7D

Agilent 10706B High Stability Plane Mirror Interferometer

Description

The Agilent 10706B High Stability Plane Mirror Interferometer (see Figure 7D-1) 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 subchapter 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 subchapter (subchapter 7C). 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.

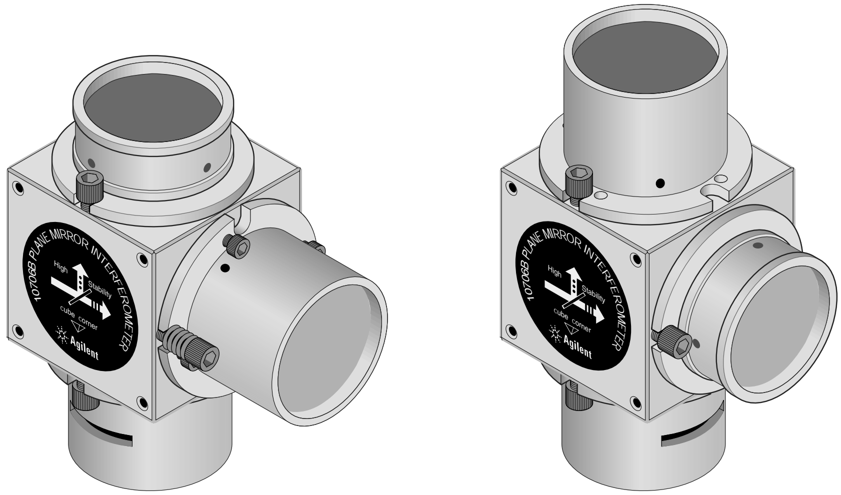
In addition to the material presented in this subchapter, you should also read about the Agilent 10706A interferometer in subchapter 7C of this manual.

Laser beam paths

Figure 7D-2 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 subchapter 7C 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.

Description



Turned Configuration **Straight Through Configuration**

Agilent 10706B
High Stability Plane Mirror Interferometer

Figure 7D-1. Agilent 10706B High Stability Plane Mirror Interferometer

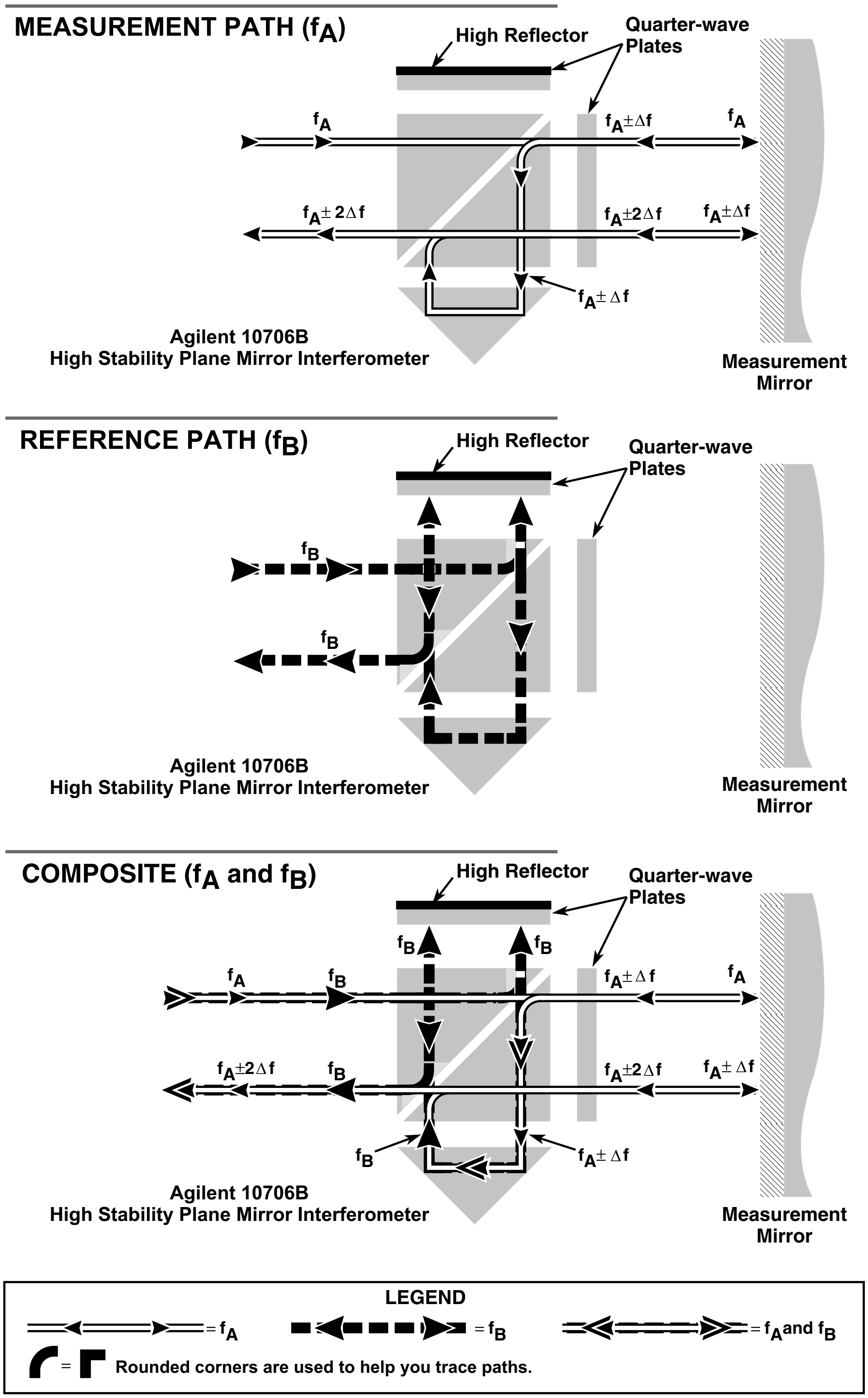


Figure 7D-2. Agilent 10706B High Stability Plane Mirror Interferometer, optical schematic

Special Considerations

See the Agilent 10706A "Special Considerations" information in subchapter 7C 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.

Installation

Refer to the Agilent 10706A interferometer "Installation" information in subchapter 7C 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 7D-3. 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 7D-3. 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 7D-3.

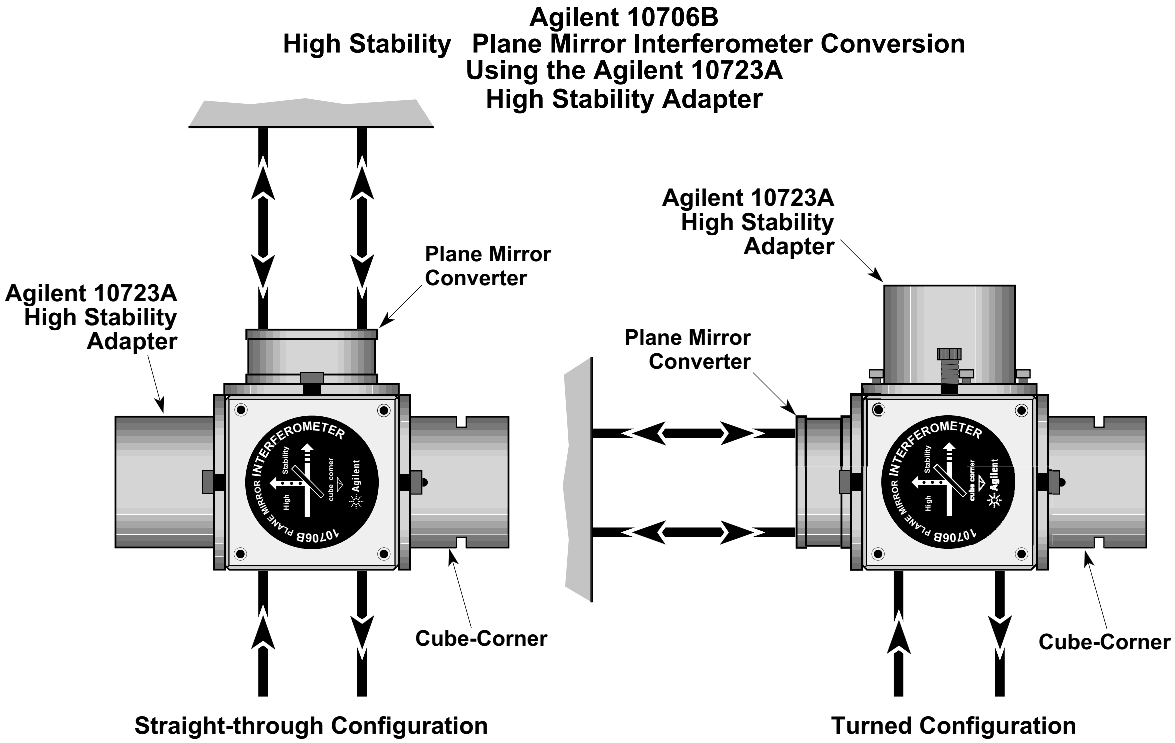


Figure 7D-3. Agilent 10706B Interferometer — configurations

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,” 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 7D-4.

- 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 subchapter 7C, 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 7D-5 illustrates how the aid is positioned between the beam splitter and the high stability adapter during alignment.

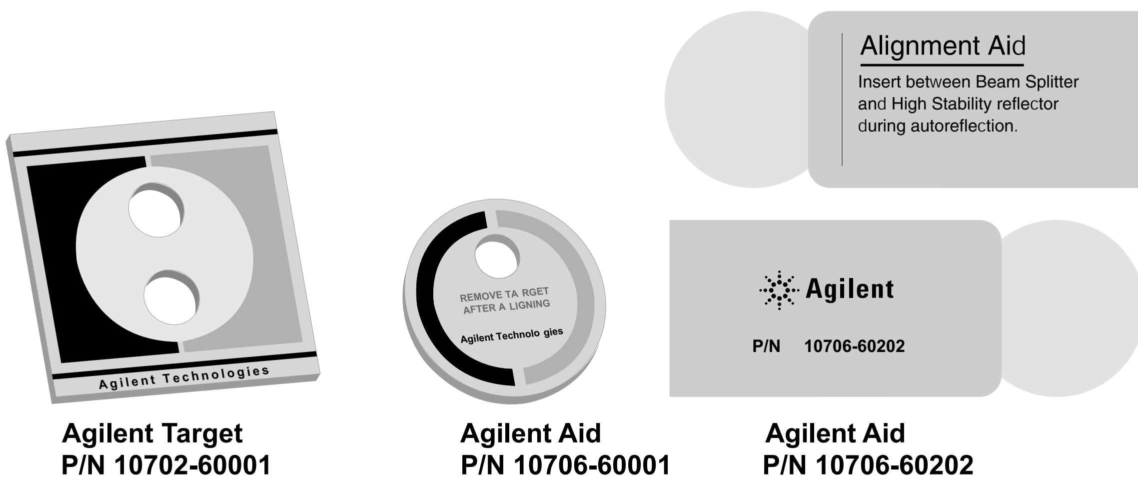
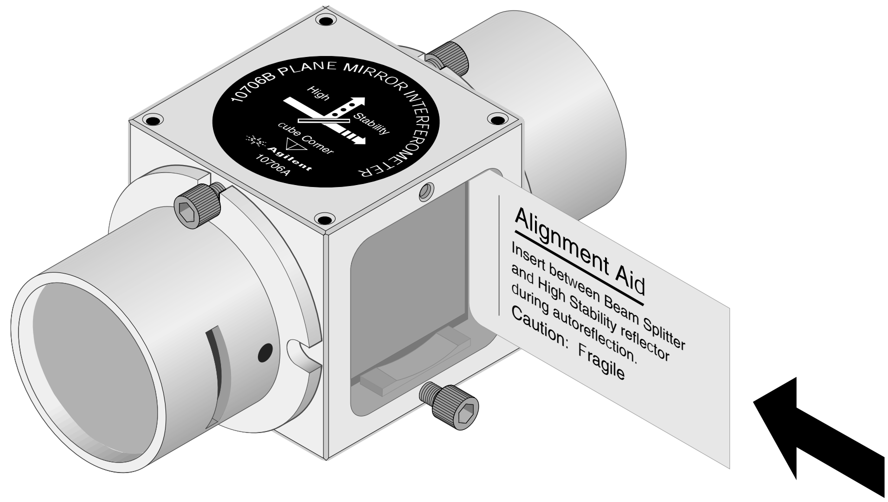


Figure 7D-4. Agilent 10706B Interferometer — alignment aids



Using the Alignment Aid

Figure 7D-5. 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,” 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 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 7D-5. 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 7D-6. Before proceeding, review the “Alignment Principles” in Chapter 4, “System Installation and Alignment,” 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.

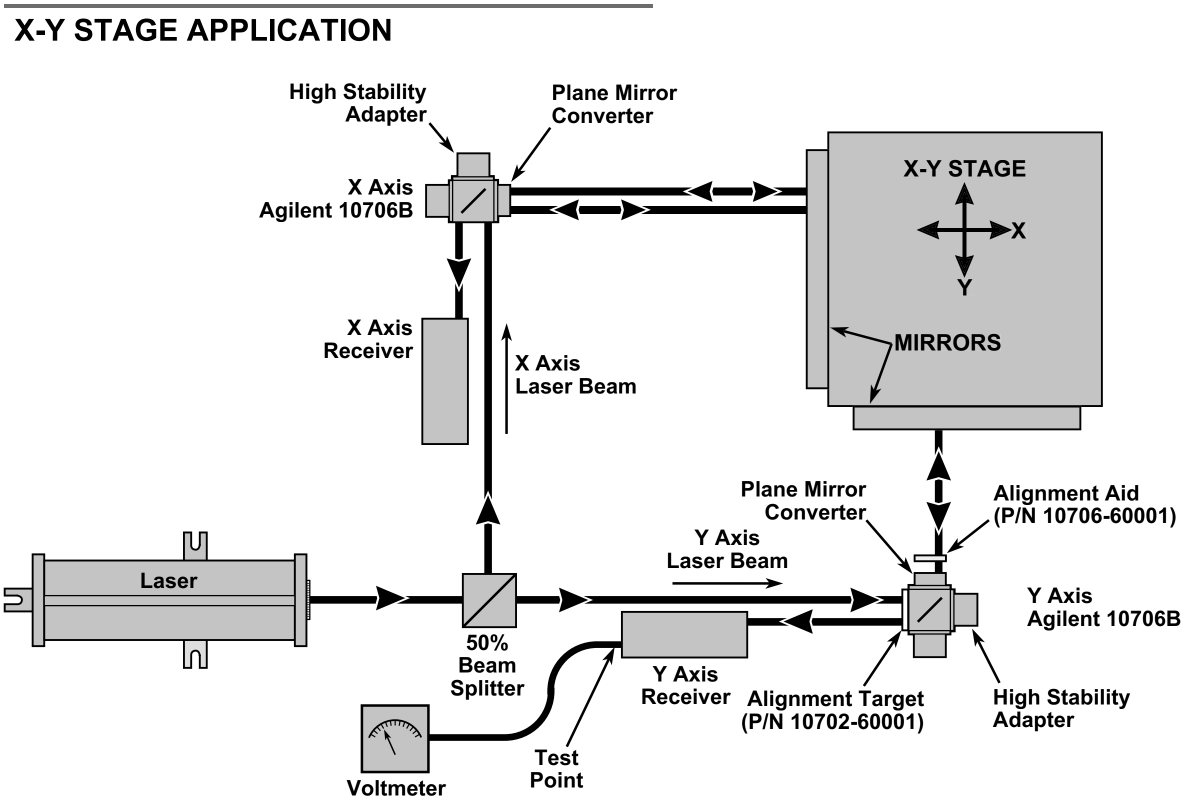


Figure 7D-6. Agilent 10706B High Stability Plane Mirror Interferometer in an X-Y Stage Application

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 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 7D-5. 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 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.

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 7D-5. 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 10897B 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 10897B 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: $\lambda/4$

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

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 $\lambda/4$ to $\lambda/20$; 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.

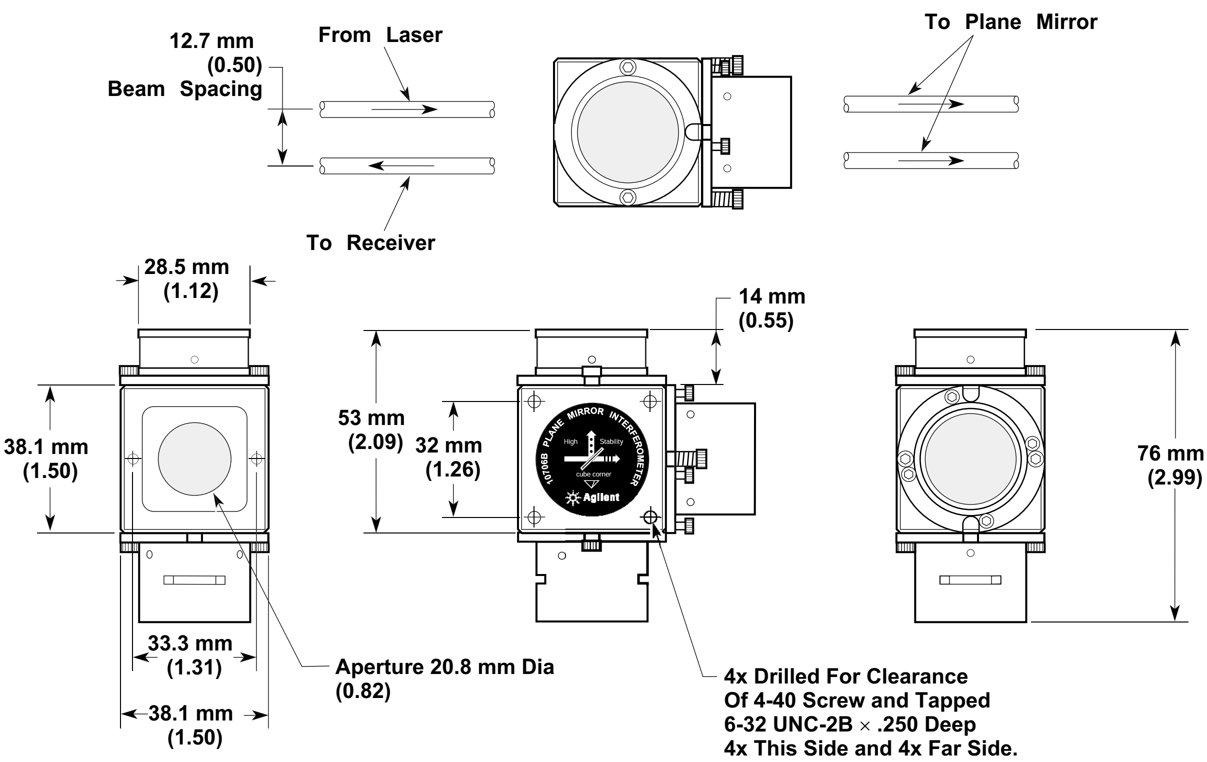


Figure 7D-7. Agilent 10706B Plane Mirror Interferometer — dimensions

This is a chapter from the manual titled:
Laser and Optics User's Manual
For complete manual, order:
Paper version: p/n 05517-90045
CD version: p/n 05517-90063
This chapter is p/n 05517-90111