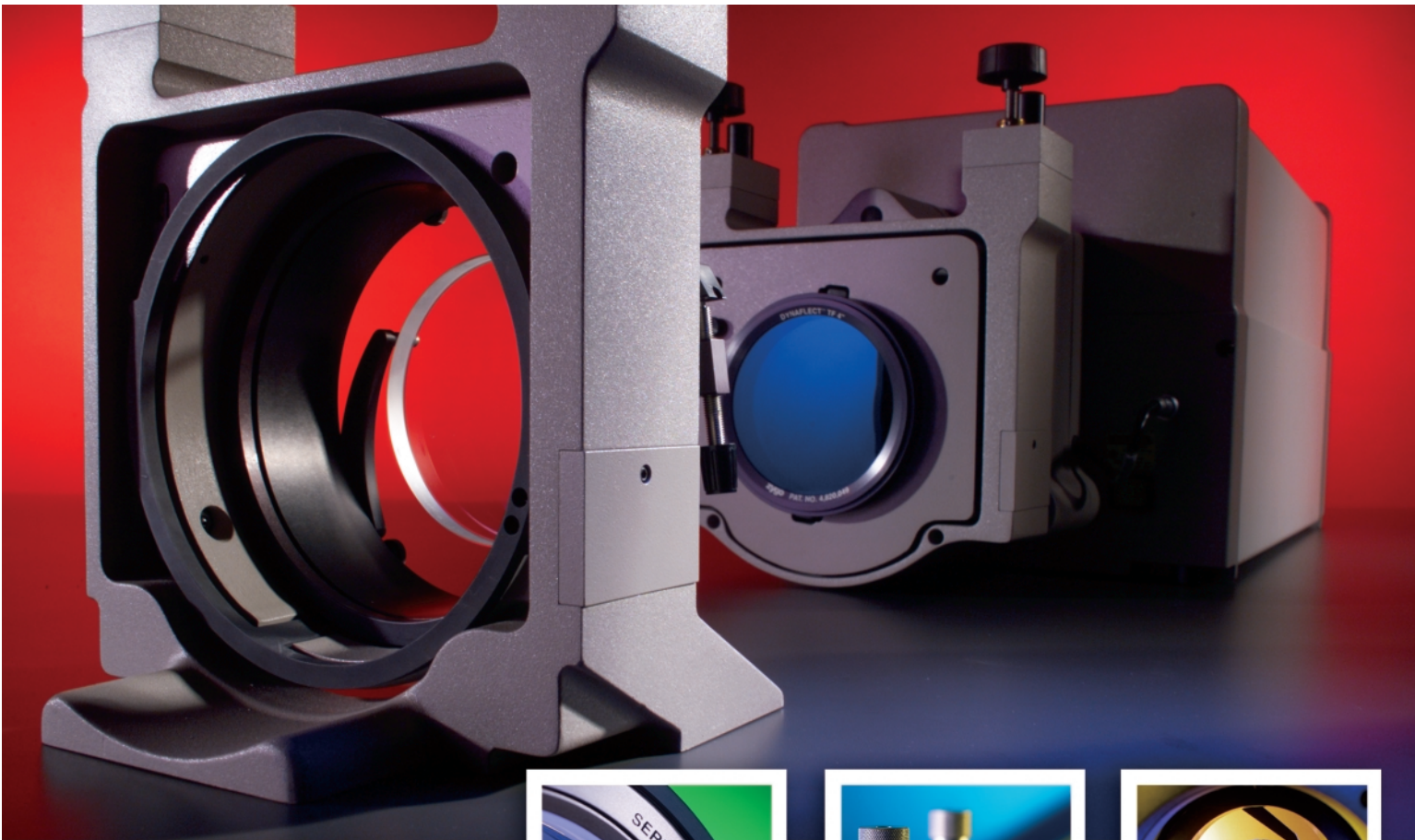


ZYGO's Guide to

# Typical Interferometer Setups

- Surfaces
- Windows
- Lens Systems



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# Welcome to the Interferometer Setups Guide

This booklet illustrates and discusses a number of the most common measurement setups for use with a Zygo Corporation interferometer. However, it is by no means a comprehensive collection of all the setups that are possible, partly because new and innovative setups are developed every day by users around the world.

Therein lies the beauty of Zygo Corporation's modular interferometer system; it is not limited to specific measurement setups that fit only specific measurement situations. It is dynamic, versatile, and limited only by the imagination and resourcefulness of the user.

With every technological advancement comes the challenge of finding a way to measure and quantify it, and an opportunity to use interferometry in a new way. Industries not previously considered to be likely candidates for interferometric testing are now utilizing this valuable tool to measure computer disks, diamond-turned surfaces, precision machined metal parts, highly polished metal surfaces, and so on.

All it takes is a little knowledge, some creativity, and a ZYGO interferometer. We hope this booklet sparks your imagination.

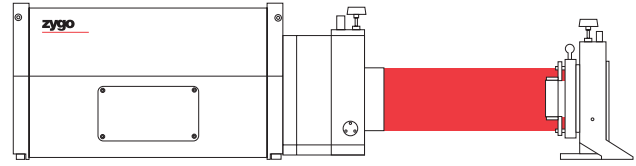
## The Setups

Each setup example in this booklet shows a Mainframe, the part being tested, and the accessories required to make the setup work. The accompanying text explains how the setup is used. A GPI Mainframe is shown in the examples; however, any ZYGO interferometer may be used with equal success.

For many measurement situations, the Mainframe and the accessories may all sit on one vibration isolation table, with the measurement beam oriented horizontally. More elaborate arrangements are certainly possible, and may be required to suit particular measurement needs.

If you have questions about any of the setups, or you would like to discuss a setup not covered in this booklet, please contact Zygo Corporation for assistance. Our Support Team is ready to help you understand and explore interferometry.

# Surface Flatness

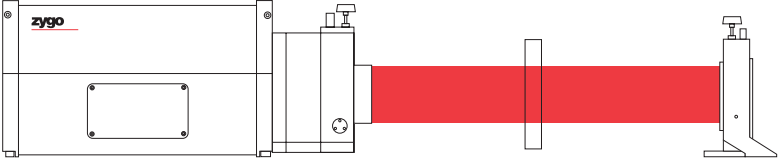


Suggested Accessories	
	Transmission flat 4%
	Mount, 2-axis
	Self-centering element holder

This setup is used for the measurement of surface flatness of plano elements such as mirrors, prisms, and windows. The test object must be held so that the surface under test can be aligned in two axes of tilt.

The Align Mode is used for rough alignment. The View Mode, using the Quick Fringe Acquisition System, is then used for fine alignment.

# Plano Transmitted Wavefront



Suggested Accessories	
	Transmission flat, 4%
	Reference flat, 4%
	Mount, 2-axis

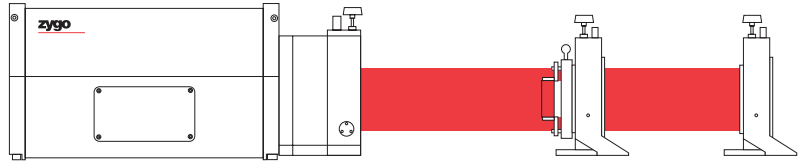
This setup is used to measure distortion of a plane wave transmitted through the element under test. It is typically used for windows, filters, and prisms. In addition, glass and other transparent raw material may be examined for homogeneity. Software packages are available for material homo-

geneity evaluation. Since the measurement beam passes through the element under test, this element need only be placed nominally perpendicular to the optical axis of the test beam. No special mount or alignment is required.

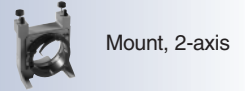
**If needed, for test element:**

	Mount (2-axis)
	Self-centering element holder

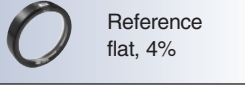
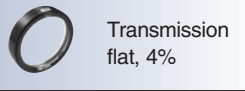
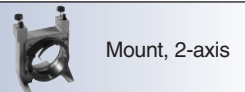
# Parallelism (Wedge)



## Suggested Accessories



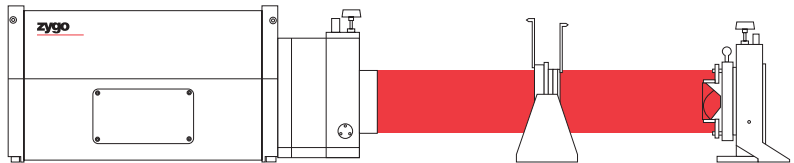
### For medium wedges add:



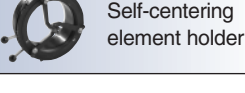
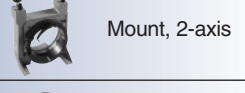
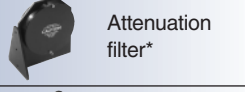
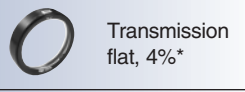
Parallelism (wedge) can be measured using the Mainframe. Measurement of very small wedges requires no auxiliary optics because interference is obtained between wavefronts reflected from the two surfaces of a transparent element. The element must only be placed nominally perpendicular to the Mainframe output beam. The optical and mechanical wedge can be calculated

from the resulting interference pattern. For medium wedges, the Plano Transmitted Wavefront setup can be used. This and other techniques, some with a fraction of an arc second resolution, can be used to measure wedge using a phase measuring Mainframe.

# Prism and Corner Cube Testing



## Suggested Accessories

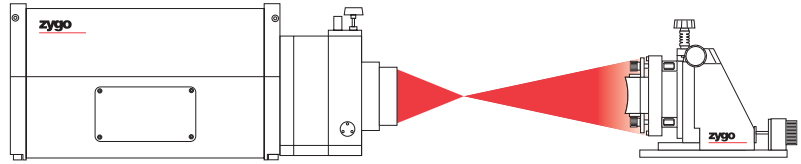


Many prisms and corner cubes can be measured as if they were a plano, that is, facing a transmission flat on the Mainframe. For pieces with high equivalent reflectivity (i.e. > 40%) an attenuation filter can be used as shown in the center of the setup, or a

Dynaflat™ flat in place of the 4% transmission flat. ZYGO's MetroPro™ software can calculate angle errors as well as transmitted wavefront errors.

\*A Dynaflect™ transmission flat may be used instead of these two accessories for high reflectivity pieces.

# Transmission Sphere Selection



## Suggested Accessories



Transmission sphere



Mount, 3-axis or 5-axis



Self-centering element holder

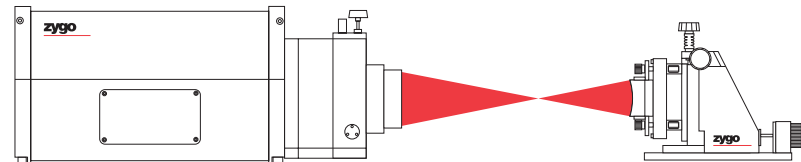
Transmission spheres of various f/numbers are available as standard items, and others may be obtained on special order. In order to select the optimum transmission sphere f/number to fill the aperture of a concave or convex surface, the R/number of the surface to be measured is calculated using the following formula:

$$R/\text{number} = \frac{\text{Radius of curvature of surface under test}}{\text{Clear aperture of surface under test}}$$

If the R/number of the surface under test does not match the f/number of the transmission sphere being used, one of two situations will occur. If the R/number is smaller than the f/number, the interferogram will not fully cover the entire aperture of the surface under test. If the R/number is larger than the f/number, the interferogram will be smaller than full size on the monitor, which can be compensated for by using the Mainframe's variable zoom.

A transmission sphere selection guide is available from Zygo Corporation to assist in choosing the correct f/number.

# Concave Surface Figure



## Suggested Accessories



Transmission sphere



Mount, 3-axis or 5-axis

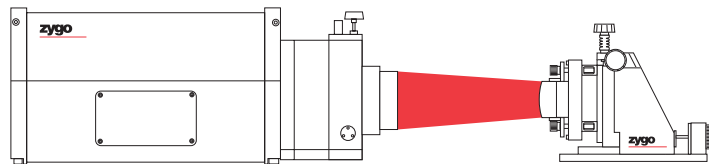


Self-centering element holder

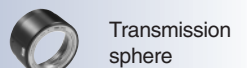
A transmission sphere transforms the Mainframe output beam into a precise spherical wavefront for the evaluation of spherical surfaces and lenses. A concave spherical surface is examined for surface figure and irregularity, i.e., the deviation from the best-fitting sphere, by placing its center of curvature coincident with the focus of the transmission sphere. This usually difficult

alignment is simple and takes only seconds using the Mainframe's Quick Fringe Acquisition System. Adjustment of the surface under test can be provided by a 3- or 5-axis mount. The 3-axis adjustment is necessary for spheres. However, the 5-axis mount is often chosen to be used with both spheres and flats (which need tilt adjustment).

# Convex Surface Figure



## Suggested Accessories



Transmission sphere



Mount, 3-axis or 5-axis

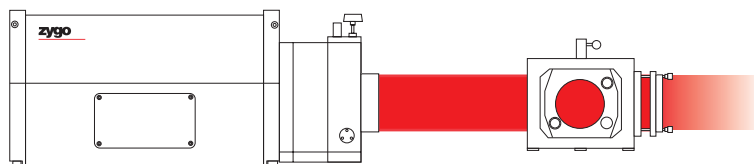


Self-centering element holder

Convex spherical surfaces are examined for surface figure and irregularity using the setup shown. In order to select the optimum transmission sphere, two criteria must be met. First, the radius of curvature of the convex surface under test must be less than the back focal length of the transmission sphere. Second, the radius of curvature of

the surface under test divided by the clear aperture, i.e., the R/number, should be greater than or equal to the f/number of the transmission sphere. Both four-inch and six-inch diameter transmission spheres are available for these applications. Adjustment of the surface under test can be provided by either a 3-axis or 5-axis mount.

# Two or More Simultaneous Measurement Channels



## Suggested Accessories

MUX Cube

Other accessories as required

This illustration shows how two horizontal measurement channels are produced with a MUX (multiplexing) cube. Each channel can support its own measurement setup and has all of the Mainframe's features.

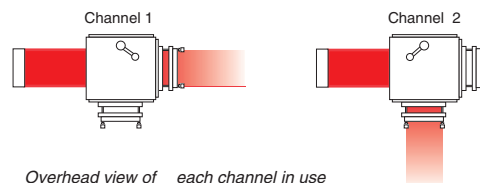
The transmission elements for each channel snap in the accessory receptacle on the MUX cube.

The two measurement channel feature is particularly useful because it significantly enhances the utilization of the Mainframe. Two common use modes are:

Two operators can each use one of the measurement channels and thereby share one Mainframe.

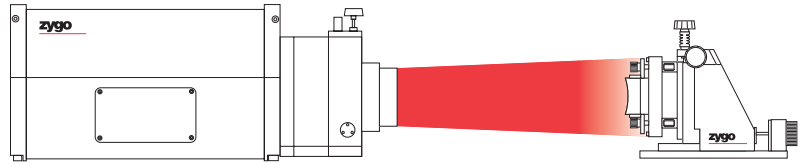
An operator can take measurements in one channel while the test setup in the second channel is coming to thermal equilibrium.

Very simply, the Mainframe can remain in use while a test setup comes to thermal equilibrium or while test setup is being put together in the other channel.





Overhead view of each channel in use


# Slow Concave Surface Figure (Moderately-Long Radii)



## Suggested Accessories

 Transmission sphere, diverger

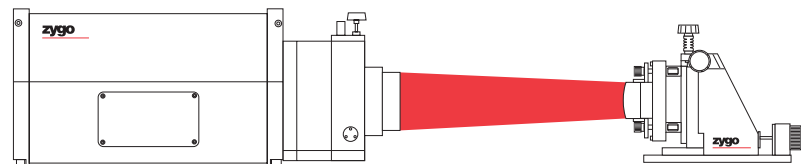
 Mount, 3-axis or 5-axis

 Self-centering element holder


Spherical surfaces with R/numbers in the range from 11 to 50 are best measured using the converger/diverger series of transmission spheres. The illustration depicts the


measurement of a slow concave surface using a diverger. Refer to the converger/diverger accessory sheet for the range of radii covered by each member of this series.

# Slow Convex Surface Figure (Moderately-Long Radii)



## Suggested Accessories

 Transmission sphere, converger

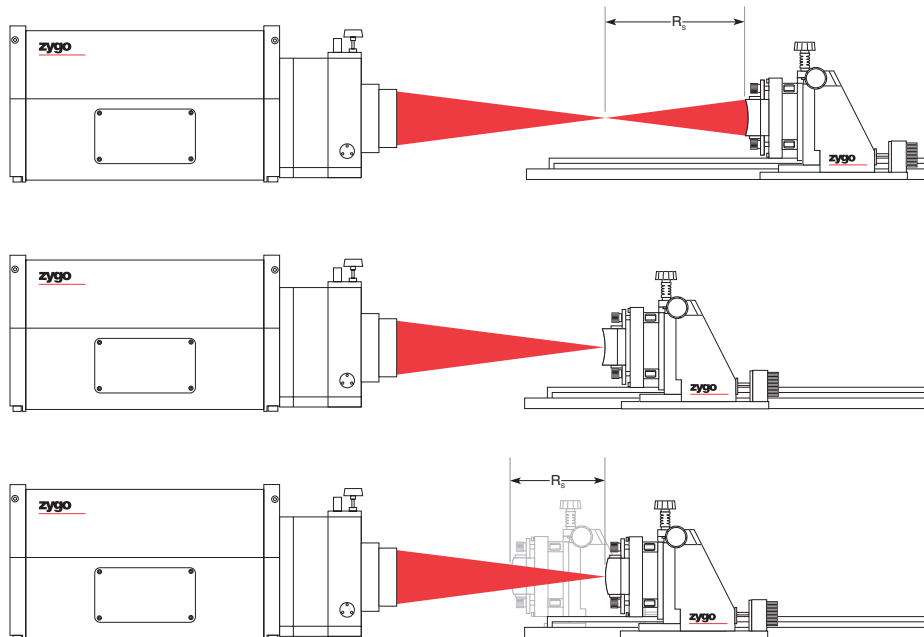
 Mount, 3-axis or 5-axis

 Self-centering element holder

This illustration depicts the measurement of a slow convex surface using a converger.

**Note:** For surfaces with very long concave or convex radii, contact Zygo Corporation for a quotation on a custom transmission sphere.

# Noncontact Radius of Curvature and Figure



## Suggested Accessories



Transmission sphere



Mount, 3-axis or 5-axis



Self-centering element holder

Digital Radius Slide

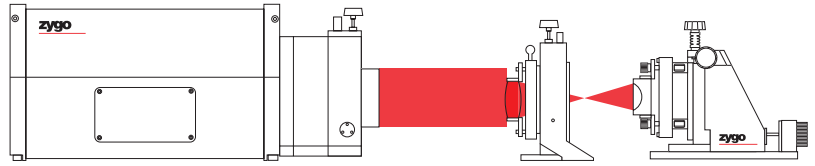
In addition to surface figure and irregularity, the radius of curvature of both concave and convex spherical surfaces can be measured. The center of curvature of the test surface is positioned to coincide with the focus of the spherical wave emanating from the transmission sphere. In this arrangement, shown in the first illustration, the fringe pattern provides information not only about the figure and irregularity of the surface under test, but also about the precise location of the center of curvature of the test surface with respect to the focus of the transmission sphere. The surface under test is then translated along the optical axis of the interferometer until the surface under test coincides with the transmission sphere focus, as shown in the second illustration. The fringe pattern again provides a very sensitive indicator of the point where the surface coincides with the focus. The distance that the surface under test is translated,  $R_s$ , is equal to the radius of curvature of the surface.

A digital radius slide provides a convenient read-out of the translated distance. Used with an encoder, this technique is accurate to 20  $\mu\text{m}$  or 0.1%, whichever is larger. For cases where very high accuracy is required (1 $\mu\text{m}$  or 0.001%) an Interferometric Radius Slide is available. Both the encoder and the Interferometric Radius Slide can input these distance measurements directly to the interferometer's processor to correct for positioning errors.

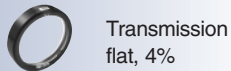
The accuracy to which the radius of curvature of a high quality spherical or cylindrical surface can be determined is not just a function of the distance measurement accuracy. It is also a function of the  $R/\text{number}$  of the surface being measured, as well as the user's ability to judge fringe straightness (if the user does not choose to correct for positioning errors).

The third illustration shows the equivalent surface figure and irregularity and radius of curvature measurement setups for convex surfaces.

# Lens/System Performance



## Suggested Accessories



Transmission flat, 4%



Mount, 2-axis



Mount, 3-axis or 5-axis



Reference sphere



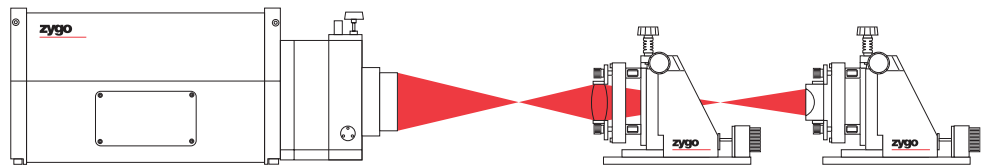
Self-centering element holders (2)

Lens or system quality can be measured by examining the distortion of the transmitted wavefront. For a lens or system focused for infinity, the lens can be placed in the collimated measurement beam and a high quality concave or convex sphere can be

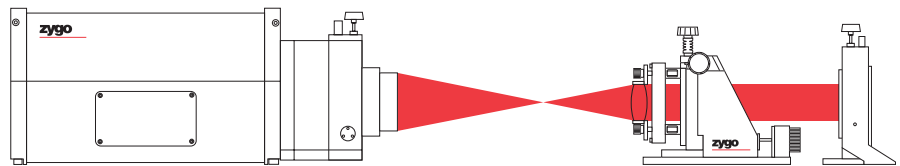
used to retroreflect the transmitted wavefront. By rotating the optical axis of the lens under the test with respect to the axis of the measurement beam, performance at various field angles can be determined.

# Lens/System Performance (Alternate Method)

Finite conjugate lens test



Alternate infinite conjugate lens test



## Suggested Accessories



Transmission sphere



Mount, 5-axis

### For finite conjugate lens test add:



Reference sphere



Mount, 3-axis or 5-axis

### For infinite conjugate lens test add:



Reference flat



Mount, 2-axis

Particular situations may require an alternate lens/system setup. For lenses or systems with finite conjugates, a transmission sphere is necessary to form the “object” position in front of the lens under test. For systems with apertures larger than the sample beam of the interferometer, or for systems with apertures much smaller than the sample beam of the interferometer, this alternate setup may be advantageous. The alignment of the elements, however, may be significantly more difficult, and errors due to misalignment may be introduced.

Data is subject to change without notice.

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