LTIR

System for testing and boresight thermal infrared lasers

Fig. 1.Photo of the LTIR boresight system

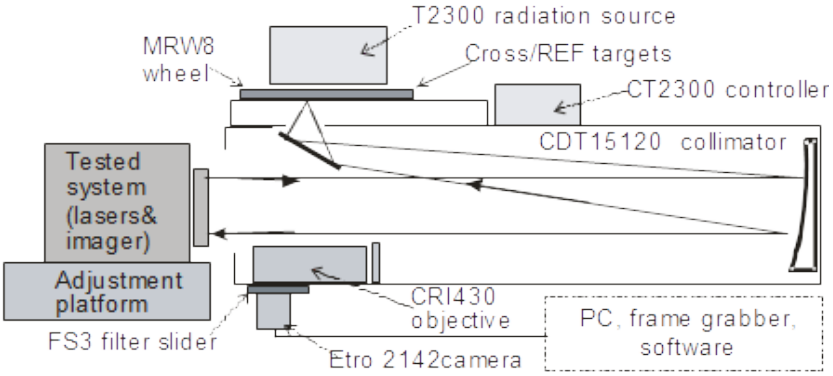

Fig. 2. Block diagram of the LTIR boresight system

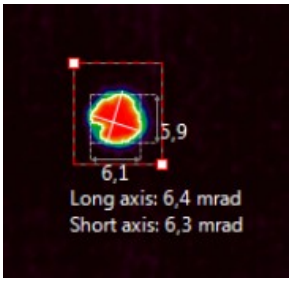

Fig. 3. Spatial intensity profile of laser beam at optical infinity

BASIC INFORMATION:

Infrared lasers operating in long wavelength spectral range (thermal infrared) from about 2 µm to 15 µm have found a series of both civilian and military applications. These lasers are longwave SWIR lasers operating at wavelengths over 2µm, MWIR lasers - 3-6µm, and LWIR lasers - 6-15µm. Such lasers are used in atmospheric pollution detection systems, laser radars (LIDARs), remote systems to detect explosives, in chemical warfare agents, or in directional infrared countermeasure systems (DIRCM). In all these applications the lasers are typically integrated with an imager (VIS-NIR camera, SWIR camera or thermal imager) used to aim the laser to the target of interest. Therefore proper aligning of optical axis of the lasers with optical axis of the imager is of critical importance. Badly aligned laser means that the laser beam will miss the target.

Light emitted by these lasers is not visible for human eye, night vision devices, VIS-NIR cameras and for typical SWIR cameras. Next, thermal imagers integrated with such IR lasers have often filters that reduce their sensitivity at wavelengths where the lasers operate. In such situation aligning of thermal range lasers with imaging systems cannot be done with help of earlier mentioned imaging systems.

Rough aligning and measurement of divergence angle of thermal range lasers can be done using liquid crystal cards as imaging sensors. These cards change color when irradiated by such lasers. However, this method is inherently non accurate particularly during measurement of divergence angle. Liquid crystal cards are also characterized by low dynamic and are not useful for testing lasers of unknown intensity.

LTIR is a professional system for boresight of long wavelength range (2µ to 15µm) infrared lasers to optical axis of an imaging system (VIS-NIR camera, SWIR camera or thermal imager) used as an aiming device. This boresight system enables also ultra accurate measurement of divergence angle of tested lasers. Temporal and spatial stability of emitted laser beams can be determined, too.

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DESIGN CONCEPT

LTIR is based on a idea to use three main blocks:

1. a broadband reflective off axis collimator (CDT15120 collimator) that creates at its focal plane laser spot and later projects image of this spot,
2. a broadband radiation source (T2300 source) capable to irradiate reference alignment target radiation in ultra wide VIS-LWIR spectral band that could be seen by all potential aiming imagers (thermal imager, VIS-NIR camera or SWIR camera),
3. a special broadband thermal camera (Etro214 camera integrated with CRI objective) located inside the reflective collimator sensitive in range from 2µm to 14µm of ultra high dynamic capable to withstand laser radiation.

to built a system capable to:

1. generate aiming target seen by imager combined with tested laser
2. generate live image of image of spatial profile of beam of tested laser at optical infinity
3. calculate 2D spatial profile of laser beam at optical infinity.

In detail LTIR is built from following blocks: CDT15120 collimator, T2300 radiation source, CT2300 controller, MRW-8 motorized rotary wheel, set of targets, Etro 2142 broadband camera, FS3 filter slider, CRI430 objective, frame grabber, PC set, LTIR Control program, BOL program.

TESTED SYSTEMS

LTIR enables following tasks:

1. Optimal focusing of thermal range lasers (focus when divergence angle is minimal)
2. Measurement of 2D spatial profile of laser beam at optical infinity and calculation of divergence angle of the lasers (different definitions of divergence angle can be used)
3. Aligning of several thermal range lasers (situation when all laser beams are parallel)
4. Aligning of thermal range laser with an aiming imager (thermal imager, VIS-NIR camera, SWIR camera) – situation when laser beam is parallel to optical axis of the aiming imaging system
5. Measurement of temporal stability of beam of tested laser
6. Focusing and measurement of resolution, MTF, and relative sensitivity of the aiming imagers cooperating with tested thermal range laser (thermal imager, SWIR camera or VIS-NIR camera).

Any multi sensor system (thermal range lasers and imager) can be testing if aperture of LTIR collimator in form of approximately half of 150mm circle at least partially (30% minimum) overlaps the the sensors in tested system).

Beam quality parameter M^2

M^2 or Beam Propagation Ratio, is a value that indicates how close a laser is to being a single mode TEM00 beam, which in turn determines how small a beam waist can be focused. For the perfect Gaussian TEM00 condition the M^2 equals 1. M^2 cannot be determined from a single beam profile measurement.

The ISO/DIS 11146 standard requires that M^2 be calculated from a series of profile measurements at different distances. LTIR does not enable direct measurement of M^2 parameter because it makes possible only to measure laser beam profile at a single distance: optical infinity. It means that LTIR cannot measure M^2 and cannot deliver information to compare tested divergent laser to a perfect laser. However, LTIR delivers precision information about laser beam intensity at optical infinity – the intended distance of targeted long range thermal lasers. Therefore, information delivered by LTIR is fully satisfactory for final testing and boresight long range lasers to be used in atmospheric pollution detection systems, laser radars (LIDARs), remote systems to detect explosives, in chemical warfare agents, or in directional infrared countermeasure systems (DIRCM). M^2 parameter is not needed to evaluate final performance of long range lasers to be used in earlier mentioned applications.

Next, big advantage of LTIR is that it can test virtually all long range thermal range lasers offered on market. Design of LTIR could be modified to enable measurement of M^2 but this universality should be sacrificed. These are reasons why M^2 parameter is not on list of parameters measured by LTIR system.

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SPECIFICATIONS

No	Parameter/feature	Value
	Parameters of tested lasers	
1	Overall aperture	Optics of both lasers and thermal imager should be at least partially be within a semimoon of diameter 150mm
2	Max beam diameter	100 mm
3	Types	Both DC and pulsed
4	Wavelengths	Any wavelength in spectral band 2 µm to 14µm
5	Max divergence angle	20 mrad
6	Min divergence angle	0.2 mrad
	Resolution of measurement of divergence angle	0.07 mrad
7	*DC lasers*	
8	Max acceptable power of beam	100 W
9	Max acceptable ratio of laser mean power and divergence angle	10 W/mrad
10	Minimal acceptable ratio of laser mean power and divergence angle	10 mW/mrad
	Pulsed lasers	
11	Max acceptable pulse energy	2 mJ
12	Max acceptable ratio of pulse energy and divergence angle	200 uJ/mrad
13	Max acceptable ratio of laser mean power and divergence angle	10 W/mrad
14	Minimal acceptable ratio of laser mean power and divergence angle	10 mW/mrad
15	PRF range	From DC to 100 kHz
	Parameters of aiming imager	
16	Maximal NETD of aiming imager	100mK
17	Maximal sensitivity of aiming VIS-NIR camera	50 lx
18	Maximal sensitivity of aiming SWIR camera	10 mW/m^2
	Other parameters	
19	Work temperature	+5C to 35C
20	Storage temperature	-5C to 45C
21	Humidity	Up to 85% (non condensing)
22	Dimensions	About 200x250x1350 mm
23	Mass	About 35 kg

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VERSIONS

LTIR system can be delivered in form of slightly different versions. There are three main criterion:

1. Wavelengths of lasers to be tested (SWIR and MWIR lasers – code A1; SWIR, MWIR, LWIR lasers – code A2).
2. Test range of the lasers (standard – code B1; expanded = code B2),
3. Test range of the imagers (basic - code C1, expanded – code C2)

Standard test range of the lasers means all test capabilities mentioned in previous section except measurement of temporal and spatial stability of emitted laser beams. In case of expanded range software enables automatic analysis of dependence of beam of tested laser on time.

Typical test range of the imager means measurement of resolution of aiming imagers. Expanded – means measurement of resolution, MTF, relative sensitivity.

LTIR A1B2C1 means a system capable to do boresight and expanded tests of SWIR/MWIR lasers, and basic tests of aiming imagers (thermal imager, SWIR camera or VIS-NIR camera).

LTIR A2B2C2 means a system capable to do boresight and expanded tests of all types of thermal range lasers (SWIR/MWIR/LWIR lasers) and expanded tests of aiming imagers (thermal imager, SWIR camera or VIS-NIR camera).

Version: 3.1

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