ORI test station

Tester of optical systems

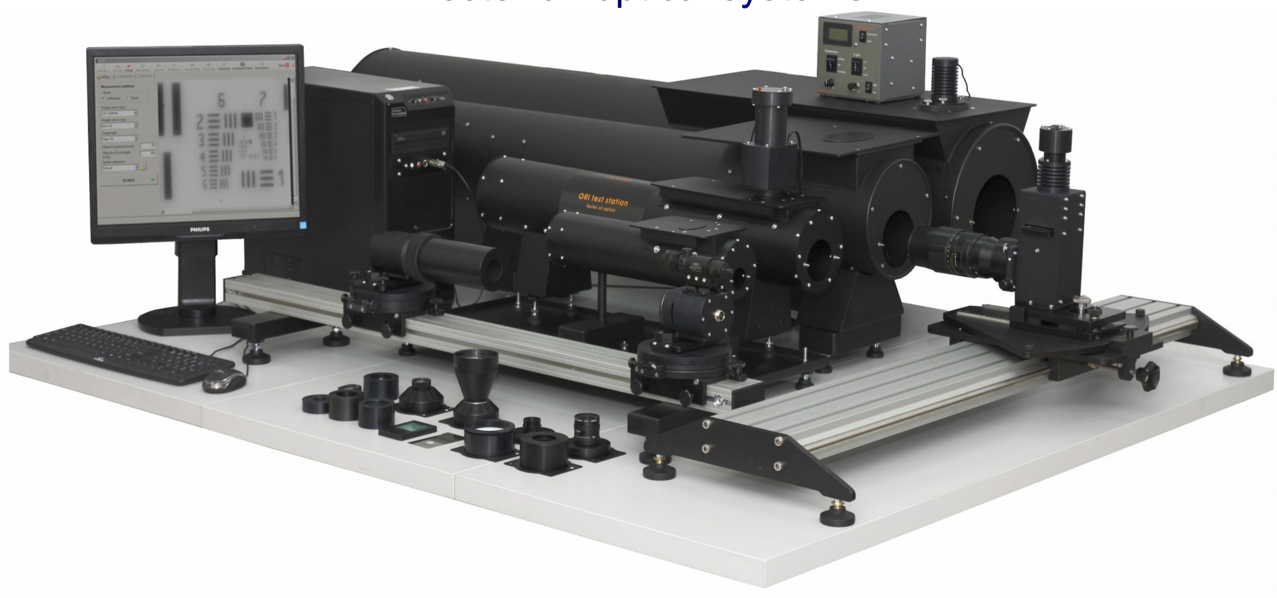

Fig. 1. Photo of ORI test station

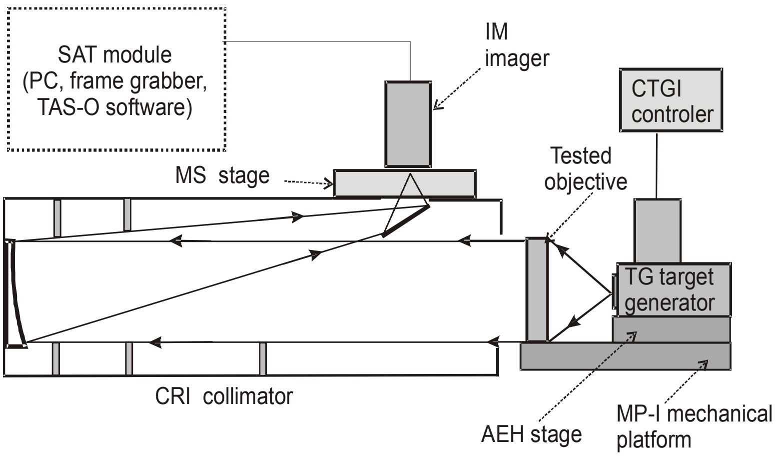

Fig. 2. Simplified block diagram of the ORI test station

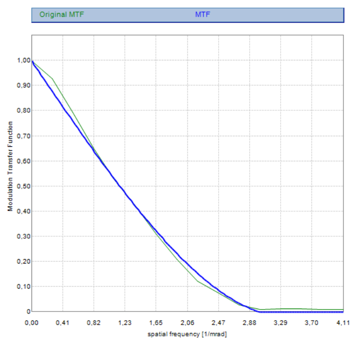

Fig. 3. MTF curve of an exemplary diffraction limited LWIR objective

BASIC INFORMATION:

ORI test station is a modular, quasi universal station for extensive testing of optical systems. This station enables measurement of a series of important parameters of optical modules: MTF (on axis, off axis), resolution (visible/NIR objectives), effective focal length, distortion, vignetting, transmission, back focal length, working focal length, depth of focus, field curvature. Both converging objectives and afocal systems can be tested.

ORI test station uses a concept of inverse imaging for testing optical objectives. This means a target generator module is located at the focal plane of tested optical objective that works as an image projector. Quality of the output images are evaluated with help of a series of electronic imagers (different spectral bands) and specialized software and parameters of tested objective are determined.

This test method was for decades a secret of famous manufacturers of ultra high resolution optical objectives. Combinations of this simple, technically challenging, but efficient test method with Inframet know how in electronic imagers and test software has enabled to create this modern, powerful, reliable and user friendly test station. Next, ORI test station can be optimized for requirements of any optical manufacturer/scientific institute/test laboratory that needs professional system for testing any type of optical objectives.

ORI test station

Tester of optical systems

HOW IS BUILT

The ORI test station is built from a series of CRI off axis reflective collimators, a series of TG target generators, set CTG controllers, set of mechanical adapters, AEH optical stage, MP mechanical platform , set of spectral filters, set of optical attenuators, set of targets, set of IM electronic imagers (versions optimized for different spectral bands), PC set, frame grabber, TAS-O computer program, and optional set of reference objectives. .

A series of off axis reflective collimators is used in order to enable accurate testing of optical objectives of different aperture and focal length. A series of electronic imagers is used to enable tests of optical objectives optimized for work in different spectral bands:

The ORI test station is an unique design that enables to test all types of optical systems in the optical spectral range from UV to LWIR (UV optics, VIS optics. VIS/NIR optics, SWIR optics, MWIR optics, LWIR optics). Such universality is achieved by designing several versions of some modules (imager, set of targets, target generator) optimized for different spectral range of tested optics. By exchange of these modules ORI system can be easily converted from version for testing visible objectives to a version optimized for testing infrared objectives.

High quality of collimators and high-res imagers used as modules in ORI test station enables accurate testing even diffraction limited optical systems in all optical spectral ranges. A series audit objectives used as optional modules of ORI test system enables convenient during recalibration of this test system.

MEASUREMENT RANGE AND ACCURACY

Measurement range and measurement accuracy depend on version of ORI station. Precision data is delivered when ORI version is determined. Below is presented general data.

Table. 1. Acceptable parameters of tested objectives

Parameter	VIS and VIS/NIR objectives	SWIR objectives	MWIR objectives	LWIR objectives
Range of acceptable focal length	10 – 800 mm	10 – 800 mm	10 – 800 mm	10 – 800 mm
Range of acceptable back focal length	10 – 700 mm	10 – 700 mm	10 – 700 mm	10 – 700 mm
Acceptable Optics length	5-300 mm	5-300 mm	5-300 mm	5-300 mm
Range of acceptable aperture of tested objectives	From about 2 mm to 200 mm	From about 4 mm to 200 mm	From about 3 mm to 200 mm	From about 5 mm to 200 mm
Range of acceptable F-number	From 0.8 to 10	From 1 to 5	from 1 to 5	from 1 to 3
Maximal simulated sensor	18 mm image intensifier tube or 1" sensor (12.8x9.6 mm)	Max 15x15 mm	IR FPA of dimension: 17.4x13.1 mm	IR FPA of dimension: 17.4x13.1 mm

Table. 2. Measurement range and measurement accuracy

Parameter	Visible/NIR objectives	SWIR objectives	MWIR objectives	LWIR objectives
Spatial frequency range for MTF measurement	0- 400 lp/mm	0- 200 lp/mm	0-150 lp/mm	0-100 lp/mm
Maximal spatial frequency of resolution target	456 lp/mm	228 lp/mm	-	-
Off-axis angle range	from 0^0 to 30^0	from 0^0 to 30^0	from 0^0 to 30^0	from 0^0 to 30^0
MTF measurement uncertainty	+/-0.02 (at MTF >0.2)	+/-0.02 (MTF>0.2)	+/-0.02 (MTF >0.2)	+/-0.02 (MTF >0.2)
MTF measurement repeatability	+/-0.01 (when MTF >0.2)	+/-0.01 (MTF >0.2)	+/-0.01 (MTF >0.2)	+/-0.01 (MTF >0.2)
Focal length measurement relative uncertainty	≤1%	≤1%	≤2%	≤ 2%
Distortion measurement relative uncertainty	≤ 4% but measurement resolution 1%	≤ 4% but measurement resolution 1%	≤ 9% but measurement resolution 1%	≤ 9% but measurement resolution 1%
Vignetting measurement relative uncertainty	≤ 3%	≤ 3%	≤ 5%	≤ 5%
Relative uncertainty of relative transmittance measurement	≤ 3%	≤ 3%	≤ 8%	≤ 8%
Relative uncertainty of absolute transmission measurement	≤ 7%	≤ 7%	≤ 10%	≤ 10%
Relative uncertainty of back focal length	≤ 1%	≤ 1%	≤ 1.5%	≤ 2%
Relative uncertainty of working focal length	≤ 1%	≤ 1%	≤ 1.5%	≤ 2%
Relative uncertainty of depth of focus	≤ 7%	≤ 7%	≤ 10%	≤ 10%
Relative uncertainty of field curvature	≤ 10%	≤ 10%	≤ 14%	≤ 14%

ORI test station

Tester of optical systems

VERSIONS

ORI stations can be delivered in many different versions. The version is described using five letter code (abcd) presented in the table below.

Table. 3. Definition of codes used to describe versions of ORI test system

	1	2	3	4	5
Code	**Aperture/ range/ focal length range**	**Test capabilities**	**Type of tested optical system**	**Spectral range of tested optical system**	**Simulated distance**
A	3-70mm 3-240mm	MTF (on axis), resolution (for VIS optics)	Converging objectives	VIS/NIR	Fixed - optical infinity
B	3-100mm 3-400 mm	MTF (on-axis, off-axis- sagital, tangential), effective focal length, resolution (for VIS/NIR optics)	Afocal systems only	MWIR/ LWIR (option: LWIR)	Regulated: from 3 up to 20 focal length
C	3-150mm 3-600 mm	As in point B but additionally distortion, vignetting, relative transmission of converging objectives	Converging objectives and Afocal systems	MWIR/LWIR/ VIS/NIR	Test to be done at both distances
D	3-200 mm 3-800 mm	As in point C but additionally absolute transmission		SWIR/VIS/NIR	
E	3-250 mm 3-1000 mm	As in point C but additionally back focal length, working focal length, depth of focus, field curvature		MWIR/LWIR/ SWIR	
F	3-300 mm 3-1200 mm	As in point E but additionally absolute transmission		MWIR/LWIR/ SWIR/VIS/NIR	

Attention:

1. A special version of ORI coded as OTEC is offered for testing ultra big optical objectives of apertures in range from 200mm to 5000 mm and focal length from 1000mm to 4000mm.
2. If different combination of spectral range of tested optics (or additional UV band) is needed please contact Inframet.

Example: ORI -CAACA means the following ORI test system: 1) maximal aperture of tested optical objective equals 150mm, maximal focal length equals 600mm, 2) test system capable to measure MTF(on axis), resolution(visible objectives); 3) the test system capable to test only Converging optical objectives; 4) MWIR / LWIR/VIS/NIR objectives can be tested, 5) objective is to be tested at infinity simulated distance.

ADDITIONAL OPTIONS:

There are several additional options that can expand test capabilities of ORI test station:

1. Ability to test broadband optical objectives covering range from about 600 nm to 1700nm (modified TG-S target generator and modified IM-S imager)
2. Ability to test optical objectives optimized to cooperate with image intensifier tubes (additional optical plate in TG-V target generator).
3. Objectives of longer focal lengths can be tested than shown in column 1 (modified set of collimators).

WHY INFRAMET?

Inframet is a relative newcomer on market of equipment for testing optical modules. We developed first system for testing optical modules in 2008 year in situation when some of our competitors are present on this market for over 30 years. However, in spite of this short activity on market of equipment for testing optical modules Inframet claims that offers technically superior test equipment. The reason for this situation is a fact that Inframet is the only company on market manufactures high tech test equipment for testing all types of electro-optical imaging/laser systems and modules. The same rules that enabled Inframet to develop a series of successful test stations for testing different types of electro-optical systems have been used to develop ORI station for testing optical modules.

1. A test method that can potentially generate highest measurement accuracy.
2. Maximal use of 2D imaging for both focusing and testing applications in order to enable user friendly operation and increase measurement speed.
3. Test station is to be operational at any time.
4. Design optimized to increase reliability and life time.
5. Maximal use of advanced software to achieve expanded test capabilities.
6. Near perfect off axis collimators to be used as image projectors.
7. Universal modular design that enables testing variety of different systems. Ad 1) Inframet is the first manufacturer of equipment for testing optical modules who use exclusively inverse imaging method. Due to elimination of relay lenses used in traditional test stations potential test accuracy is higher because influence of relay lens (both limited quality and alignment errors) on final image generated by tested optical module is eliminated.

Ad 2) Inframet is the first manufacturer of equipment for testing optical modules who use 2D imaging modules for not only testing visible/NIR objectives but also for testing IR objectives. Other manufacturers use typically CCD cameras for testing visible/NIR objectives but use single, discrete IR detectors integrated with a scanning system for testing IR objectives.

Ad 3) Inframet uses a non-cooled thermal camera (IM-I imager) instead of typical discrete IR detectors cooled using liquid nitrogen. This means that Inframet test station can be operated as any time (assuming electricity is available) in situation when test stations offered by some other manufactures can be operated only when liquid nitrogen is available. It should be noted that liquid nitrogen can be stored in typical metal dewars for no longer than about 12 hours.

Ad 4) Test stations offered by other manufacturers require precision, long range, multi axis movement of optical/mechanical parts typically controlled from PC: positioning of tested objective, focusing of tested objective, scanning of discrete IR detector, etc. Inframet concept is different: minimal use of movable mechanical/optical parts in order to increase station reliability and life time. Next, Inframet prefers to use motorized, PC controlled movements of parts in compact systems that have closed case that prevent access of use to these parts (example LTF test station for testing laser range finders). However, in case of modular, open systems like ORI system for testing optical modules Inframet prefers manually movable parts due higher reliability of such solution.

Ad 5) The center of ORI test system is not precision mechanical stages but advanced imaging systems and test software. When the user connects tested optical objective to target generator block then without changes of mechanical configuration the user can carry out measurement of all important parameters of optical objectives: MTF (on axis, off axis), effective focal length, distortion, vignetting, and transmission. The measurement range can be optionally extended to other parameters like back focal length, and different types of aberrations.

Ad 6) Inframet offers a series of off axis reflective collimators built using our extended know how in design of these image projectors. These collimators combined with electronic imagers and test software enables capturing images generated by even near perfect objectives (diffraction limited) and increase accuracy of resolution/MTF measurement. Below is presented an image of USAF 1951 targets generated by a diffraction limited visible/NIR objective. This image show that objective resolution equals resolution of measured resolution at least is equal to 406 lp/mm in situation when best other test system available on market claim objective resolution as equal to 256 lp/mm.

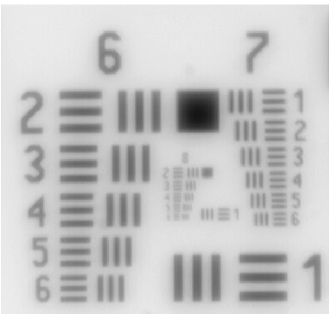

Fig. 4. Image of USAF 1951 target obtained during a test of hi-res optical objective (visible 3-bar patterns of spatial frequency over 500 lp/mm)

Ad 7) ORI test system is a modular system can be easily configured to testing all types optical modules used in imaging systems: optics for VIS/NIR cameras, optics for optical sights, optics for night vision devices, optics for thermal imagers, optics for SWIR imagers, optics for UV imagers etc.

To summarize, there are on world market test stations for testing optical modules offered by several manufacturers. However, due to earlier mentioned design features of ORI test systems Inframet claims that ORI station is the best choice for both scientific institutes and manufacturers of optical objectives. High performance of ORI test station is confirmed by a long series of manufactures of optical objectives/oculars who use this station and are satisfied.

CONTACT:

Tel: +48 226668780 Fax: +48 22 3987244 Email: info@inframet.com

Version 3.5 dated 15.01.2017