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THORLABS

GCM002 - July 29, 2016

Item # GCM002 was discontinued on July 29, 2016. For informational purposes, this is a copy of the website content at that time and is valid only for the stated product.

SMALL BEAM DIAMETER SCANNING GALVO MIRROR SYSTEMS

- ▶ For Small (<5 mm) Beam Diameters
- ▶ Choice of Mirror Coatings
- ▶ 1D and 2D Kits Available
- ▶ Easy Integration into OEM Systems
- ▶ Analog Control Electronics

GVS001
Galvo Scanning System

GVS102
Dual-Axis Motor/Mirror Assembly with Gold Mirrors

GVS002
Dual-Axis Motor/Mirror Assembly
with GHS003 Post Adapter Heatsink

OVERVIEW

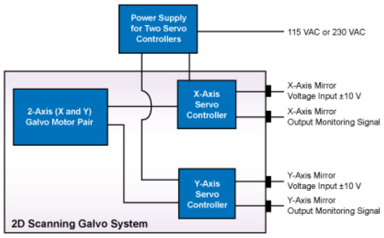
Features

- Single- and Dual-Axis Systems
- Moving Magnet Motor Design for Faster Response
- High-Precision Optical Mirror Position Detection
- Analog PD Control Electronics with Current Damping
  and Error Limiter
- Choice of Mirror Coatings:
  - Protected Silver (GVS001 and GVS002)
    500 nm to 2.0 µm
  - Protected Gold (GVS101 and GVS102)
    800 nm to 20.0 µm
  - Broadband Dielectric E02 (GVS201 and GVS202)
    400 nm to 750 nm
  - High-Power Dual-Band K13 (GVS301 and GVS302)
    532 and 1064 nm
- Custom Coatings (e.g., Aluminum) Available upon Request
  Contact Tech Support for More Details

These high-speed Scanning Galvanometer Mirror Positioning Systems are designed for integration into OEM or custom laser beam steering applications that utilize laser beams smaller than 5 mm in diameter. Each system includes a single- or dual-axis galvo motor and mirror assembly, associated driver card(s), and driver card heatsink(s). A low noise, linear PSU (GPS011) and motor/mirror assembly heatsink (GHS003) are available separately.

Key Specifications[a]	
Max Beam Diameter	5 mm
2-Axis System Beam Offset	10 mm
Wavelength Range (R_{avg} > 95%)	GVS00x (Silver): 500 nm - 2.0 µm GVS10x (Gold): 800 nm - 20.0 µm GVS20x (-E02): 400 nm - 750 nm GVS30x (-K13): 532 nm and 1064 nm
Repeatability	15 µrad
Damage Threshold GVS00x (Silver) GVS10x (Gold) GVS20x (-E02) GVS30x (-K13)	3 J/cm^2 at 1064 nm, 10 ns pulse 2 J/cm^2 at 1064 nm, 10 ns pulse 0.25 J/cm^2 at 532 nm, 10 ns pulse 5 J/cm^2 at 1064 nm, 10 ns pulse
Linearity	99.9%
Max Scan Angle (Mechanical Angle)	±12.5° (w/ 0.8 V/deg scaling)
Resolution (Mechanical)	With GPS011 Linear PSU: 0.0008 ° (15 µrad) With Standard Switch Mode PSU: 0.004° (70 µrad)
Full Scale Bandwidth	DC to 100 Hz Sq wave, DC to 250 Hz Sine wave
Small Angle (±0.2°) Bandwidth	DC to 1 kHz
Small Angle Step Response[b]	300 µs
Optical Position Sensor Output	40 to 80 µA
Power Supply Requirements	±15 to ±18 VDC

- For additional specifications, please see the *Specs* tab.
- Time Delay Between the Signal Source and When the Angular Adjustment of the Mirror Occurs



Galvo Motor/Mirror Assembly

The galvo consists of a galvanometer-based scanning motor with an optical mirror mounted on the shaft and a detector that provides positional feedback to the control board. The moving magnet design for the GVS series of galvanometer motors was chosen over a stationary magnet and rotating coil design in order to provide the fastest response times and the highest system resonant frequency. The position of the mirror is encoded using an optical sensing system located inside of the motor housing.

Due to the large angular acceleration of the rotation shaft, the size, shape and inertia of the mirrors become significant factors in the design of high performance galvo systems. Furthermore, the mirror must remain rigid (flat) even when subjected to large accelerations. All these factors have been precisely balanced in our galvo systems in order to match the characteristics of the galvo motor and maximize performance of the system.

The mirrors are available from stock with silver, gold, broadband or high power dual band coatings. Custom coatings (e.g., aluminum) are available on request. Please contact Tech Support for more details.

Scanning Galvo Mirror Assembly and Driver Board

All Thorlabs scanning galvo mirror systems feature a mounted single or dual axis mirror/motor assembly and driver card(s). Shown to the left is the GVS301 1D galvo mirror and driver card with heatsink. The mirror assembly feature multiple mounting holes and a rotatable collar mount for the mirror/motor. These small 5 mm galvo mirrors feature a plug style connector to the mirror assembly. Please see below for additional mounting options and accessories.

Servo Driver Board (All Systems)

The Proportional Derivative (PD) servo driver circuit interprets the signals from the optical position detecting system inside the motor and then produces the drive voltage required to rotate the mirror to the desired position. The scanner uses a non-integrating, Class 0 servo that is ideal for use in applications that require vector positioning (e.g., laser marking), raster positioning (printing or scanning laser microscopy), and some step-and-hold applications. Furthermore, the proportional derivative controller gives excellent dynamic performance. The circuit includes an additional current term to ensure stability at high accelerations. The same driver board is used in all our galvo systems.

System Operation

The servo driver must be connected to a DC power supply, the galvo motor, and an input voltage source (the monitoring connection is optional). For continuous scanning applications, a function generator with a square or sine wave output is sufficient for scanning the galvo mirror over its entire range. For more complex scanning patterns, a programmable voltage source should be used. The ratio between the input voltage and mirror position is switchable, either 0.5, 0.8 or 1. When set to 0.8, the ±10 V input will rotate the mirror over its full range of ±12.5°. The control circuit also provides monitoring outputs that allow the user to track the position of the mirror. In addition, voltages proportional to the drive current being supplied to the motor and the difference between the command position and the actual position of the mirror are supplied by the control circuit.

Closed-Loop Mirror Positioning

The angular orientation (position) of the mirror is optically encoded using an array of photocells and a light source, both of which are integrated into the interior of the galvanometer housing. Each mirror orientation corresponds to a unique ratio of signals from the photodiodes, which allows for the closed-loop operation of the galvo mirror system.

The systems can be driven to scan their full mechanical range of ±12.5° at a frequency of 100 Hz when using a square wave control input voltage or at 350 Hz when using a sine wave. For a single small-angle step of 0.2°, it takes the mirror 300 μs to come to rest at the command position. The scan frequency range is DC to 1 kHz and the angular resolution is 0.0008° (15 μrad).

SPECS

Galvanometer System Specifications

Item #	GVS001 and GVS002	GVS101 and GVS102	GVS201 and GVS202	GVS301 and GVS302
Mirror				
Maximum Beam Diameter	5 mm			
2-Axis System Beam Offset	10 mm			
Material	Quartz			
Coating	Protected Silver	Protected Gold	Broadband Dielectric (-E02)	Nd:YAG Fundamental and 2nd Harmonic (-K13)
Wavelength Range	500 nm to 2.0 µm	800 nm to 20.0 µm	400 nm to 750 nm	532 nm and 1064 nm
Damage Threshold[a]	3.0 J/cm^2	2.0 J/cm^2	0.25 J/cm^2	5.0 J/cm^2
Parallelism	<3 arcmin			
Surface Quality	40-20 Scratch-Dig			
Front Surface Flatness (@633 nm)	λ/4			
Clear Aperture	>90% of Dimension			
Motor and Position Sensor				

Linearity	99.9%
Scale Drift	40 ppm/°C (Max)
Zero Drift	10 µrad/°C (Max)
Repeatability	15 µrad
Resolution (Mechanical)	With GPS011 Linear PSU: 0.0008° (15 µrad) With Standard Switch Mode PSU: 0.004° (70 µrad)
Average Current	1 A
Peak Current	5 A
Maximum Scan Angle (Mechanical Angle)	±12.5° (Input Scale Factor 0.8 V per degree)
Motor Weight (inc Cables, excl Brackets)	50 g
Operating Temperature Range	0 to 40 °C
Optical Position Sensor Output Range	40 to 80 µA
Drive Electronics	
Full Scale Bandwidth	DC to 100 Hz Square Wave, DC to 250 Hz Sine Wave
Small Angle (±0.2°) Bandwidth	DC to 1 kHz
Small Angle Step Response[b]	300 µs
Power Supply	±15 to ±18 VDC (1.25 A rms, 5 A peak Max)
Analog Signal Input Resistance	20 kΩ ± 1% (Differential Input)
Position Signal Output Resistance	1 kΩ ± 1%
Analog Position Signal Input Range	±10 V
Mechanical Position Signal Input Scale Factor	Switchable: 1.0 V, 0.8 V or 0.5 V per degree
Mechanical Position Signal Output Scale Factor	0.5 V per degree
Operating Temperature Range	0 to 40 °C
Servo Board Size (W x D x H)	85 mm x 74 mm x 44 mm (3.35" x 2.9" x 1.73")

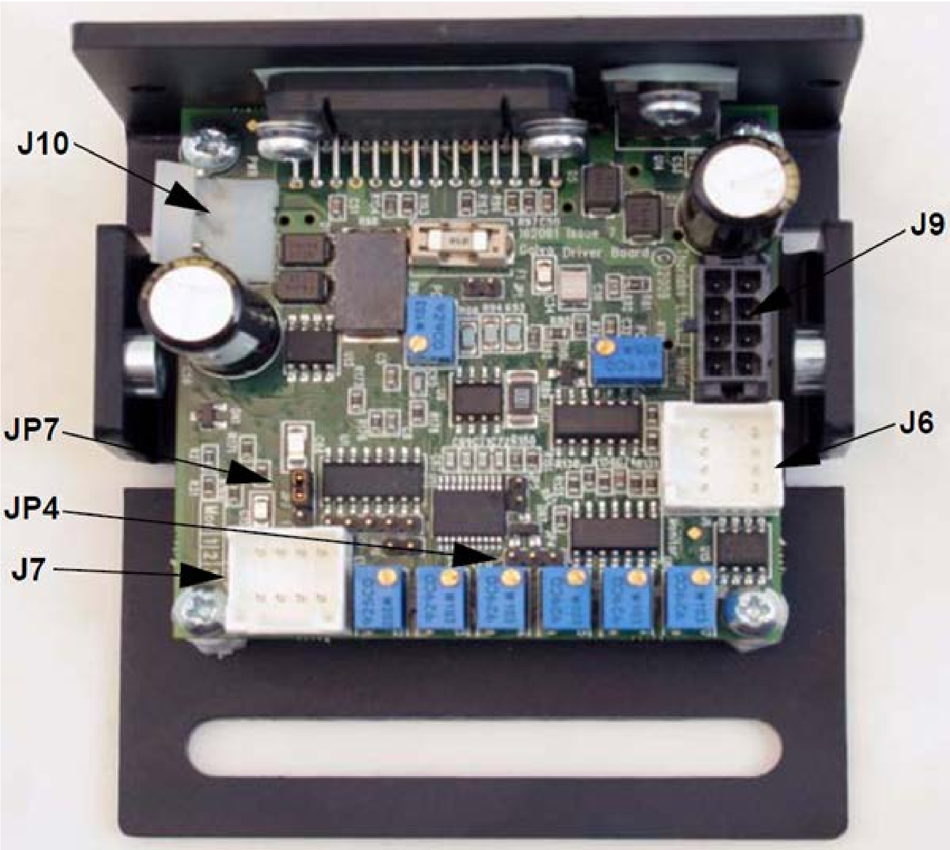
- Measured with pulsed laser at 1064 nm, 10 ns, 10 Hz, and Ø1.000 mm beam diameter.
- Time Delay Between the Signal Source and When the Angular Adjustment of the Mirror Occurs

GPS011 Power Supply Specifications

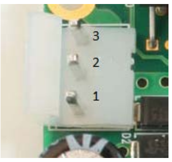
Specification	Value
Input Voltage Range	Switchable: 115 to 120 VAC or 230 to 240 VAC, 47 to 63 Hz
Output Voltage	+15 V 3 A, -15 V 3 A, DC
Fuses	2 A 250 V Anti-surge
Dimensions	179 mm x 274 mm (Max) x 122 mm (7.05" x 10.79" (Max) x 4.8")
Weight	4.73 kg (10.4 lbs)

PIN DIAGRAMS

GVS Series Driver Connections

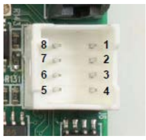


J10 Power Connector



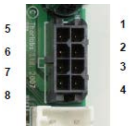
Pin	Designation
1	+ 15 V
2	Ground
3	- 15 V

J6 Diagnostics Connector



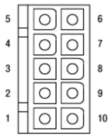
Pin	Designation
1	Scanner Position
2	Internal Command Signal
3	Positioning Error x 5
4	Motor Drive Current
5	Not Connected
6	Test Input (NC)
7	Motor + Coil Voltage / 2
8	Ground

J9 Motor Connector



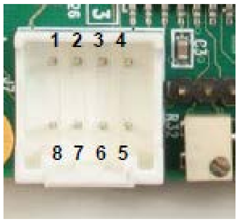
Pin	Designation
1	Position Sensor A Current
2	Position Sensor Ground
3	Position Sensor Cable Shield
4	Drive Cable Shield
5	Position Sensor B Current
6	Position Sensor Power
7	Motor + Coil
8	Motor - Coil

Galvo Assembly Motor Connector GVS001/GVS002 Only

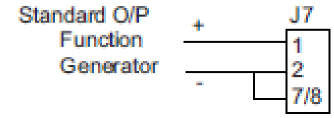


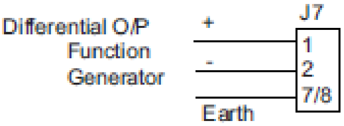
Pin	Designation
1	Motor + Coil (Power Shield Floating)
2	Motor - Coil (Power Shield Floating)
3	Not Used
4	Not Used
5	Position Sensor B Current
6	Position Sensor Ground
7	Position Sensor A Current
8	Position Sensor Power (Automated Gain Control)
9	Position Sensor Cable Shield
10	Not Used

J7 Command Input Connector

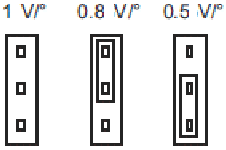


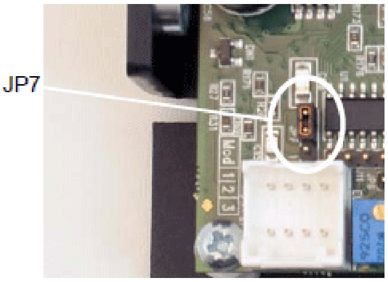
Pin	Designation
1	Command Input +ve
2	Command Input -ve
3	DRV OK
4	External Enable
5	-12 V Output (low impedance O/P)
6	+12 V Output (low impedance O/P)
7	Ground
8	Ground





JP7 Volts/Degree Scaling Factor Control





Servo driver cards manufactured after October 2009 have a jumper which is used to set the Volts per Degree scaling factor. The cards are shipped with the scaling set to 1.0 V/°, where the max scan angle is 10°, and is compatible with driver cards manufactured before October 2009.

To set the maximum scan angle to ±12.5°, set the scaling factor to 0.8 V/° by placing a jumper across the pins as shown above. Similarly, the 0.5 V/° scaling factor is provided to allow the full scan angle to be achieved using small input signals. In this case, the input voltage should be limited to ±6.25 V max.

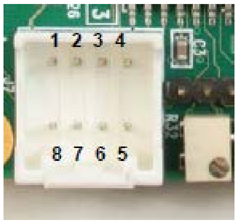
External Enabling of the Driver Board

The drive electronics can be configured for external enabling by placing a jumper across pins 2 and 3 of JP4.

JP4

Once this has been done, the user can enable or disable the drive electronics by applying a 5 V CMOS signal to J7 pin 4.

If a logic high or no signal is applied, the drive electronics will be enabled. If a logic low signal is applied, then the driver will be disabled.

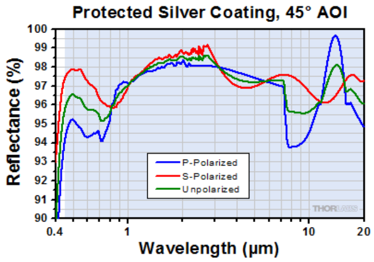


J7

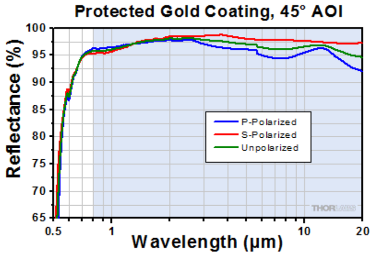
Pin	Designation
1	Command Input +ve
2	Command Input -ve
3	No Connect
4	External Enable
5	-12 V Output
6	+12 V Output
7	Ground
8	Ground

GRAPHS

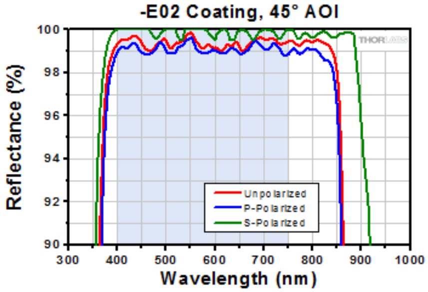
The curves below show the reflection data for the coated mirrors supplied with the GVS series galvo systems. The shaded regions denote the ranges over which we recommend using the respective coating. Please note that the reflectance outside of these bands is not as rigorously monitored in quality control, and can vary from lot to lot, especially in out-of-band regions where the reflectance is fluctuating or sloped.



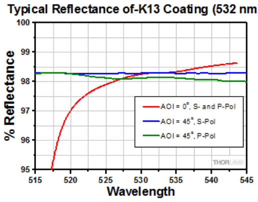
Click to Enlarge
Excel Spreadsheet with Raw Data for Protected Silver



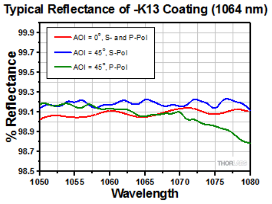
Click to Enlarge
Excel Spreadsheet with Raw Data for Protected Gold



Click to Enlarge
Excel Spreadsheet with Raw Data for -E02 Coating, 8° and 45° AOI



Click to Enlarge
Excel Spreadsheet with Raw Data for 532 nm -K13 Coating



Click to Enlarge
Excel Spreadsheet with Raw Data for 1064 nm -K13 Coating

DAMAGE THRESHOLDS

Damage Threshold Data for Thorlabs' Small Beam Diameter Scanning Galvo Mirror Systems

The specifications to the right are measured data for Thorlabs' small beam diameter scanning galvo mirror systems. Damage threshold specifications are constant for a given item number prefix, regardless of the number of drivers or measuring system.

Damage Threshold Specifications	
Coating Designation (Item # Suffix)	**Damage Threshold**
GVS00-	3 J/cm^2 at 1064 nm, 10 ns
GVS10-	2 J/cm^2 at 1064 nm, 10 ns
GVS20-	0.25 J/cm^2 at 532 nm, 10 ns
GVS30-	5 J/cm^2 at 1064 nm, 10 ns

Laser Induced Damage Threshold Tutorial

The following is a general overview of how laser induced damage thresholds are measured and how the values may be utilized in determining the appropriateness of an optic for a given application. When choosing optics, it is important to understand the Laser Induced Damage Threshold (LIDT) of the optics being used. The LIDT for an optic greatly depends on the type of laser you are using. Continuous wave (CW) lasers typically cause damage from thermal effects (absorption either in the coating or in the substrate). Pulsed lasers, on the other hand, often strip electrons from the lattice structure of an optic before causing thermal damage. Note that the guideline presented here assumes room temperature operation and optics in new condition (i.e., within scratch-dig spec, surface free of contamination, etc.). Because dust or other particles on the surface of an optic can cause damage at lower thresholds, we recommend keeping surfaces clean and free of debris. For more information on cleaning optics, please see our *Optics Cleaning* tutorial.

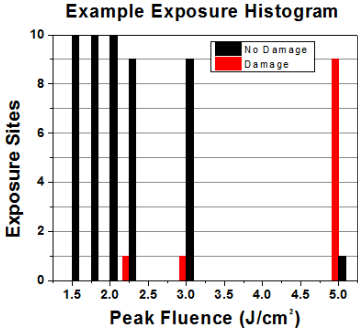
Testing Method

Thorlabs' LIDT testing is done in compliance with ISO/DIS11254 specifications. A standard 1-on-1 testing regime is performed to test the damage threshold.

First, a low-power/energy beam is directed to the optic under test. The optic is exposed in 10 locations to this laser beam for a set duration of time (CW) or number of pulses (pulse repetition frequency specified). After exposure, the optic is examined by a microscope (~100X magnification) for any visible damage. The number of locations that are damaged at a particular power/energy level is recorded. Next, the power/energy is either increased or decreased and the optic is exposed at 10 new locations. This process is repeated until damage is observed. The damage threshold is then assigned to be the highest power/energy that the optic can withstand without causing damage. A histogram such as that below represents the testing of one BB1-E02 mirror.

The photograph above is a protected aluminum-coated mirror after LIDT testing. In this particular test, it handled 0.43 J/cm^2 (1064 nm, 10 ns pulse, 10 Hz, Ø1.000 mm) before damage.

According to the test, the damage threshold of the mirror was 2.00 J/cm^2 (532 nm, 10 ns pulse, 10 Hz, Ø0.803 mm). Please keep in mind that these tests are performed on clean optics, as dirt and contamination can significantly lower the damage threshold of a component. While the test results are only representative of one coating run, Thorlabs specifies damage threshold values that account for coating variances.



Example Test Data			
Fluence	# of Tested Locations	Locations with Damage	Locations Without Damage
1.50 J/cm^2	10	0	10
1.75 J/cm^2	10	0	10
2.00 J/cm^2	10	0	10
2.25 J/cm^2	10	1	9
3.00 J/cm^2	10	1	9
5.00 J/cm^2	10	9	1

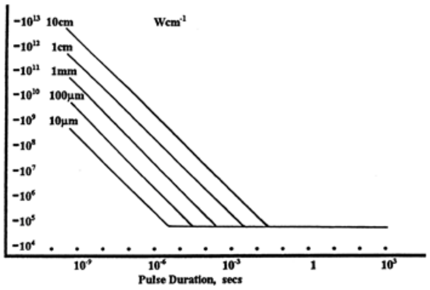
Continuous Wave and Long-Pulse Lasers

When an optic is damaged by a continuous wave (CW) laser, it is usually due to the melting of the surface as a result of absorbing the laser's energy or damage to the optical coating (antireflection) [1]. Pulsed lasers with pulse lengths longer than 1 µs can be treated as CW lasers for LIDT discussions. Additionally, when pulse lengths are between 1 ns and 1 µs, LIDT can occur either because of absorption or a dielectric breakdown (must check both CW and pulsed LIDT). Absorption is either due to an intrinsic property of the optic or due to surface irregularities; thus LIDT values are only valid for optics meeting or exceeding the surface quality specifications given by a manufacturer. While many optics can handle high power CW lasers, cemented (e.g., achromatic doublets) or highly absorptive (e.g., ND filters) optics tend to have lower CW damage thresholds. These lower thresholds are due to absorption or scattering in the cement or metal coating.

Pulsed lasers with high pulse repetition frequencies (PRF) may behave similarly to CW beams. Unfortunately, this is highly dependent on factors such as absorption and thermal diffusivity, so there is no reliable method for determining when a high PRF laser will damage an optic due to thermal effects. For beams with a large PRF both the average and peak powers must be compared to the equivalent CW power. Additionally, for highly transparent materials, there is little to no drop in the LIDT with increasing PRF.

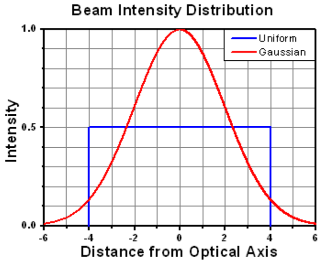
In order to use the specified CW damage threshold of an optic, it is necessary to know the following:

1. Wavelength of your laser
2. Linear power density of your beam (total power divided by 1/e^2 spot size)
3. Beam diameter of your beam (1/e^2)
4. Approximate intensity profile of your beam (e.g., Gaussian)



LIDT in linear power density vs. pulse length and spot size. For long pulses to CW, linear power density becomes a constant with spot size. This graph was obtained from [1].

The power density of your beam should be calculated in terms of W/cm. The graph to the right shows why the linear power density provides the best metric for long pulse and CW sources. Under these conditions, linear power density scales independently of spot size; one does not need to compute an adjusted LIDT to adjust for changes in spot size. This calculation assumes a uniform beam intensity profile. You must now consider hotspots in the beam or other nonuniform intensity profiles and roughly calculate a maximum power density. For reference, a Gaussian beam typically has a maximum power density that is twice that of the uniform beam (see lower right).



Now compare the maximum power density to that which is specified as the LIDT for the optic. If the optic was tested at a wavelength other than your operating wavelength, the damage threshold must be scaled appropriately. A good rule of thumb is that the damage threshold has a linear relationship with wavelength such that as you move to shorter wavelengths, the damage threshold decreases (i.e., a LIDT of 10 W/cm at 1310 nm scales to 5 W/cm at 655 nm):

$$Adjusted\ LIDT = LIDT\ Power\left(\frac{Your\ Wavelength}{LIDT\ Wavelength}\right)$$

While this rule of thumb provides a general trend, it is not a quantitative analysis of LIDT vs wavelength. In CW applications, for instance, damage scales more strongly with absorption in the coating and substrate, which does not necessarily scale well with wavelength. While the above procedure provides a good rule of thumb for LIDT values, please contact Tech Support if your wavelength is different from the specified LIDT wavelength. If your power density is less than the adjusted LIDT of the optic, then the optic should work for your application.

Please note that we have a buffer built in between the specified damage thresholds online and the tests which we have done, which accommodates variation between batches. Upon request, we can provide individual test information and a testing certificate. The damage analysis will be carried out on a similar optic (customer's optic will not be damaged). Testing may result in additional costs or lead times. Contact Tech Support for more information.

Pulsed Lasers

As previously stated, pulsed lasers typically induce a different type of damage to the optic than CW lasers. Pulsed lasers often do not heat the optic enough to damage it; instead, pulsed lasers produce strong electric fields capable of inducing dielectric breakdown in the material. Unfortunately, it can be very difficult to compare the LIDT specification of an optic to your laser. There are multiple regimes in which a pulsed laser can damage an optic and this is based on the laser's pulse length. The highlighted columns in the table below outline the relevant pulse lengths for our specified LIDT values.

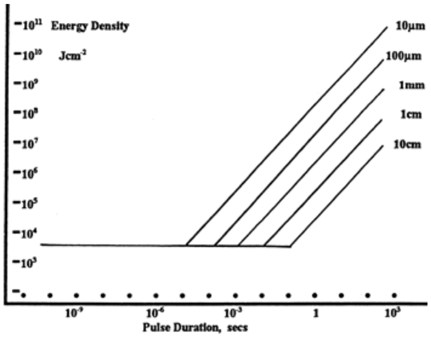
Pulses shorter than 10^{-9} s cannot be compared to our specified LIDT values with much reliability. In this ultra-short-pulse regime various mechanics, such as multiphoton-avalanche ionization, take over as the predominate damage mechanism [2]. In contrast, pulses between 10^{-7} s and 10^{-4} s may cause damage to an optic either because of dielectric breakdown or thermal effects. This means that both CW and pulsed damage thresholds must be compared to the laser beam to determine whether the optic is suitable for your application.

Pulse Duration	$t < 10^{-9}$ s	$10^{-9} < t < 10^{-7}$ s	$10^{-7} < t < 10^{-4}$ s	$t > 10^{-4}$ s
Damage Mechanism	Avalanche Ionization	Dielectric Breakdown	Dielectric Breakdown or Thermal	Thermal
Relevant Damage Specification	N/A	Pulsed	Pulsed and CW	CW

When comparing an LIDT specified for a pulsed laser to your laser, it is essential to know the following:

1. Wavelength of your laser
2. Energy density of your beam (total energy divided by $1/e^2$ area)
3. Pulse length of your laser
4. Pulse repetition frequency (prf) of your laser
5. Beam diameter of your laser ($1/e^2$)
6. Approximate intensity profile of your beam (e.g., Gaussian)

The energy density of your beam should be calculated in terms of J/cm^2. The graph to the right shows why the energy density provides the best metric for short pulse sources. Under these conditions, energy density scales independently of spot size, one does not need to compute an adjusted LIDT to adjust for changes in spot size. This calculation assumes a uniform beam intensity profile. You must now adjust this energy density to account for hotspots or other nonuniform intensity profiles and roughly calculate a maximum energy density. For reference a Gaussian beam typically has a maximum energy density that is twice that of the $1/e^2$ beam.



LIDT in energy density vs. pulse length and spot size. For short pulses, energy density becomes a constant with spot size. This graph was obtained from [1].

Now compare the maximum energy density to that which is specified as the LIDT for the optic. If the optic was tested at a wavelength other than your operating wavelength, the damage threshold must be scaled appropriately [3]. A good rule of thumb is that the damage threshold has an inverse square root relationship with wavelength such that as you move to shorter wavelengths, the damage threshold decreases (i.e., a LIDT of 1 J/cm^2 at 1064 nm scales to 0.7 J/cm^2 at 532 nm):

$$\text{Adjusted LIDT} = \text{LIDT Energy}\sqrt{\frac{\text{Your Wavelength}}{\text{LIDT Wavelength}}}$$

You now have a wavelength-adjusted energy density, which you will use in the following step.

Beam diameter is also important to know when comparing damage thresholds. While the LIDT, when expressed in units of J/cm², scales independently of spot size; large beam sizes are more likely to illuminate a larger number of defects which can lead to greater variances in the LIDT [4]. For data presented here, a <1 mm beam size was used to measure the LIDT. For beams sizes greater than 5 mm, the LIDT (J/cm2) will not scale independently of beam diameter due to the larger size beam exposing more defects.

The pulse length must now be compensated for. The longer the pulse duration, the more energy the optic can handle. For pulse widths between 1 - 100 ns, an approximation is as follows:

$$\text{Adjusted LIDT} = \text{LIDT Energy}\sqrt{\frac{\text{Your Pulse Length}}{\text{LIDT Pulse Length}}}$$

Use this formula to calculate the Adjusted LIDT for an optic based on your pulse length. If your maximum energy density is less than this adjusted LIDT maximum energy density, then the optic should be suitable for your application. Keep in mind that this calculation is only used for pulses between 10^{-9} s and 10^{-7} s. For pulses between 10^{-7} s and 10^{-4} s, the CW LIDT must also be checked before deeming the optic appropriate for your application.

Please note that we have a buffer built in between the specified damage thresholds online and the tests which we have done, which accommodates variation between batches. Upon request, we can provide individual test information and a testing certificate. Contact Tech Support for more information.

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[1] R. M. Wood, Optics and Laser Tech. **29**, 517 (1997).
[2] Roger M. Wood, *Laser-Induced Damage of Optical Materials* (Institute of Physics Publishing, Philadelphia, PA, 2003).
[3] C. W. Carr *et al*., Phys. Rev. Lett. **91**, 127402 (2003).
[4] N. Bloembergen, Appl. Opt. **12**, 661 (1973).

Hide LIDT Calculations

LIDT CALCULATIONS

LIDT Calculator

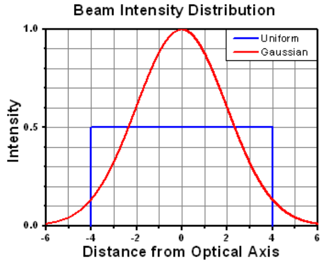
In order to illustrate the process of determining whether a given laser system will damage an optic, a number of example calculations of laser induced damage threshold are given below. For assistance with performing similar calculations, we provide a spreadsheet calculator that can be downloaded by clicking the button to the right. To use the calculator, enter the specified LIDT value of the optic under consideration and the relevant parameters of your laser system in the green boxes. The spreadsheet will then calculate a linear power density for CW and pulsed systems, as well as an energy density value for pulsed systems. These values are used to calculate adjusted, scaled LIDT values for the optics based on accepted scaling laws. This calculator assumes a Gaussian beam profile, so a correction factor must be introduced for other beam shapes (uniform, etc.). The LIDT scaling laws are determined from empirical relationships; their accuracy is not guaranteed. Remember that absorption by optics or coatings can significantly reduce LIDT in some spectral regions. These LIDT values are not valid for ultrashort pulses less than one nanosecond in duration.

CW Laser Example

Suppose that a CW laser system at 1319 nm produces a 0.5 W Gaussian beam that has a 1/e^2 diameter of 10 mm. A naive calculation of the average linear power density of this beam would yield a value of 0.5 W/cm, given by the total power divided by the beam diameter:

$$\text{Linear Power Density} = \frac{\text{Power}}{\text{Beam Diameter}}$$

However, the maximum power density of a Gaussian beam is about twice the maximum power density of a uniform beam, as shown in the graph to the right. Therefore, a more accurate determination of the maximum linear power density of the system is 1 W/cm.



A Gaussian beam profile has about twice the maximum intensity of a uniform beam profile.

An AC127-030-C achromatic doublet lens has a specified CW LIDT of 350 W/cm, as tested at 1550 nm. CW damage threshold values typically scale directly with the wavelength of the laser source, so this yields an adjusted LIDT value:

$$\text{Adjusted LIDT} = \text{LIDT Power}\left(\frac{\text{Your Wavelength}}{\text{LIDT Wavelength}}\right)$$

The adjusted LIDT value of 350 W/cm x (1319 nm / 1550 nm) = 298 W/cm is significantly higher than the calculated maximum linear power density of the laser system, so it would be safe to use this doublet lens for this application.

Pulsed Nanosecond Laser Example: Scaling for Different Pulse Durations

Suppose that a pulsed Nd:YAG laser system is frequency tripled to produce a 10 Hz output, consisting of 2 ns output pulses at 355 nm, each with 1 J of energy, in a Gaussian beam with a 1.9 cm beam diameter (1/e^2). The average energy density of each pulse is found by dividing the pulse energy by the beam area:

$$\text{Energy Density} = \frac{\text{Pulse Energy}}{\text{Beam Area}}$$

As described above, the maximum energy density of a Gaussian beam is about twice the average energy density. So, the maximum energy density of this beam is ~0.7 J/cm^2.

The energy density of the beam can be compared to the LIDT values of 1 J/cm^2 and 3.5 J/cm^2 for a BB1-E01 broadband dielectric mirror and an NB1-K08 Nd:YAG laser line mirror, respectively. Both of these LIDT values, while measured at 355 nm, were determined with a 10 ns pulsed laser at 10 Hz. Therefore, an adjustment must be applied for the shorter pulse duration of the system under consideration. As described on the previous tab, LIDT values in the nanosecond pulse regime scale with the square root of the laser pulse duration:

$$\text{Adjusted LIDT} = \text{LIDT Energy}\sqrt{\frac{\text{Your Pulse Length}}{\text{LIDT Pulse Length}}}$$

This adjustment factor results in LIDT values of 0.45 J/cm^2 for the BB1-E01 broadband mirror and 1.6 J/cm^2 for the Nd:YAG laser line mirror, which are to be compared with the 0.7 J/cm^2 maximum energy density of the beam. While the broadband mirror would likely be damaged by the laser, the more specialized laser line mirror is appropriate for use with this system.

Pulsed Nanosecond Laser Example: Scaling for Different Wavelengths

Suppose that a pulsed laser system emits 10 ns pulses at 2.5 Hz, each with 100 mJ of energy at 1064 nm in a 16 mm diameter beam (1/e^2) that must be attenuated with a neutral density filter. For a Gaussian output, these specifications result in a maximum energy density of 0.1 J/cm^2. The damage threshold of an NDUV10A Ø25 mm, OD 1.0, reflective neutral density filter is 0.05 J/cm^2 for 10 ns pulses at 355 nm, while the damage threshold of the similar NE10A absorptive filter is 10 J/cm^2 for 10 ns pulses at 532 nm. As described on the previous tab, the LIDT value of an optic scales with the square root of the wavelength in the nanosecond pulse regime:

$$Adjusted\ LIDT = LIDT\ Energy\sqrt{\frac{Your\ Wavelength}{LIDT\ Wavelength}}$$

This scaling gives adjusted LIDT values of 0.08 J/cm^2 for the reflective filter and 14 J/cm^2 for the absorptive filter. In this case, the absorptive filter is the best choice in order to avoid optical damage.

Pulsed Microsecond Laser Example

Consider a laser system that produces 1 µs pulses, each containing 150 µJ of energy at a repetition rate of 50 kHz, resulting in a relatively high duty cycle of 5%. This system falls somewhere between the regimes of CW and pulsed laser induced damage, and could potentially damage an optic by mechanisms associated with either regime. As a result, both CW and pulsed LIDT values must be compared to the properties of the laser system to ensure safe operation.

If this relatively long-pulse laser emits a Gaussian 12.7 mm diameter beam (1/e^2) at 980 nm, then the resulting output has a linear power density of 5.9 W/cm and an energy density of 1.2 x 10^{-4} J/cm^2 per pulse. This can be compared to the LIDT values for a WPQ10E-980 polymer zero-order quarter-wave plate, which are 5 W/cm for CW radiation at 810 nm and 5 J/cm^2 for a 10 ns pulse at 810 nm. As before, the CW LIDT of the optic scales linearly with the laser wavelength, resulting in an adjusted CW value of 6 W/cm at 980 nm. On the other hand, the pulsed LIDT scales with the square root of the laser wavelength and the square root of the pulse duration, resulting in an adjusted value of 55 J/cm^2 for a 1 µs pulse at 980 nm. The pulsed LIDT of the optic is significantly greater than the energy density of the laser pulse, so individual pulses will not damage the wave plate. However, the large average linear power density of the laser system may cause thermal damage to the optic, much like a high-power CW beam.

- 1D and 2D Scanning Galvo Mirror Systems
- Silver, Gold, Broadband (E02) and High Power Dual Band Coating Options
- Includes 1 or 2 Driver Cards for Single or Dual Mirror Systems, Respectively
- Includes Driver Card Heat Sink(s)
- **Power Supply Not Included**

Thorlabs Scanning Galvo Mirror Systems are available in single and dual axis configurations for small (<5 mm) beam applications. A choice of mirror coatings is available as described above. Each 1D system includes one driver card, one driver card heat sink, and one single mirror system. Each 2D system includes two driver cards, two driver card heatsinks, and a dual mirror system. These galvo systems do not include a power supply, driver card cover, or galvo mirror heatsinks, which are highly recommended for demanding applications where vigorous scanning and stability are required. These accessories can be purchased together with the GVS001 or GVS002 system in the GVSM001 and GVSM002 complete packages, sold below, or as individual items, also sold below.

Part Number	Description	Price	Availability
GVS001	1D Galvo System, Silver-Coated Mirror, PSU Not Included	$934.00	Today
GVS101	Customer Inspired!1D Galvo System, Gold-Coated Mirror, PSU Not Included	$1,004.00	Today
GVS201	Customer Inspired!1D Galvo System, Broadband Mirror for 400-750 nm (-E02), PSU Not Included	$1,260.00	Today
GVS301	Customer Inspired!1D Galvo System, Dual Band Mirror for 532/1064 nm (-K13), PSU Not Included	$1,260.00	Today
GVS002	2D Galvo System, Silver-Coated Mirrors, PSU Not Included	$1,905.00	Today
GVS102	Customer Inspired!2D Galvo System, Gold-Coated Mirrors, PSU Not Included	$1,905.00	Today
GVS202	Customer Inspired!2D Galvo System, Broadband Mirrors for 400-750 nm (-E02), PSU Not Included	$2,260.00	Today
GVS302	Customer Inspired!2D Galvo System, Dual Band Mirrors for 532/1064 nm (-K13), PSU Not Included	$2,260.00	Today

Small Beam Diameter Galvo System Complete Packages

- Includes GVS001 or GVS002 Galvo System + Power Supply, Mirror Heatsink, and Driver Card Cover
- Complete 1D and 2D Scanning 5 mm Galvo Mirror Packages
- Protected Silver Mirror Coating
- Other Coatings Available on Request
- Optically Encoded Mirror Position
- 99.9% Motor and Position Sensor Linearity

▶ Advanced Analog Control Circuit (Servo Driver) with Current Damping and Error Limiter

The GVSM001 and GVSM002 Galvo Mirror System Packages are complete kits for operating 1D and 2D, scanning mirror systems for small diameter beams. These closed-loop systems are ideal for raster and vector scanning applications as well as some step-and-hold applications. The GVSM001 and GVSM002 packages include the GVS001 or GVS002 silver coated mirror systems described above, together with the GPS011 linear power supply, a GHS003 post mounting adapter and a GCE001 cover for the servo driver boards. Other coatings (e.g. gold or broadband) are available on request - please contact tech support for more details.

The power supply (GPS011) and additional mirror heatsink (GHS003), included in these packages, are highly recommended for rapid scanning and the most demanding applications where power supply stability and heat dissipation are needed. The power supply can power two 1D scanning mirrors or one 2D scanning mirror assembly, and can be powered by 115 VAC or 230/240 VAC.

Part Number	Description	Price	Availability
GVSM001/M	**1D Galvo System with Metric Accessories**	**$1,461.00**	**Today**
GVSM002/M	**2D Galvo System with Metric Accessories**	**$2,431.00**	**Today**
GVSM001	**1D Galvo System with Accessories**	**$1,461.00**	**Today**
GVSM002	**2D Galvo System with Accessories**	**$2,431.00**	**Today**

Small Beam Diameter Galvo System Accessories

In order to ease the integration of the Thorlabs GVSX01 and GVSX02 galvo systems into optical systems a range of accessories have been created. The accessories include a galvo mount heatsink, a linear power supply, 30 mm cage mounts and PY003 tip tilt platform adapters. Also included is an optional enclosure for the galvo driver cards.

The **GHS003** galvo mirror heatsink attaches directly to the 1D and 2D mirror mounts to provide device cooling and alternate mounting options.

Heat from the galvo mirrors is typically dissipated through the normal mounting options, however for applications involving vigorous changing drive signals, we recommend using the GHS003 heat sink. Excess heat buildup will cause the galvo motor to fail or driver board thermal cut out to trip.

The **GPS011** power supply is a low noise, linear supply designed to minimize electrical interference for maximum system resolution. The power supply is compatible with all our galvo systems and can power two server driver cards simultaneously. Two 2 m power cables are included.

The GPS011 delivers ±15 VDC at 3 A and can be powered by 115 VAC or 230/240 VAC. A standard switch mode power supply may be used for low demand applications.

The **GCM001** cage system adapter is used to mount the GVSX01 single-axis galvo systems into a 30 mm cage system. The adapter also features four SM1 threads and an open bottom for further mounting options.

Note: The input and output are on the same plane.

Similarly, the **GCM002** cage system adapter is used to mount the GVSX02 dual-axis galvo systems into a 30 mm cage system.The adapter also features two SM1 threads and an open bottom for further mounting options. A B1C cover is included with this adapter for light tight applications.

Note: The input and output are on different planes. Cage systems should be adapted accordingly.

The **GCE001** is a convenient enclosure for servo driver cards. Simply bolt onto the servo driver bracket.

Note: This item is not compatible with early models of the servo driver card. Contact Tech Support for more information.

The **GTT001** Tilt Platform Adapter allows the GVSX01 and GVSX02 Galvo Systems to be mounted on a PY003 Tilt Platform.

Part Number	Description	Price	Availability
GHS003/M	Galvo Mount/Post Adapter Heatsink, Metric	$20.00	Today
GCM002/M	2D Galvo 30 mm Cage System Mount, Metric	$120.00	Today
GPS011	1D or 2D Galvo System Linear Power Supply	$450.00	Today
GCM001	1D Galvo 30 mm Cage System Mount	$120.00	Today
GCE001	Galvo Driver Card Cover	$56.00	Today
GTT001	Galvo Mount Tip-Tilt Platform Adapter	$18.00	Today
GHS003	Galvo Mount/Post Adapter Heatsink, Imperial	$20.00	Today
GCM002	2D Galvo 30 mm Cage System Mount	$120.00	Lead Time