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Laser Speckle Reducer LSR-3000 Series

Speckle noise from a laser-based system is reduced by dynamically diffusing the laser beam. A diffuser is bonded to a thin elastic membrane, which includes four independent electo-active polymer electrodes that induce a circular oscillation of the diffuser in x- and y-direction. The LSR-3000 Series integrates fully certified drive electronics powered through a single micro-USB connector. Two sizes are available: the LSR-3005 and the LSR-3010 exhibiting a clear aperture of 5 mm and 10 mm, respectively. The following table outlines the specifications of Optotune's LSR-3000 Series. The diffusion angle can be adapted on demand.

Mechanical specifications

	LSR-3005	LSR-3010	
Clear aperture	5	10	mm
Outer diameter	41	48	mm
Thickness	8.8	8.8	mm
Weight	24.43	32.84	g

Electrical specifications[1]

Power supply (micro-USB interface)	5	5	VDC
Power consumption	310	310	mW

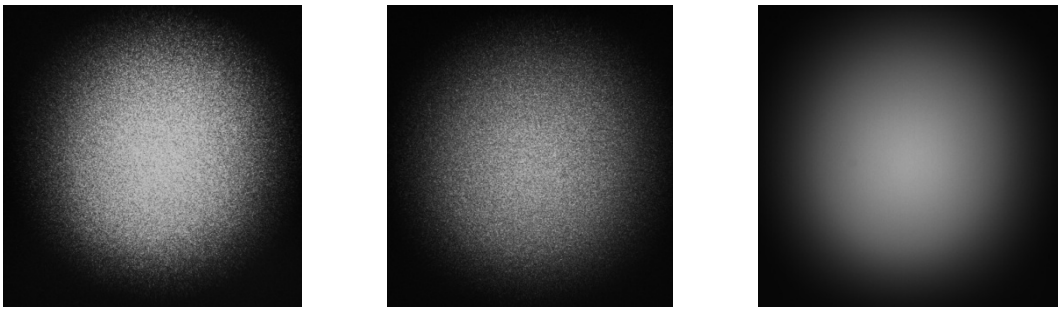
Optical specifications

Diffusion angle (FWHM)	6°/12°/17°/24°	6°/12°/17°/24°	
Transmission spectrum[2]	see figures 2&3	see figures 2&3	
Damage threshold	>300	>300	W/cm^2
Oscillation frequency	~300	~180	Hz
Oscillation amplitude (peak to peak)	~300	~400	µm

Thermal specifications

Storage temperature	[-40,+85]	[-40,+85]	°C
Operating temperature	[-30,+85]	[-30,+85]	°C

Figure 1 (a-c) show the effect of the LSR-3005 on a laser spot (λ = 650 nm, P = 5 mW).



(a) without LSR (b) with LSR OFF (c) with LSR ON

Figure 1: CCD images of a laser spot without and with LSR-3005 on.

[1] 100-230 VAC to 5 VDC micro-USB power supply provided by Optotune

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The following two figures show the transmission spectrum of the LSR-3000 series with polymer diffusers and coated BK7 cover glasses. The LSR-3000-xx**D** series include both a static and an oscillating diffuser for increased speckle reduction efficiency. Only an oscillating diffuser and no static diffuser are present in the LSR-3000-xx**S** series.

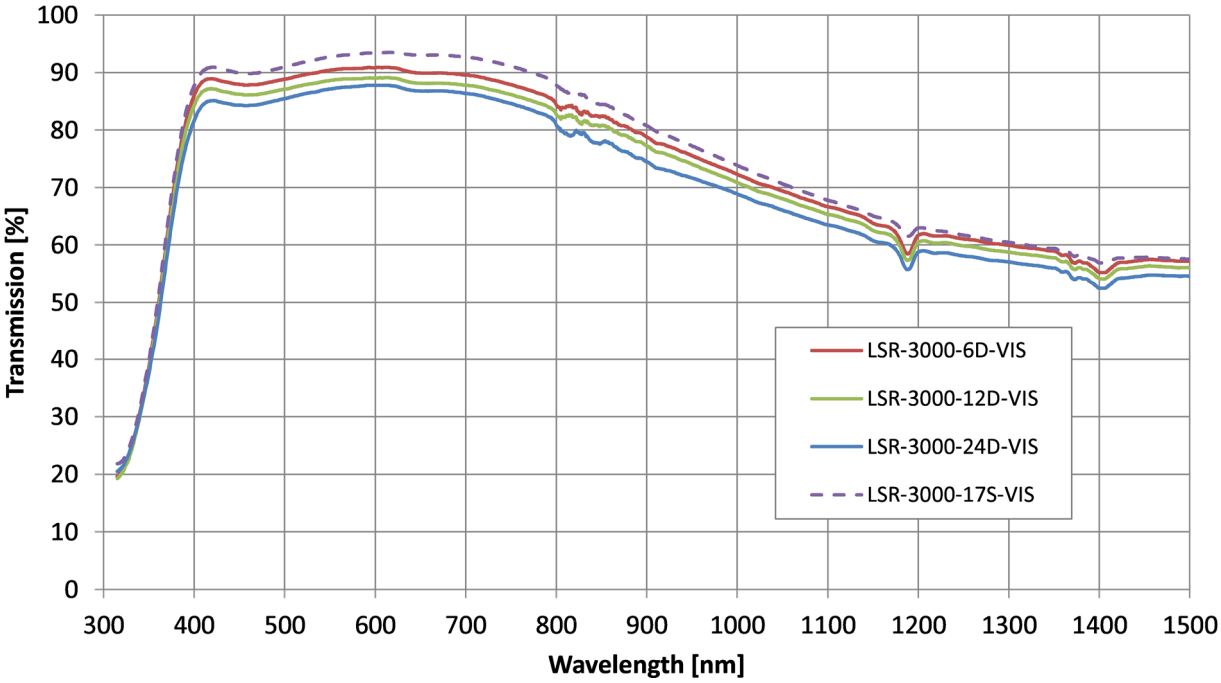

Figure 2: Transmission spectrum of the LSR-3000 series with VIS-coated cover glasses (0° angle of incidence)

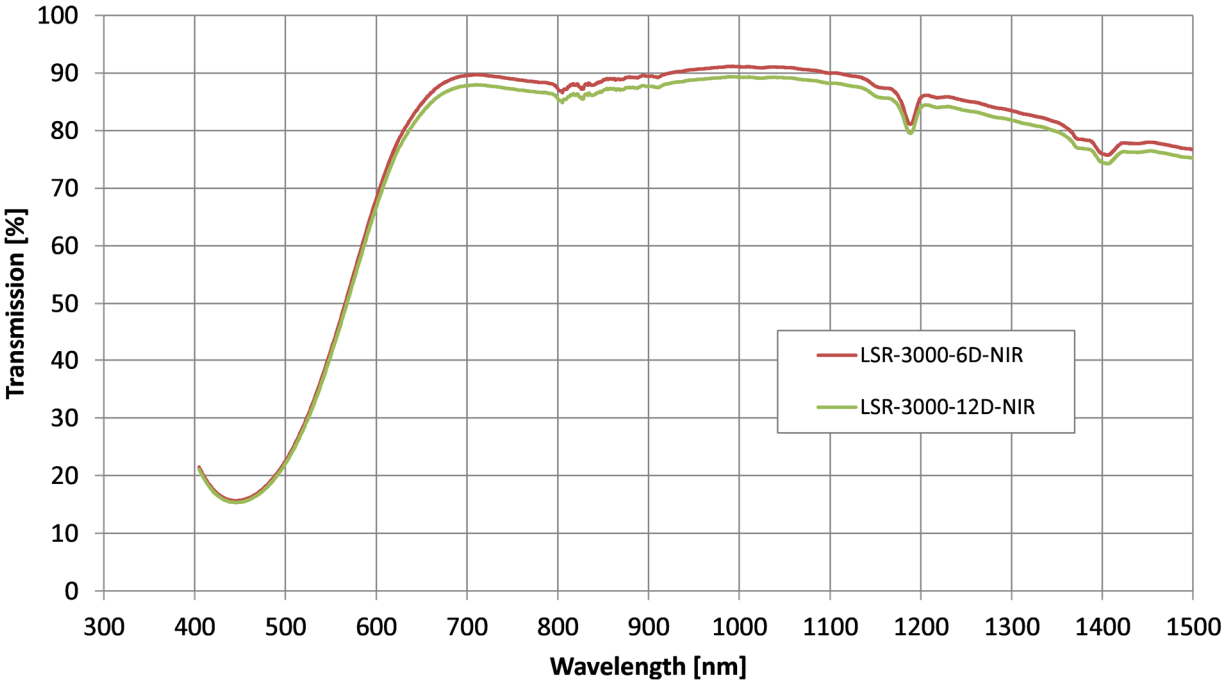

Figure 3: Transmission spectrum of the LSR-3000 series with NIR-coated cover glasses (0° angle of incidence)

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Figure 4 and Figure 5 show the dimensions of the LSR-3005 and the LSR-3010, respectively. The housing exhibits a M4 thread, in order to facilitate the integration of the LSR on an optical table. The power supply interface is made through a micro-USB connector. The LSR-3000 series is also available without housing (see datasheet of LSR-OEM).

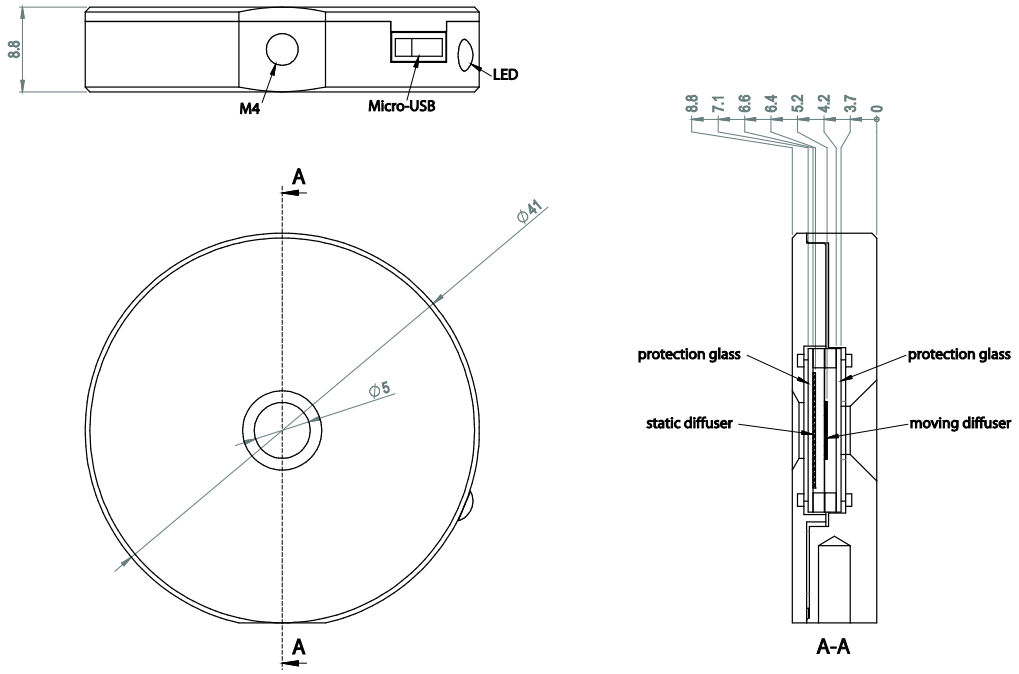

Figure 4: Mechanical drawing of the LSR-3005 (unit: mm)

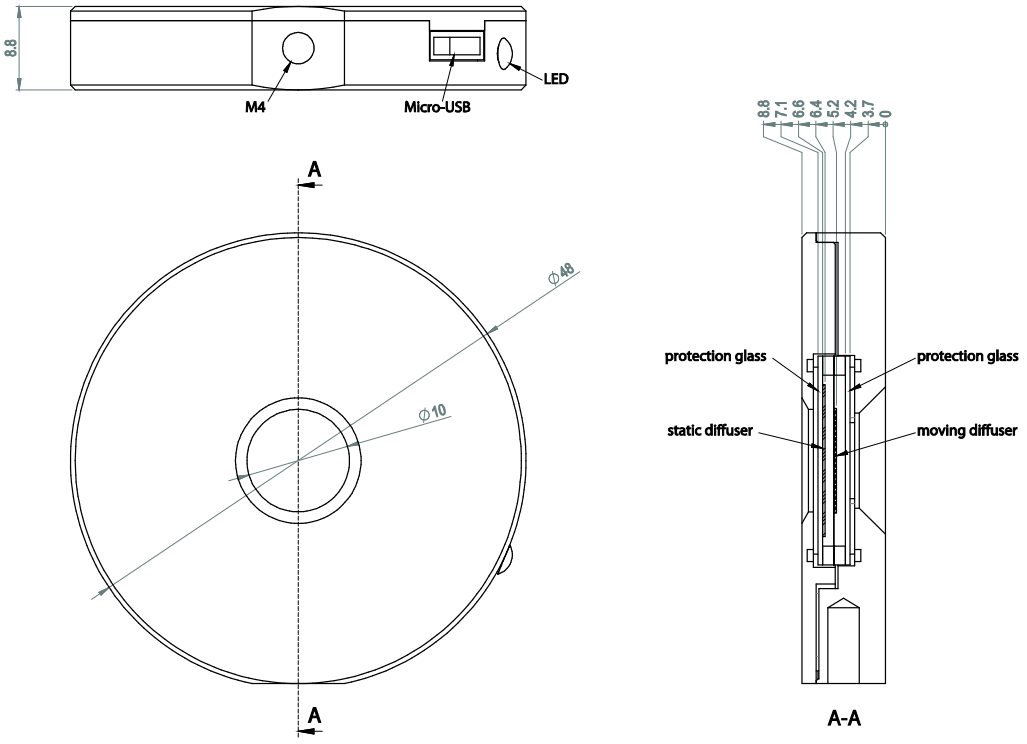

Figure 5: Mechanical drawing of the LSR-3010 (unit: mm)

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Life time

The LSR has passed the following accelerated aging tests. The tests were performed on 5-10 samples each and are considered as passed if the oscillation amplitude of all samples did not change more than 5%.

Test	LSR-3005
A1 – High temperature (operating): • Test temperature: 85°C ±5°C • Test duration: 48 hours • Reference: JESD22-A108-B, JESD47-A and JESD74	Passed
A2 – Low temperature (operating): • Test temperature: -30°C ±5°C • Test duration: 48 hours • Reference: JESD22-A108-B, JESD47-A	Passed
A3.1 – Temperature cycling (non-operating): • Low temperature: –40°C, high temperature: +85°C • Transition time: <3 minutes • Test duration: 30 min for each under low and high temperature • Number of cycles: 100 cycles • Recovery time: 2 hours • References: IEC 60068-2-1, IEC 60068-2-2 and IEC 60068-2-14	Passed
A3.2 – Damp heat cycling (non-operating): • Low temperature: 25°C, high temperature: +55°C • Test humidity: 90-100% relative humidity • Test duration: 12 hours dwell • Temperature change rate: Less than 1°C per minute • Number of cycles: 18 cycles • Recovery time: No recovery time • References: IEC 60068-2-30 Db Variant 1	Passed
A4 – High temperature (non-operating): • Test temperature: Static 85°C ±2°C • Test humidity: Less than 20 g/m^3 of water vapor (corresponding to approximately 50% relative humidity at 35°C) • Test duration: 168 hours • Temperature change rate: Less than 1°C per minute • Reference: IEC 60068-2-2 Bb	Passed
Operating lifetime test: • Test temperature: 22 ±2°C • Test duration: 6000 hours • Driving frequency: 300 Hz	Passed
Shock test: • 400 g for 1 ms duration • 5 pulses in each direction (30 pulses in total)	Passed

Table 1: Environmental and accelerated aging tests performed on the LSR Series

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Ordering information for standard products

The LSR-3000 can be delivered with two sizes of clear aperture, different diffusing angles (circular) and two types of cover glasses. When ordering, please refer to these specifications as follows:

LSR-30CA-θN-AR

CA = Clear aperture (05 or 10 mm)
θ = Total diffusion angle (6°, 12°, 17°, 24° available as standard)
N = Diffuser configuration, whereas D = double (one oscillating, one static), S = single (one oscillating only)
AR = Antireflection coating (VIS or NIR)

Example: LSR-3005-12D-VIS refers to a speckle reducer of 5-mm aperture with a total diffusion angle of 12°, with both an oscillating and a static diffuser and VIS-coated cover glasses.

Standard models with different diffuser combinations

The standard models combine an oscillating diffuser with a static diffuser to reduce the correlation length of the random patterns that are generated. This provides more effective speckle reduction yet minimizing the increase in beam divergence. Three standard diffuser configurations are available: LSR-3000-xxD series with 6° (FWHM) for highest optical efficiency and 24° for best speckle reduction. For optical systems where the spot on the LSR is imaged e.g. by a 4f-system, no static diffuser is allowed. In that case, the LSR-3000-xxS series with a oscillating diffuser only is recommended.

Standard products	Total diffusion angle	Diffuser configuration	Cover glass coating
LSR-3010-6D-VIS	6°	4.2° oscillating, 4.2° static	400 – 700 nm
LSR-3010-12D-VIS	12°	8.5° oscillating, 8.5° static	400 – 700 nm
LSR-3005-6D-VIS	6°	4.2° oscillating, 4.2° static	400 – 700 nm
LSR-3005-12D-VIS	12°	8.5° oscillating, 8.5° static	400 – 700 nm
LSR-3005-24D-VIS	24°	17° oscillating, 17° static	400 – 700 nm
LSR-3005-17S-VIS	17°	17° oscillating, no static	400 – 700 nm
LSR-3005-6D-NIR	6°	4.2° oscillating, 4.2° static	700 – 1100 nm
LSR-3005-12D-NIR	12°	8.5° oscillating, 8.5° static	700 – 1100 nm

Table 2: Overview of standard LSR-3000 models

Custom products

Optotune offers customized versions of the LSR. This datasheet only contains variations of the LSR-3000 Series products. For LSRs with substantially smaller or larger apertures, please contact sales@optotune.com.

Diffusers

In principle, any type of diffuser can be used as long as size and weight are similar to the standard diffuser. Furthermore, it is possible to use specialty coated glass diffusers if they are light enough. If necessary, it is also possible to remove the membrane from the optical path.

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The following table summarizes these options:

Diffuser type	Optotune polymer	Glass diffusers (typical)
Thickness	330 µm	As thin as possible
Density	1.03 g/cm³	2.2 g/cm³
Weight		
5 mm aperture[2]	9 mg	up to 20 mg
10 mm aperture	30 mg	up to 70 mg
Resonance frequency		
5 mm aperture	300 Hz	$\omega \propto \sqrt{\frac{1}{m}}$
10 mm aperture	180 Hz	
Transmission range	240 – 2500 nm	170 – 12000 nm (depending on material)
Damage threshold	> 300 W/cm²	1 kW/cm² (depending on material)

Please note that diffusers cannot be exchanged after the LSR has been produced. Also, when using customized diffusers it might be necessary to select an appropriate cover glass to match the transmission range.

Cover glasses

Cover glasses can be customized with respect to material and AR-coating. The standard cover glasses are VIS or NIR coated BK7. If the LSR is to be integrated into a clean environment, then the cover glasses can be omitted.

Frequency

The oscillation frequency is set to the measured resonant frequency of the LSR during production. With the current standard electronics it is not possible to change that frequency after production. However, Optotune can provide customized electronics to control both voltage and frequency of the electro-active polymer.

Safety and compliance

The product fulfills the RoHS and REACH compliance standards. The customer is solely responsible to comply with all relevant safety regulations for integration and operation.

For more information on optical, mechanical and electrical parameters, please contact sales@optotune.com.

[2] Note: The 5mm and 10mm aperture LSR is usually equipped with 6mm and 11mm diameter diffuser, respectively.

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