7A

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

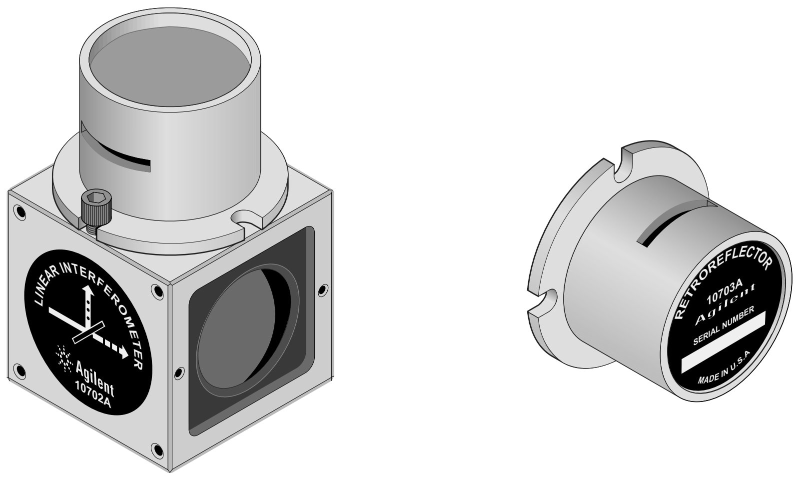
Introduction

This subchapter 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
- the Agilent 10722A Plane Mirror Converter
- the Agilent 10722B High Stability Plane Mirror Interferometer

Description

The Agilent 10702A Linear Interferometer (see Figure 7A-1) 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 7A-1) or the Agilent 10767A Retroreflector (see Figure 7A-4), respectively.



Agilent 10702A
Linear Interferometer

Agilent 10703A
Retroreflector

Agilent 10702A-001 Linear Interferometer
with Windows

Figure 7A-1. 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 7A-2).

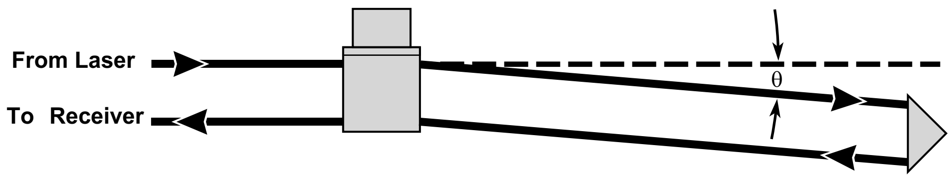
Normally, one optic is mounted on a moving part and the other is mounted on a fixed part and the displacement between the two is measured. A diagram of this is shown in Figure 7A-3. Note that for multi-axis installations each axis must be mechanically independent of the other. In other words, motion in the Y-axis should have no effect on the alignment of the X-axis optics.

The Agilent 10766A Linear Interferometer (see Figure 7A-4) 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.

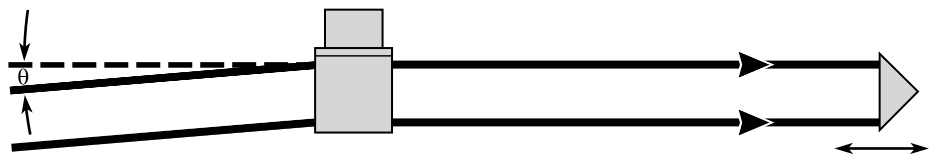
Similarly, the Agilent 10767A Linear Retroreflector (see Figure 7A-4) is optically identical to the Agilent 10703A Retroreflector. However, in order to withstand the handling and repeated installations of calibrator-type applications, the Agilent 10767A retroreflector has a more-robust housing than the 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 7A-5) 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.

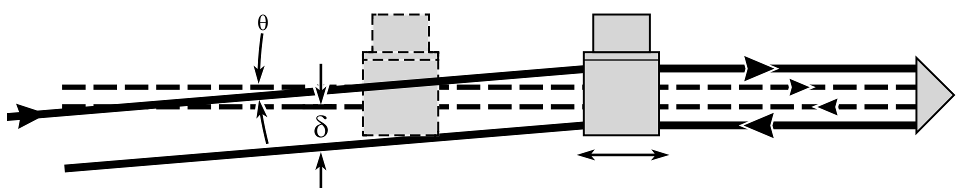
With the Agilent 10722A Plane Mirror Converter and the Agilent 10723A High Stability Adapter, the Agilent 10702A Linear Interferometer can be converted to an Agilent 10706B High Stability Plane Mirror Interferometer. This configuration also allows measurements of axial displacement of a plane mirror. The Agilent 10723A adapter is discussed in the subchapter 7C, “Agilent 10706A Plane Mirror Interferometer,” of this manual. The High-stability Plane Mirror Interferometer is described in subchapter 7D of this manual.



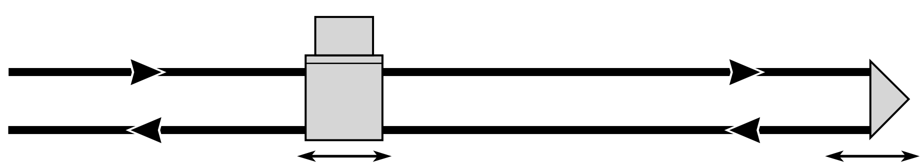
If the Agilent 10702A Linear Interferometer is placed in a beam which has been aligned parallel to the motion of travel, the outgoing beam can be deflected by as much as 30 arc-minutes (θ) due to the incoming-outgoing beam parallelism specifications of the Agilent 10702A interferometer. This could cause 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 stationay. (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 7A-2. Agilent 10702A-001 Linear Interferometer with Windows

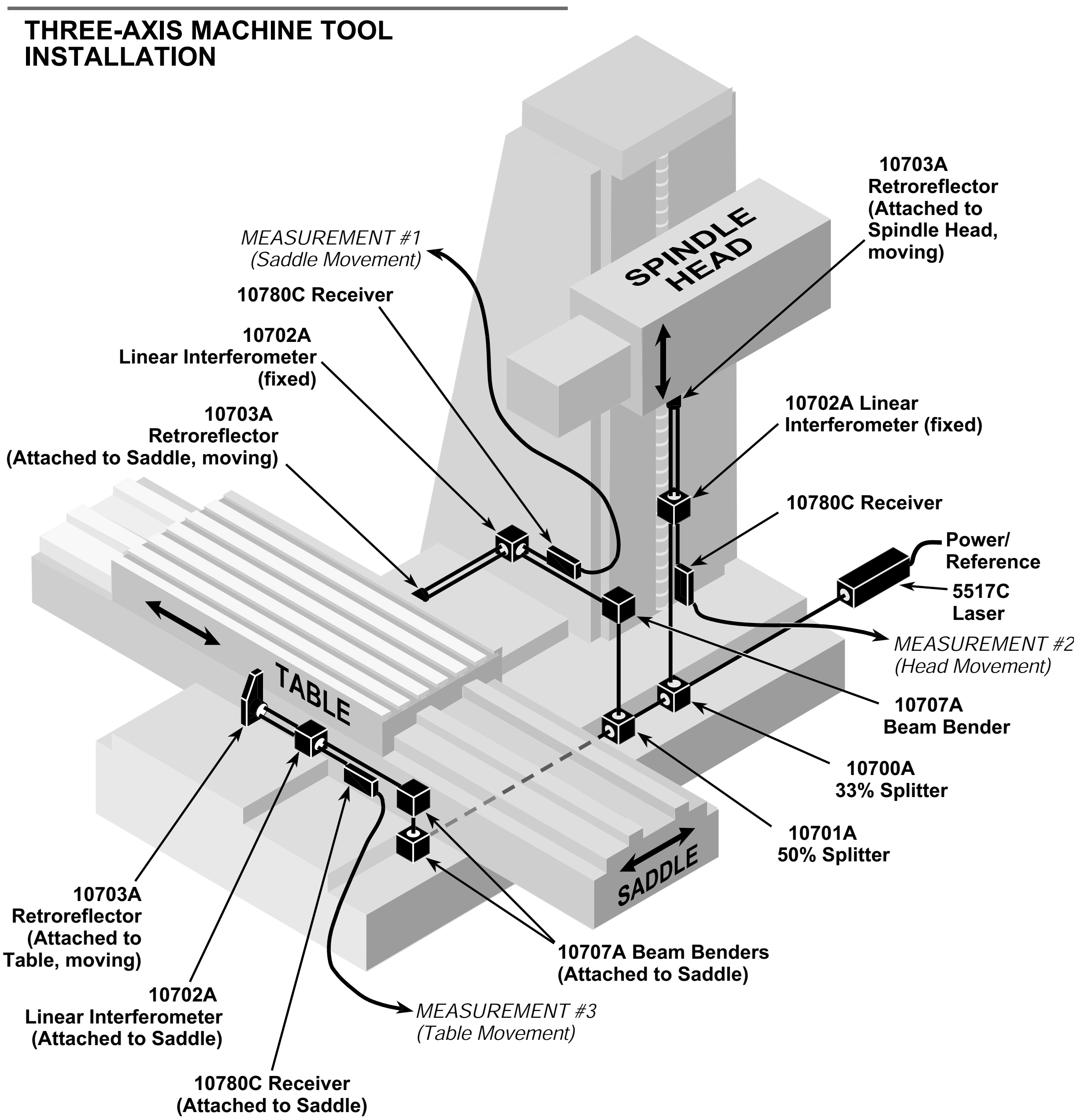
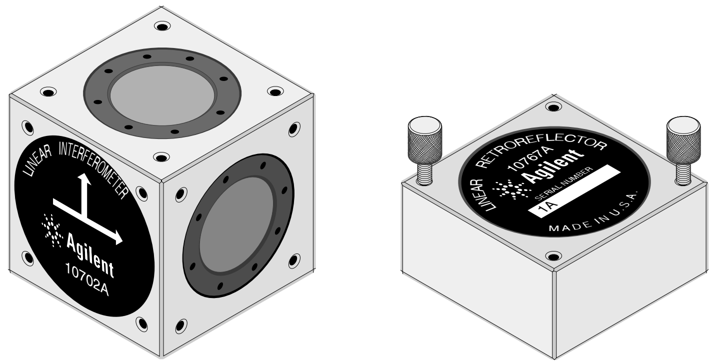


Figure 7A-3. Three-axis machine tool Installation



Agilent 10766A
Linear Interferometer

Agilent 10767A
Linear Retroreflector

Figure 7A-4. Agilent 10766A Linear Interferometer and Agilent 10767A Linear Retroreflector

Agilent 10722A
Plane Mirror Converter

Figure 7A-5. 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 7A-6). *See "Measurement Direction Sense" section in Chapter 7, "Measurement Optics," 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.

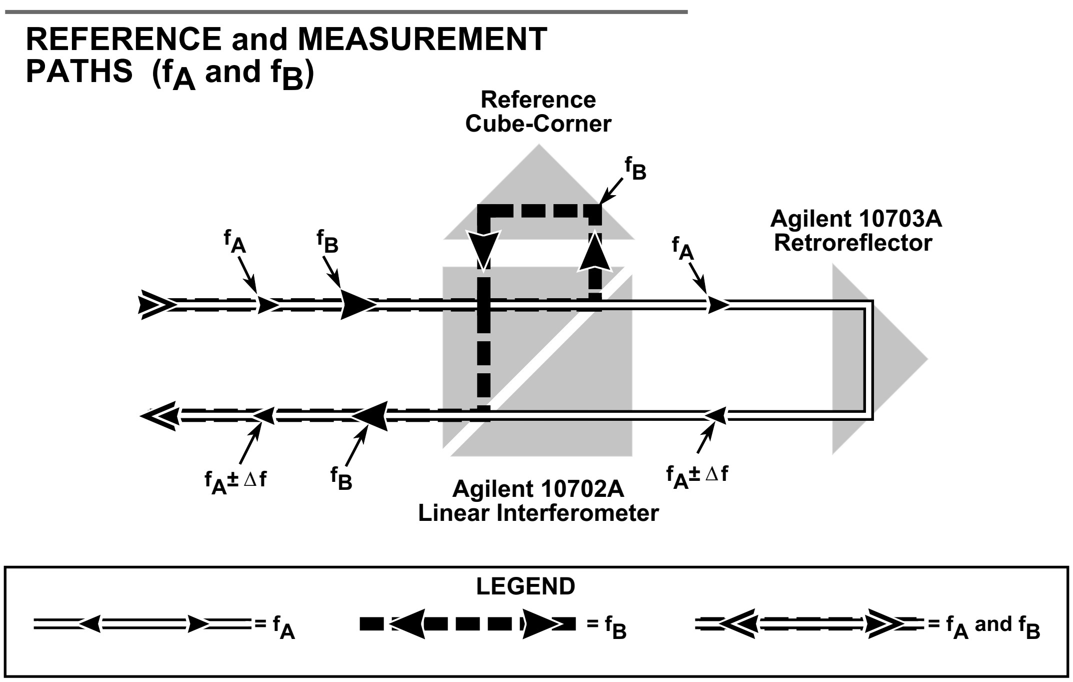


Figure 7A-6. Linear interferometer laser beam path

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 7A-7. Be aware that all installation and alignment requirements for the measurement reflector now apply also to the reference reflector.

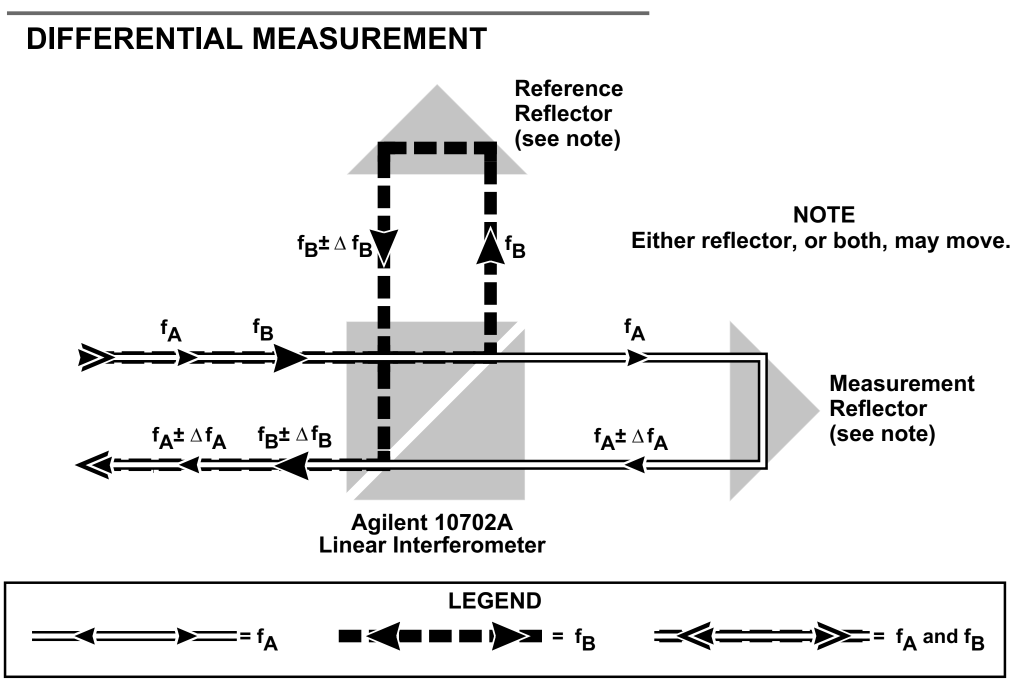


Figure 7A-7. Differential measurements with the Agilent 10702A

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, Agilent 5517B, or Agilent 5517C Laser Head (mounting feet in horizontal plane) with an Agilent 10702A Linear Interferometer mounted with labels facing up and down (see Figure 7A-6). 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 7A-6, 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 7A-2.

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 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 15, “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,“ 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 5, “Laser Heads,” Chapter 14, “Principles of Operation,” and Chapter 15, “Accuracy and Repeatability,” 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” heading at the end of this subchapter.)

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

Alignment

Alignment aids

Alignment aids for these interferometers are listed in Chapter 4, "System Installation and Alignment" and Chapter 9, "Accessories," of this manual.

Procedure

Refer to Chapter 4, "System Installation and Alignment" in 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 10897B 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 Transmitted Beam Deviation: ± 30 arc-minutes

Optical Efficiency (including Agilent 10703A Reflector):

Typical: 75%
Worst Case: 71%

Fundamental Optical Resolution: $\lambda/2$

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

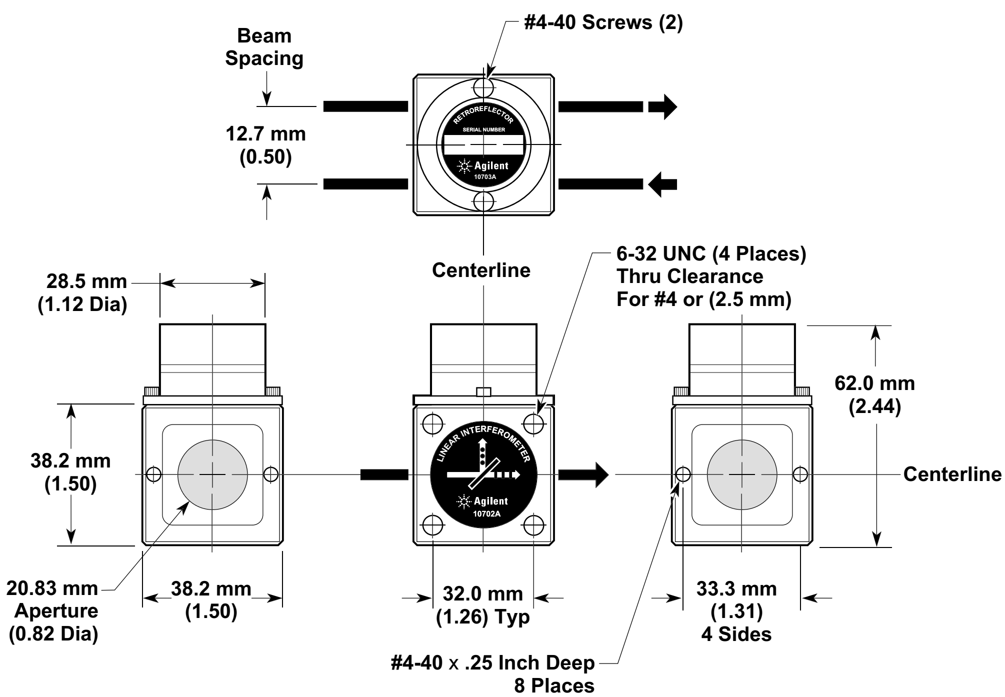


Figure 7A-8. Agilent 10702A Linear Interferometer — dimensions

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 Transmitted Beam Deviation: ± 30 arc-minutes

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)

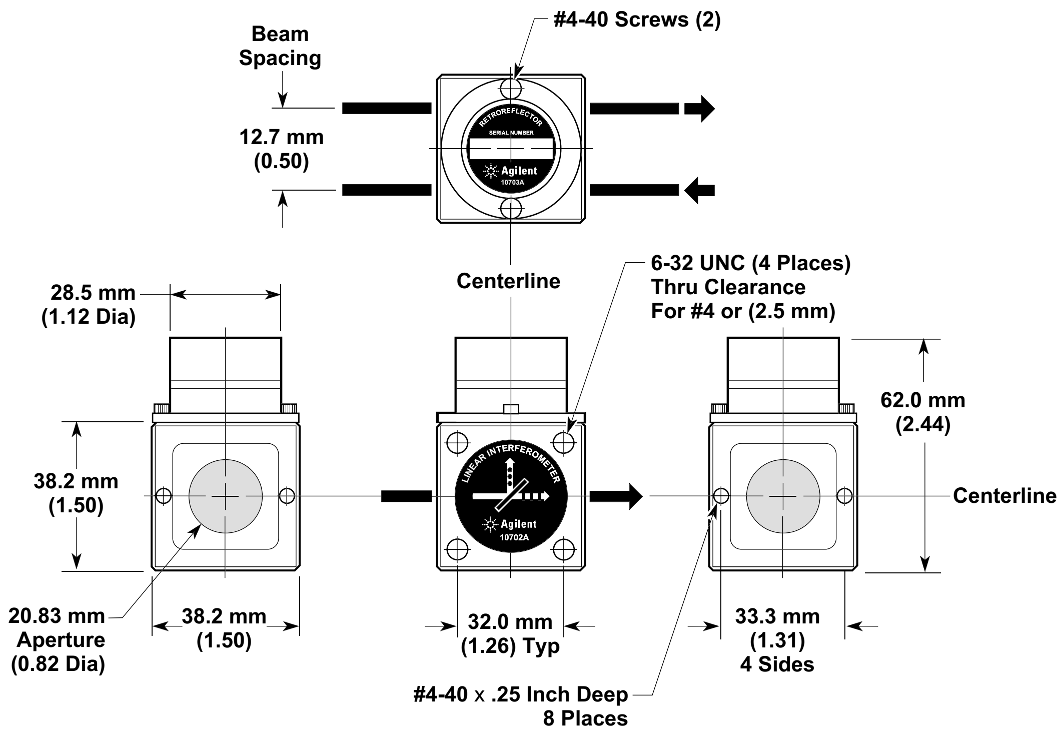


Figure 7A-9. Agilent 10702A-001 Linear Interferometer with Windows — dimensions

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)

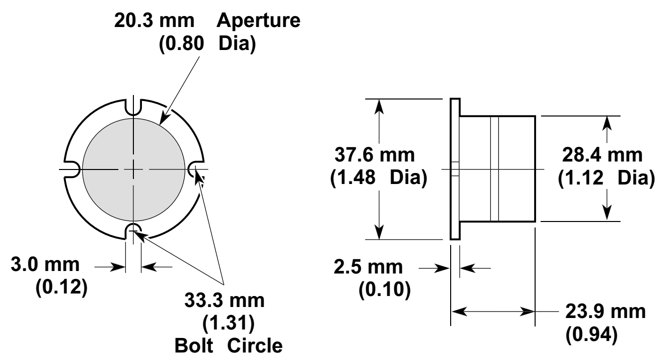


Figure 7A-10. Agilent 10703A Retroreflector — dimensions

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)

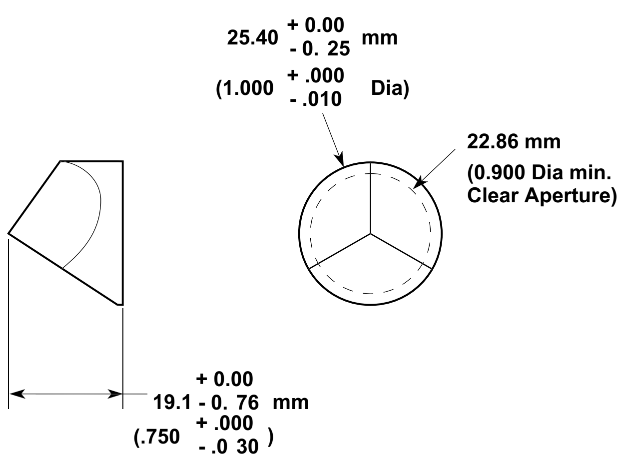


Figure 7A-11. Agilent 10713B 1-Inch Cube Corner, no housing — dimensions

Agilent 10766A Linear Interferometer Specifications

Dimensions: see figure below

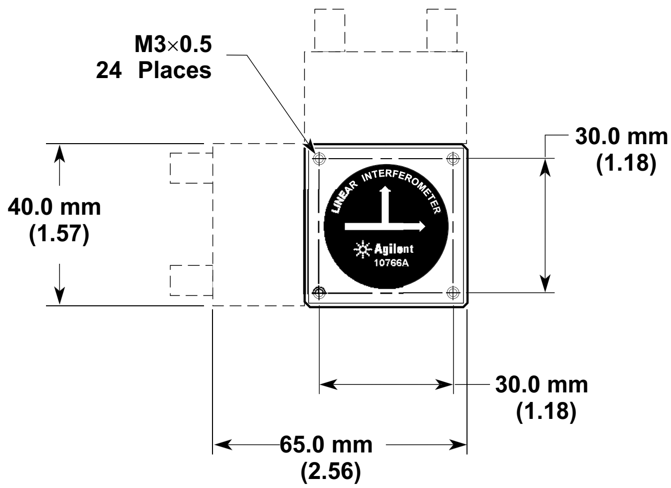
Weight: 312 grams (11 ounces)

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%



Note
Dotted outline shows possible Agilent 10767A retroreflector mounting positions.

Figure 7A-12. 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)

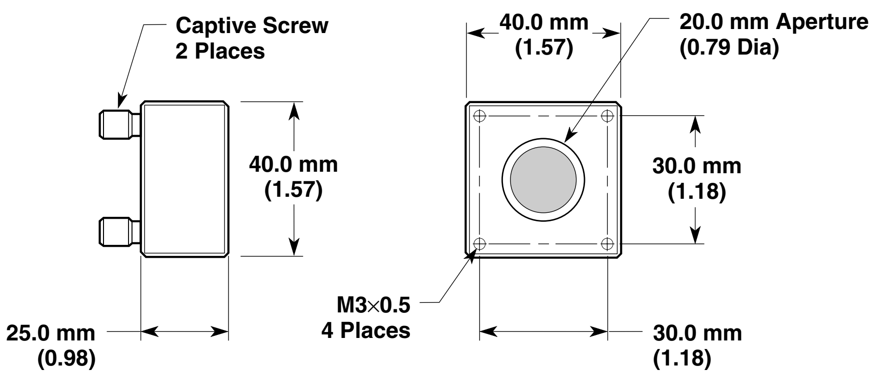


Figure 7A-13. Agilent 10767A Linear Retroreflector — dimensions

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