

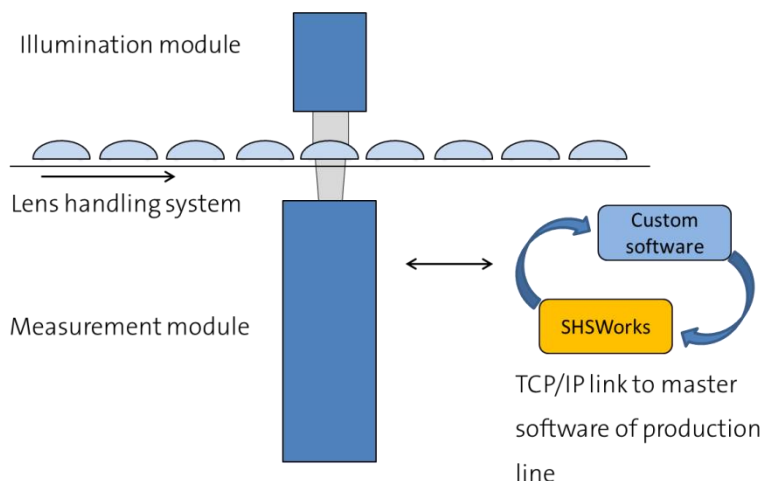
## Application note:

# SHSInspect 1Xpass: Inline inspection of focus tunable lenses

## 1 Inline lens inspection

Optotune is one of the market leaders in focus tunable lenses. These lenses are widely used, for example, in machine vision or consumer electronics where many applications profit from a fast and flexible refocussing.

For quality assurance in production and in R&D, Optotune uses Optocrafts Shack-Hartmann wavefront sensors (SHS). For an inline measurement of the transmitted wavefront, the lenses under test (LUT) are sequentially presented to the SHSInspect 1Xpass module, which consists of an illumination unit and a wavefront detection unit. After a LUT has been moved into the measurement module, its focus is tuned stepwise. For each focal length, the transmitted wavefront is recorded and checked for several pass/fail criteria. The entire process including lens handling, wavefront measurement and data storage and analysis is automated, an operator is only needed to load/unload the tray containing the lenses. Typ. cycle times of below 2 seconds from LUT to LUT are achieved.



## 2 Performance and features

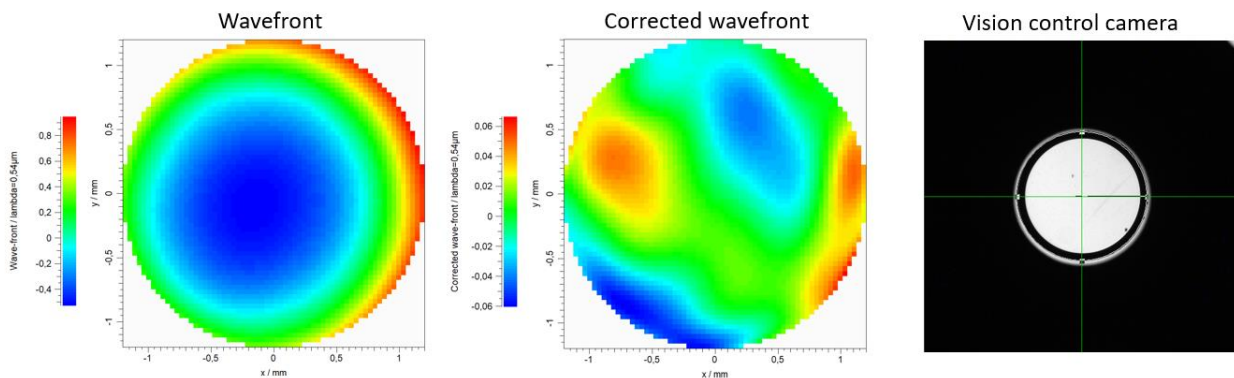
Due to the single shot measurement principle of Optocrafts wavefront sensor technology, high wavefront evaluation rates are possible and the cycle time is primarily governed by the handling of the LUT. Additionally, the short shutter time makes the measurement robust and insensitive to vibrations that might be introduced by, e.g., the sample handling device.

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Optocrafts SHS is able to measure wavefronts with extreme (a)sphericity. This allows Optotune to measure the broad range of refractive powers of their focus tunable lenses. The SHSInspect 1Xpass module is able to detect wave aberrations also at high refractive powers, where a strong defocus “hides” the features that are of interest for quality inspection. That means that on one hand, the refractive power from -30dpt to +30dpt can be measured. On the other hand, the lens higher order aberrations like astigmatism, coma and spherical aberration are retrieved from the same wavefront measurement.

The reproducibility of the power measurement, i.e. the error of the power measurement when a lens is removed and re-inserted into the measurement module is  $<0.02\text{dpt}$  ( $1\sigma$ ). The wavefront accuracy (on 4.5mm pupil) is in the range of 3nm rms to 45nm rms, depending on the refractive power of the LUT.



Besides the SHS, the SHSInspect 1Xpass module contains a vision control camera that provides a high resolution image of the lens. In addition to the measurement of the lens diameter and position, the vision control camera is used to detect visual defects like scratches or edge defects and to check that the lens is free of dust or other contamination.

High measurement speed, robustness and the capability to measure highly dynamic wavefronts with high precision are the main reasons why Optotune chose Optocrafts wavefront sensors for their application. These features are critical for the efficient inline quality control of focus tunable lenses. Today, practically no lens leaves Optotunes facilities without having been tested for its transmitted wavefront at several different focal lengths within its tuning range.

### *SHSInspect 1Xpass module*

- ▣ Wavefront evaluation rate: 5Hz
- ▣ Single shot measurement of wavefront, imaging quality, refractive data, defects
- ▣ Vibration insensitive
- ▣ Easy integration to automated environment
- ▣ Automated Pass/Fail decision