L64

System for testing directional pulsed laser receivers

Fig. 1.Photo of the L64 test system

1 Basic information

Directional pulsed laser receivers have found a series of applications: laser seekers, LIDARs, optical communication systems, laser trackers, and laser range finders. Task of these directional receivers is to detect a target irradiated by a pulse laser. These directional receivers are typically built as a set of blocks: high sensitivity discrete detector (quadrant photodiode in case of laser seekers), optical objective, signal processing electronics and a mechanical case. Sometimes the receivers cooperates with aiming device or laser transmitter but sometimes like in case of laser seekers it is an independent device.
It is basically a general purpose test system that can be used by both civilian (testing LRFs, laser trackers, lidars) and military users (laser seekers). Therefore this data sheet is universal and some features useful for customers from first group are not useful for customers from the second group or inverse

2 How L64 works?

L64 system is a laser spot projector that simulate a target irradiated by pulsed laser radiation of variable radiometric, temporal and spatial properties:

1. radiometric parameters: peak irradiance at plane of optics of tested receiver (peak radiant intensity at target plane),
2. temporal properties: pulse width, pulse repetition frequency,
3. spatial parameters: target angular size, target angular position.

Regulation of peak irradiance is carried out by fusion of electronic regulation of peak power of laser source, motorized step attenuators and variable size of the target.
Regulation of temporal properties is done by direct electronic regulation of laser source,
Regulation of target angular size is done using motorized mechanical targets that precisely define area seen by optical objective.
Regulation of target angular position is done is achieved by placing L64 system on a rotation stage.
Due to wide range of regulation of both radiometric, temporal and spatial parameters L64 system can be used so simulate virtually all scenarios of work of real directional laser receivers.

L64 test system is typically offered to test laser receivers working at 1064nm wavelength. However, it can be optionally offered in versions optimized to test laser receivers working at 1550nm, 1530nm, 1570nm, 910nm, 980nm, 530nm or at other wavelengths.

3 Comparison to LAR64 system

L64 system offers similar test capabilities like a recently developed system coded LAR64. However, there are three main differences: 1)LAR64 is built using a small refractive collimator when L64 uses a bigger reflective collimator, 2)LAR64 simulated spatially dynamic target by rotating itself as it is located on an angular stage when collimator of

L64 system is stationary but tested receiver is located at angular stage, 3) LAR64 system is much smaller than L64 system.

4 Design concept

L64 test system is built from a set of modules: LS64 pulse generator, OML64 optical module, CDT10100 reflective collimator, MAEP platform, L64 control program, laptop.

LS64 light source is the main module of L64 test system. This source enables generation of optical pulses of regulated radiant exitance at collimators output and pulse repetition frequency in response to internal or external electrical/optical synchronization signal.The emitted optical pulses are transmitted through OML64 optical module which is responsible for homogeneity of radiant exitance at collimators output and regulation of apparent size of laser source.. Finally, spot of pulsed light source is projected in direction of a tested laser receiver by CDT off axis reflective collimator. Regulation of spatial angular position of simulated laser source can be achieved by putting tested laser receiver on MAEP motorized azimuth-elevation platform that enable regulation of angular position of tested laser receiver.

L64 generate also image of pulsed laser spot in both visible/near infrared and far infrared spectral range.

5 Emission modes

Typical L64 system can generate pulse images of laser light source working in PRF (pulse repetition frequency) mode. In this mode the station emits light pulses of constant frequency. It should be noted that the emission frequency can be regulated in wide range by user of L64 system but when the station start emission of laser pulses then the frequency is constant.

The system can work using three synchronization modes:

1. internal electrical trigger (free run)- pulses are emitted after start button is pressed and emission is until stop button is pressed,
2. external electrical trigger emission series of pulses or a single pulse,
3. external optical signal trigger emission series of pulses or a single pulse.

The station offers very high accuracy of regulation of both pulse repetition frequency because this feature is crucial in most applications of directional laser receivers.

6 Test capabilities

L64 system is basically an imitator of a laser pulsed light source of regulated temporal-spatial properties. L64 system does not analyze output signal generated by the tested directional laser receiver. Therefore the user is expected to do such analysis by himself. The analysis of reactions of tested directional laser receiver to a series of pulsed images projected by L64 station enables to do following tests:

1. Measurement of receiver sensitivity (checking what is minimal output irrandiance at L64 exit that is still detectable by tested laser receiver,
2. Basic performance tests: reactions of laser receiver to a simulated laser source of manually regulated properties: pulse power, temporal properties (PRF, pulse time width), angular size, and angular position,
3. Advanced performance tests: reactions of laser receiver to a simulated laser source of automatically regulated source properties (pulse power, temporal properties (PRF, pulse time width), angular size, and angular position) according to preset scenario. In this case the station can realistically simulate laser spot located at variable distance (shorter distance – stronger peak pulse power and bigger angular size).

7 Boresight capabilities

Directional laser receivers differ in design. All Lidars and some LRFs are equipped with external imaging aiming device (visible camera, thermal camera) when laser seekers and some LRFs are used as independent devices without imaging aiming tools. There are significant consequences of this difference.

Laser receivers from the first group have a two optical axis:

1. optical axis of laser receiver (axis that passes through center of detector and center of optical objective)
2. line of sight of the aiming device like VIS camera or thermal imager,

The aim of boresight tests of such laser receiver is to measure angle between these two axis and later to reduce this angle to zero (or other required angle).

Laser receivers from the second group have also two axis:

1. optical axis of laser receiver (axis that passes through center of detector and center of optical objective)
2. reference mechanical axis of the receiver.

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The reference mechanical axis is a symmetry axis of receiver mounted inside cylindrical mechanical cases, or is axis parallel to a reference mechanical rail where receiver is to be mounted, or it can be an axis perpendicular to a reference mechanical plane on front wall of receiver case.
The aim of boresight tests of such non imaging laser receivers is to measure angle between optical and mechanical axis and later to reduce this angle almost to zero.

L64 enables boresight tests of both groups of laser receivers.
In order to enable boresight tests of imaging laser receivers LAR project not only image of pulsed laser spot at 1060nm band but also projects a static image of this target at visible band. Therefore it is possible to check if line of sight of the aiming device indicates center of visible laser target for angular position when receiver get maximal signal or quadrant photodiode of tested receiver indicates that the target is at receiver center of FOV.

If non imaging laser receivers are to be tested then Inframet delivers special visible camera having a mechanical axis identical as its optical axis. This special camera is used to check if mechanical axis of tested receiver agree with its optical axis using four step procedure:

1. Tested receiver is fixed to its typical mechanical mount that if fixed to MAEPI platform.
2. Angular position of tested receiver is regulated to achieve maximal signal from the discrete detector or situation when quadrant photodiode of tested receiver indicates target at receiver center of FOV,
3. The tested receiver is replaced by reference camera. The reference boresight camera is fixed in the same position as the receiver.
4. If optical axis of the receiver is parallel to its mechanical axis then the aiming mark of the reference camera indicates center of simulated target seen at visible band. .

Attention: Reference boresight camera for boresight to a reference mechanical axis is an optional block. It can be delivered only when customers delivers mechanical drawing of tested receivers.

8 Technical specifications

L64 station can be delivered in form of a series of versions of different design and different test capabilities. Below are presented technical specifications of most advanced version.

Table 1. Technical specifications of most advanced version of L64 test system

Parameter	Value
Tested receiver	
Application	Laser seekers, LIDARs, LRFs, trackers, optical communication systems
Optical aperture	< 100 mm (practically <90mm)
Wavelength	1064nm (other wavelengths optional)
Design	1. large quadrant detector with an imaging optics 2. single detector with an imaging optics
Max weight of tested receiver	No limit as it is to be put on table to be delivered by customer
Basic parameters	
Collimator type	reflective
Collimator aperture	100 mm (150mm - option)
Collimator resolution	> 100 lp/mrad
Power uniformity at collimator output[1]	≤10% (measured using 40mm aperture)
Center wavelength of emitted radiation	1064±5 nm
Width of spectral band	≤12 nm
Pulse emission modes	
Emission modes	1. Preset pulse repetition frequency (PRF) 2. Preset pulse interval modulation algorithm (PIM) -

1 Measured at central 60mm diameter using 25mm aperture

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	option
Pulse Repetition Frequency range in internal synchronisation mode	1Hz – 20 kHz
Pulse Repetition Frequency range in external synchronisation mode	0.1 to 20 kHz
PRF stability	Period regulation raster = 1 µsec. Maximal error: 0.0001% for frequencies where ratio of period to raster is a natural number (virtually all applications) 0.00001% times frequency in Hz for other frequencies
Synchronization/triggering	
Synchronization modes	1) internal electrical trigger(free run) 2) external electrical trigger (start series of pulses or pulse to pulse operation), 3)external optical signal
Synchronization output	Yes. TTL standard
Input trigger voltage range	2.4V to 4.1V
Pulse intensity properties	
Regulation type	Manual or automatic according to pre-programmed temporal trajectory (simulation of variable distance)
Radiant Exitance [W/cm^2] at collimator output (for max target size)	50nW/cm^2 to 20 mW/cm^2
Dynamic of regulation or radiant exitance	At least 400 000:1
Peak to peak non stability (peak power)	<2%
Resolution of regulation of radiant exitance	Not worse 1%
Temporal properties of laser pulse	
Range of regulation of pulse time width	20-500ns; continuous regulation
Resolution of pulse time width regulation	1 ns
Temporal delay of laser pulse relative to synchronization pulse	0.1-650µs
Simulated laser source	
Target shape	Rhomboid (option circle)
Target size range	0.2-15mrad (continuous regulation)
Method of regulation of target size	Continuous PC control
Angular position of simulated laser source	
Angular position of pulsed laser source	Dynamic. PC control. Tested receiver on MAEP platform
Angular range	Azimuth up to 50º Elevation up to 6º
Speed of regulation of angular position	Azimuth – 1.5º/s Elevation – 0.5º/s
Resolution of angular position	0.05º
Target movement trajectory	Pre-programing up to 10 angular positions

Image projection	
Number of modes	Two: 1)pulsed image at 1060nm band, 2)static image
Spectral bands of static image	Two: 1)visible band, 2)thermal band
Other parameters	
PC communication port	USB 2.0
Power supply	AC230V
Working temperature	+5ºC to +35ºC
Storage temperature	-5ºC to +55ºC
Mass	Below 12 kg (rotation stage not included)
Dimensions	Below 500x280x190mm (rotation stage not included)

9 Versions

L64 station can be delivered in form of a series of versions of different design and different test capabilities. The specs presented in Table 1 refer to most advanced typical version (work at PRF mode) coded as L64 XD version. The station can be optionally delivered in several versions of different test capabilities:

1. L64 XD - most advanced version capable to work in typical PRF mode. Technical details in Section 8 . This is recommended version for expanded testing typical directional laser receivers working in PRF mode.
2. L64 XC – most features as in L64 XD but there is no automatic continuous regulation of laser source properties (pulse peak power, PRF, target angular size, target angular position) with time according to pre-programmed temporal trajectory (simulation of variable distance scenario). Manual regulations using control software of all source properties are still possible.
3. L64 XB – as in L64 XC but the station simulates only spatially static pulses light source (no regulation of source angular position).
4. L64 XA – as in L64 XB but additionally but maximal radiant exitance at collimator output is limited to 0.4 mW/cm^2. This is low cost version recommended for basic checks (sensitivity) of directional laser receivers.

Parameter	Version of the test system			
	XA	XB	XC	XD
Software regulation of laser source properties at pre-programmed temporal trajectory	No	No	No	Yes
Regulation of angular position of laser source	No	No	Yes	Yes
Maximal radiant exitance	0.2 mW/cm^2	1 mW/cm^2	5 mW/cm^2	20 mW/cm^2

10 Options

Most of directional laser receivers work in PRF (pulse repetition frequency) mode. However, some of such receivers can work in PIM (pulse interval modulation) mode. Therefore Inframet offers optional L64 stations capable to work in PIM (pulse interval modulation) mode, too. There are myriads of possible PIM codes that can be used in different applications. Therefore customer is expected to inform Inframet on number and details of required codes. Later two options are possible:

1. Customer requires a fixed number of predefined codes (number of codes not higher than 20). Inframet delivers software where user can choose the code to be used to emit optical pulses.
2. Inframet delivers software tool that enable user to define great number of PIM codes. User is expected to inform Inframet about mathematical formulas used to created PIM code and limits on regulation parameters.

Therefore there are two optional versions capable to work in PIM mode:

Y1 – Inframet delivers software where user can choose the code to be used to emit optical pulses (number of codes not higher than 20).

Y2 – Inframet delivers software tool that enable user to define great number of PIM codes. User is expected to inform Inframet about mathematical formulas used to created PIM code and limits on regulation parameters.

Please add code of option to main code. Example: L64 XD-Y2 means L64 XD station with option Y2.

11 Summary

L64 test station is extremely powerful station for testing directional laser receivers operating at 1064nm spectral band (or other wavelengths). It enables expanded testing at laboratory conditions and gathering information about performance of tested receiver typically possible to obtain only after long and costly field tests.

Main features:

1. L64 offers wide regulation of PRF almost from 1 Hz up to 20 kHz when typical test stations have problems to emit pulses of PRF over 10kHz and below 10 Hz.
2. L64 stations generate pulses of peak power that can be regulated in a very wide range. Typical dynamic of regulation is at least 400 000 times. Maximal radiant exitance at collimator output can be as high as 20 mW/cm^2. This high dynamic of regulation coupled with high maximal power enables realistic simulation of real scenarios when distance from the receiver to irradiated target vary from dozen of kilometers to hundreds of meters. It should be noted that dynamic of regulation of power of simulated source offered by competitors systems it typically not more than 500 times and these systems cannot simulate high irradiance targets.
3. Ultra high PRF stability. L64 enables regulation of pulse period with 1 µs regulation resolution. Very low maximal error of frequency regulation is achieved: 0.0001% for frequencies where ratio of period of emitted pulses to regulation resolution (raster) is equal to a natural number (virtually all applications), or 0.00001% times frequency in Hz for other frequencies. This ultra low tolerance is important because it enables to carry out long time tests without loosing synchronization between receiver and external transmitter.
4. Ultra precision regulation of pulse width with 1 ns resolution. Typical stations enable regulation of pulse time width with resolution not better than 5 ns.
5. Ability to carry out precision boresight of receiver optical axis to a reference optical axis (axis of aiming device if used) or to a reference mechanical axis/plane of the receiver.
6. Advanced software that make possible to test reactions of laser receiver to a simulated laser source of automatically regulated source properties (pulse power, temporal properties (PRF, pulse time width), angular size, and angular position) according to preset temporal scenario. In this case the station can realistically simulate scenario when distance source-receiver changes with time (shorter distance – stronger peak pulse power and bigger angular size).
7. Optional ability to work in PIM mode. Inframet delivers software tool that enables user to define a great number of PIM codes, too.

These seven features not met in typical test stations are extremely important for many applications of directional pulse laser receivers because they enable realistic simulation of complex field scenarios at laboratory conditions.

To summarize, L64 station represent a new generation of test station for testing laser receivers. Its performance significantly exceeds performance of other commercial test stations available on market.

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