilent Technologies

Manual Part Number 05517-90086, Volume II

Printed in U.S.A, SEPTEMBER 2007