The LensCheck™ Product Line

The LensCheck instrument family has two members: LensCheck VIS for those lenses that work at visible wavelengths and LensCheck LWIR for those that operate in the long-wave infrared region of the spectrum. Both instruments use OpTest 7 software, are similar in appearance and operation and have several components in common. In the description that follows, we shall use the abbreviation UUT (Unit Under Test) to refer to the lens that is to be tested using the LensCheck instrument.

(LensCheck images)

LensCheck instruments measure the imaging performance and first-order characteristics of small to mid-size lenses by assessing image quality and image location over the field of view of the lens. Field locations of interest are specified by the operator and each is visited in turn. In the case of an infinite conjugate lens (in which the object is located infinitely far from the lens), the objects are projected into the entrance pupil of the UUT by a collimator.

(Landscape image showing targets)

In normal use, the scene that is imaged by a lens might be filled with detailed structure across the entire field, such as when a photographic objective lens views a landscape scene. However, when we measure the performance of the lens, we consider only very small regions (“field points”) within that image and use “standard” objects such as pinholes, slits, or crosshairs to illuminate one field location at a time. Standard objects are used because they have well controlled energy distributions and lend themselves well to mathematical modelling.

(LensCheck VIS with callouts)

Several of these standard objects (also referred to as “targets”) are mounted in a target wheel at the focal point of the LensCheck collimator. In the LensCheck LWIR, this target wheel is motorized and back illuminated with a small incandescent source, whereas in the LensCheck VIS, the target wheel is manual and the illumination is sourced from a fiber light that relays the visible energy from a quartz tungsten halogen bulb through a flexible light guide. In the LensCheck VIS, a filter wheel is located between the exit face of the light guide and the target assembly. Since the LensCheck may be used to measure lenses over a wide range of focal lengths, several sizes of standard targets are provided in order to ensure that a target with an appropriate image magnification is available.

(LensCheck LWIR with callouts)

As is typical, the LWIR camera used in the LensCheck LWIR is less sensitive than its visible counterpart, so it is usually necessary to boost the signal by employing slit or crosshair objects when making LWIR measurements whereas it is usually acceptable to use pinhole objects when making visible measurements. An electromechanical shutter is incorporated into all LWIR sources and into certain visible models. This shutter permits a background frame with the source extinguished to be sampled and then subtracted from the measurement frame.

(Diagram of rotation of the lens)

For an infinite conjugate lens, each point in the field corresponds to a different angle that the object location makes with respect to the axis of the UUT. The LensCheck accesses each field point by keeping the collimator stationary and rotating the lens under test about its entrance pupil. From the point of view of the UUT, the azimuthal angle of the collimated object will appear to change and the effect is equivalent to keeping the UUT stationary and rotating the line of sight of the collimator. Since the collimator is generally larger than the UUT, the arrangement in which the collimator remains fixed is more compact.

(Diagram describing off-axis field points)

Regardless of the UUT field angle, the standard object (a pinhole for example) always remains fixed on the axis of the collimating lens. This ensures that the collimator produces the same well-corrected wave front at every UUT field position. The LensCheck can access off-axis field points in the plane that is parallel to the table on which the instrument rests. In order to access field points outside of this plane the UUT must be rolled around its optical axis so that the field point in question is brought into the horizontal plane. An optional motorized rotary lens mount is available for automating this function.

(Image of rotary lens mount)

The UUT forms an aerial image of the collimated object in its focal plane. In the case of a camera lens, for example, this is the location at which an image sensor might be placed. In order to measure the geometric imaging characteristics of the UUT we need to know where in 3-dimensional space this image is formed, and to assess the resolving power of the lens (in particular to measure its MTF) we need to map to distribution of energy with in the image. The more tightly focused the energy, the greater the resolving power of the UUT (and the higher the MTF).

In order to map accurately the energy distribution with the image with sufficient spatial resolution, the LensCheck uses a microscope objective to relay a magnified image onto a camera. The microscope relay and the camera together form the image analyzer portion of the LensCheck and, since different wavebands require different cameras, there are different image analyzers for the LensCheck VIS and the LensCheck LWIR. The microscope objectives are interchangeable in the case of the LensCheck VIS but not in the case of the LensCheck LWIR.

(Diagram showing movement along the three axes) A three-axis stage assembly provides the ability to move the focus of the microscope objective along three orthogonal axes, two of which are motorized. Selecting field points in the horizontal plane by rotating the UUT about its entrance pupil causes the image to move in a horizontal plane behind the lens. The x-axis is motorized so that it can automatically move to the corresponding field height in the image plane, and the motorized z-axis (along the optical axis of the UUT) permits the location of best focus to be found automatically. The y-axis is manually adjustable so that the operator can center the image vertically within the field of view of the image analyzer after mounting the UUT. The x-axis includes a glass encoder scale to precisely measure the image location at each field point in the image plane. From this information, and from knowing the corresponding field angle (also determined using a glass scale rotary encoder), the OpTest 7 software is able to calculate geometric parameters such as focal length and distortion. By knowing the z-location of best focus at each field point we can report field curvature, and by measuring the MTF in both the sagittal and tangential directions we can measure the astigmatism at each field location.

The LensCheck instrument is controlled by a desktop computer running the OpTest 7 software. This application controls the motorized axes of motion and acquires and analyzes the image from the image analyzer. This is the same OpTest 7 software that is used to run the larger lens measurement benches provide by Optikos, although the user interfaces is tailored specifically for the LensCheck instruments.