56 Sparta Avenue • Newton, New Jersey 07860
(973) 300-3000 Sales • (973) 300-3600 Fax
www.thorlabs.com

THORLABS

# LCC3111L/M - July 7, 2016

Item # LCC3111L/M was discontinued on July 7, 2016. For informational purposes, this is a copy of the website content at that time and is valid only for the stated product.

## NOISE EATERS / LASER AMPLITUDE STABILIZERS

- **Laser Amplitude Stabilizer / Variable Attenuator**
- **Models with Wavelength Ranges Covering 425 - 1620 nm Available**
- **Closed-Loop Feedback System**


**LCC3111H**
Front


Back

**Application Idea**

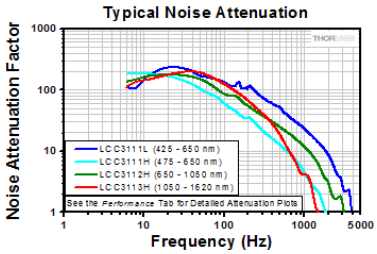

**LCC3111H**
Noise Eater with Half-Wave Plate in CRM1 Rotation Mount

Hide Overview

## OVERVIEW

### Features

- Reduces Laser Intensity Noise
- Also Functions as a Variable Attenuator or EO Modulator
- Models for use at 425 - 650 nm, 475 - 650 nm, 650 - 1050 nm, or 1050 - 1620 nm
- Maximum Input Power of up to 1 W, Depending on Model, Wavelength, and Beam Size (See the *Operation* Tab for Details)
- Excellent for Sensitive Experiments such as Optical Tweezers
- Ideal for Stabilizing CW Pump Lasers




Click to Enlarge
Noise Attenuation Factor is the Ratio of Noise Amplitude Before and After the Noise Eater


Click for Details
LCC3113H Top View Showing Power Range Adjustment Switches and Modulation Input

Thorlabs' Liquid Crystal Noise Eaters / Laser Amplitude Stabilizers are precision instruments for stabilizing, modulating, and attenuating the power of linearly polarized light. These closed-loop systems are designed for use with light in the 425 - 650 nm (LCC3111L), 475 - 650 nm (LCC3111H), 650 - 1050 nm (LCC3112H), or 1050 - 1620 nm (LCC3113H) wavelength range. We offer noise eater models for low (<100 mW) or high (<1 W) power use, all with external modulation inputs. See the *Specs* tab for details.

**Noise Reduction**

Utilizing a liquid crystal amplitude modulator, combined with a photodiode for power measurement and a feedback control circuit, the noise eaters can eliminate intensity noise in linearly polarized light, achieving amplitude stabilization of within 0.05% of a selected output power. The input power can be set to one of several ranges using the switch(es) on the top of the unit. The potentiometer is then adjusted to select the output power (see the *Operation* tab for more information). Long-term performance and frequency characterization for each noise eater model are shown on the *Performance* tab.

**Power Attenuation and Modulation**
These noise eaters are also capable of continuously attenuating and modulating the laser output using the liquid crystal retarder and integrated polarizer. Unlike most attenuators available, Noise Eaters attenuate the laser power rapidly without the use of any mechanical components. The noise eater's attenuation capabilities can be controlled via the onboard potentiometer or electrical modulation input.

Thorlabs' Noise Eaters are post mountable in two orientations via 8-32 (M4) tapped holes. They also feature 4-40 tapped holes on the front and back for 30 mm Cage System compatibility and an SM1-threaded (1.035"-40) rear aperture for Ø1" Lens Tube compatibility.

Hide Specs

## SPECS

**Product Line Note**
Our LCC3112H and LCC3113H Noise Eaters are switchable between low and high power mode, for operation at up to 8 W/cm² input power density. All other performance characteristics are similar between the different noise eater models. See the table to the left for details.

| Noise Eaters Product Line Overview | | | | |
|---|---|---|---|---|
| **Item #** | **LCC3111L** | **LCC3111H** | **LCC3112H** | **LCC3113H** |
| Modulation Input | ✓ | ✓ | ✓ | ✓ |
| Low Power Operation Only | ✓ | | | |
| High Power Operation Only | | ✓ | | |
| Switchable Low/High Power Operation | | | ✓ | ✓ |

| **Item #** | **LCC3111L(/M)** | **LCC3111H(/M)** | **LCC3112H(/M)** | **LCC3113H(/M)** |
|---|---|---|---|---|
| Wavelength Range | 425 - 650 nm | 475 - 650 nm | 650 - 1050 nm | 1050 - 1620 nm |
| **Noise Attenuation Performance Specs** | | | | |
| Output Power Stability[a] | ±0.05% | | | |
| Noise Attenuation Frequency Range[b] | DC - 1.8 kHz | | DC - 2.5 kHz | DC - 1.4 kHz |
| Noise Attenuation Amplitude Range | 0.1% to 50% of Input Signal | | | |
| Noise Attenuation Factor[c] | >150 at 10 Hz, 80 at 60 Hz<br>20 at 400 Hz, 4 at 1 kHz | | | >150 at 10 Hz, 80 at 60 Hz<br>10 at 400 Hz, 1.5 at 1 kHz |
| Output Power Attenuation Factor Range[d] | 1 - 40 | | 1 - 5 | |
| Internal Polarizer Blocking Damage Threshold (Maximum Power Attenuation) | 1 W/cm$^2$ | 10 W/cm$^2$ | | |
| Attenuation Control | Onboard Potentiometer (10 Turns) or Modulation Input | | | |
| **Optical Specs** | | | | |
| Transmission (Click for Plot) | >85% at 635 nm | >80% at 635 nm | >85% at 780 nm | >85% at 1550 nm |
| Power Level Switching | Four Position Power Range Switch | Three Position Power Range Switch | High/Low Power Mode Switch and Four Position Power Range Switch | |
| Maximum Input Power | See the *Max Powers at Various Wavelengths* section on the *Operation* tab | | | |
| Minimum Input Power | 0.5 mW | 30 mW | 0.5 mW | |
| Damage Threshold (CW)[e] | 0.8 W/cm$^2$ | 8 W/cm$^2$ | | |
| Input Aperture | Ø5 mm | | | |
| Input Beam Diameter | Ø4 mm (Max)[f] | | | |
| Output Beam Displacement | 1 mm Vertically (in the Direction of Input Polarization) | | | |
| Beam Divergence | 5 mrad (Max) | | | |

| | | | |
|---|---|---|---|
| Angle of Incidence | ±2° (Max) | | |
| Input Polarization Tolerance | ±3° | | |
| Wavefront Distortion | ≤λ/4 at 635 nm | ≤λ/2 at 635 nm | ≤λ/2 at 635 nm |
| AR Coating | $R_{avg}$ <0.5% from 400 - 650 nm | $R_{avg}$ <0.5% from 650 - 1100 nm | $R_{avg}$ <0.5% from 1050 - 1620 nm |
| **Modulation Performance Specs** | | | |
| Modulation Input | SMC Connector, 0 - 2.5 V, 10 kΩ Input Impedance | | |
| Minimum Extinction Ratio[g] | 512.6 | 7.7 | 6.5 |
| Minimum Rise / Fall Time[h] | 0.65 ms / 7.3 ms | 0.75 ms / 11.5 ms | 2.8 ms / 25 ms |
| **General Specs** | | | |
| Mounting Options | Two 8-32 (M4) Tapped Holes for Post Mounting<br>30 mm Cage System Compatible<br>Ø1" Lens Tube Compatible | | |
| Operating Temperature Range | 15 °C to 45 °C | | |

- RMS value over 8 hours
- These Noise Eaters are designed to operate down to DC frequency. However, due to external factors (e.g. ambient temperature, vibration, spatial and/or polarization stability of the light source), the noise attenuation factor below 10 Hz is difficult to measure and quantify. Therefore our specifications are guaranteed at 10 Hz and above.
- Noise attenuation factor is the ratio of noise amplitude before and after the noise eater. It was tested at 100 mW input power with a noise amplitude of 5% of the input power level. The nominal noise attenuation frequency range can reach up to 2.5 kHz, depending on the model. See detailed noise attenuation plots on the *Performance* tabs for more information. The noise eater might not be able to completely eliminate high frequency noise in certain cases, such as a laser source that contains spikes or step-like output power fluctuations.
- Range of output power adjustment for a given input power level
- Max input power density and laser damage threshold are wavelength-independent. Additionally, the absolute maximum input power varies with wavelength; see the *Operation* tab for details.
- Specified for a $1/e^2$ beam diameter
- Extinction ratio is the ratio of the signal power at minimum attenuation to the signal power at full attenuation.
- Rise time is measured on the rising edge of the output intensity from 10% to 90% of full output power.

Hide Performance

PERFORMANCE

## Noise Eater Performance Graphs

In the graphs below, noise attenuation was measured as one of three parameters was varied: input power level, input signal modulation (noise) amplitude, and output signal attenuation. The graphs show that the noise eaters provide consistent performance regardless of changes in these parameters.

## Graph Definitions

**Noise Attenuation at Various Input Power Levels**

Noise attenuation factor is the ratio of noise amplitude before and after the noise eater. In these graphs, the attenuation factor was measured for several different input power levels, with a fixed signal modulation depth (noise amplitude). The graphs below show that the noise eaters provide consistent performance regardless of input power level.

**Noise Attenuation at Various Input Signal Modulations**

In these graphs, the input signal was modulated with a sine wave to simulate noise. The attenuation factor was measured at a variety of modulation depths (noise amplitudes). The graphs below show that the noise eater provides consistent performance even at large noise levels.

**Noise Attenuation at Various Output Signal Power Levels**

Since the noise eater uses a liquid crystal modulator as the optical control element, the noise attenuation is achieved by attenuating the laser beam when noise appears. Our noise eaters are carefully designed to optimize the noise attenuation performance without needing to severely attenuate the signal. These graphs demonstrate that the specified noise attenuation can be reached with a cost of only 5% - 10% overall attenuation of the output power, and further increases in attenuation does not significantly improve the noise attenuation.

**Modulation Performance**

Noise eaters with a modulation input can also be used as EO modulators. In these graphs, a sine wave with a 2.5 V amplitude and an increasing frequency was used to modulate a noiseless input beam. The graphs show that the maximum modulation depth decreases with increasing modulation frequency. Further testing has demonstrated that the modulation performance is consistent for a given noise eater model, regardless of the laser beam's input power.

## LCC3111L: Low Power Noise Eater for Visible (425 - 650 nm)

Click here to download raw data.

| Item # | Noise Attenuation | | | Modulation Performance | Long-Term Noise Attenuation | Transmission |
|---|---|---|---|---|---|---|
| | vs. Input Power | vs. Noise Amplitude | vs. Signal Attenuation | | | |
| LCC3111L(/M) |  |  |  |  |  |  |

## LCC3111H: High Power Noise Eater for Visible (475 - 650 nm)

Click here to download raw data.

| Item # | Noise Attenuation | | | Modulation Performance | Long-Term Noise Attenuation | Transmission |
|---|---|---|---|---|---|---|
| | vs. Input Power | vs. Noise Amplitude | vs. Signal Attenuation | | | |
| LCC3111H(/M) |  |  |  |  |  |  |

## LCC3112H: High/Low Power Noise Eater for NIR (650 - 1050 nm)

Click here to download raw data.

| Item # | Noise Attenuation | | | Modulation Performance | Long-Term Noise Attenuation | Transmission |
|---|---|---|---|---|---|---|
| | vs. Input Power | vs. Noise Amplitude | vs. Signal Attenuation | | | |
| LCC3112H(/M) |  |  |  |  |  |  |

## LCC3113H: High/Low Power Noise Eater for IR (1050 - 1620 nm)

Click here to download raw data.

| Item # | Noise Attenuation | | | Modulation Performance | Long-Term Noise Attenuation | Transmission |
|---|---|---|---|---|---|---|
| | vs. Input Power | vs. Noise Amplitude | vs. Signal Attenuation | | | |
| LCC3113H(/M) |  |  |  |  |  |  |

Hide Operation

OPERATION

## Noise Eater Operation


Click to Enlarge

Thorlabs' Liquid Crystal Noise Eater is a precision instrument for stabilizing, attenuating, and modulating laser power. The noise eater consists of a variable attenuator (liquid crystal wave plate and polarizer), a calibrated beamsplitter, and a servo controller to control the modulator, as depicted in the block diagram to the right.

Linearly polarized light is input into the liquid crystal retarder, which, together with the output polarizer, acts as a variable retarder. A beamsplitter then sends a small part of the beam to a feedback loop consisting of a photodiode and control servo. The servo compares the optical signal to a preset signal level and applies the appropriate adjustment voltage until the optical signal reaches the desired level.

The noise eater can also be used as a variable attenuator, even without the presence of noise. By adjusting the resistance of the potentiometer, the user can set the desired output power level.

## Mounting and Alignment

The noise eater is designed to work with linearly polarized input light aligned with the direction of the arrow engraved on the noise eater near the input aperture. Linearly polarized light and proper alignment of the direction of polarization are important for achieving the best results from the noise eater.


Click to Enlarge
The Noise Eater can be post mounted in two different orientations to match the input light's direction of polarization. A CRM1 Cage Rotation Mount and four ER2 Cage Rods can mount a half-wave plate for fine tuning the polarization alignment.

In order to minimize optical losses, the noise eater does not have an input polarizer. If the incident light is not linearly polarized, a linear polarizer (such as our LPVIS or LPNIR ) must be placed before the noise eater to polarize the incident light.

If the incident light is linearly polarized but is not aligned exactly vertically or horizontally, a half-wave plate can be used before the noise eater to rotate the polarization axis. As shown in the photo to the right, the noise eater's cage mount can be used along with a CRM1 cage rotation mount to rotate the half-wave plate, thus aligning the polarization axis with the noise eater.

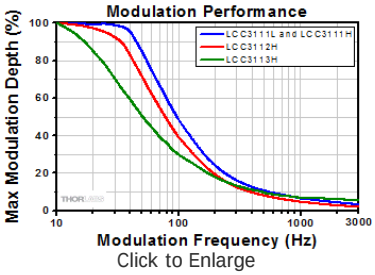
For post mounting, the noise eater is equipped with two 8-32 (M4) threaded holes. These holes are offset by 90° so that light with a vertical or horizontal polarization axis can be aligned with the noise eater. The four 4-40 holes on the front of the noise eater can also be used to mount the noise eater in either a horizontal or vertical orientation using the Thorlabs 30 mm Cage System.

For best performance of the noise eater, it is recommended that the beam be well centered within the input aperture. Due to the optical path inside the noise eater, the output beam will be shifted down by 1.0 mm if the noise eater is mounted vertically, as shown in the left view in the figure to the right. Similarly, the output beam will be shifted sideways by 1.0 mm if the noise eater is mounted horizontally, as shown in the right view in the figure to the right.

## Modulation

There is an SMC interface at the right side of the noise eater, which can be used to modulate the attenuation of the noise eater. The modulation input has a 10 kΩ input impedance. A voltage ranging from 0 to 2.5 V can be input to modulate the output power from 0 to full output. Before modulating the output power, first turn the output power level knob clockwise to the end of its travel (minimum output power setting).

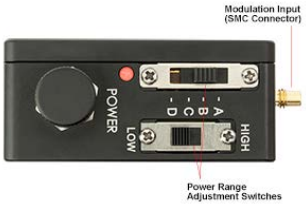
Click to Enlarge
SMC Modulation Input Jack



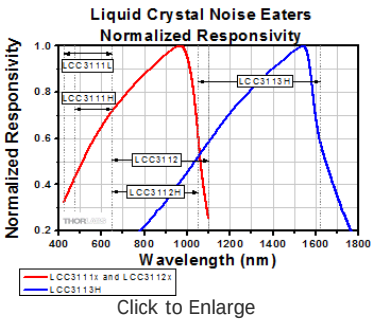
Click to Enlarge

## Power Range Adjustment

The selection switch(es) at the top of the noise eater are used to select the input power range. The power selector should be set to the lowest value that is still higher than the actual power of the laser. For example, if the LCC3111L is being used with a beam power of 8 mW at 635 nm, the selector should be set to 10 mW.



Click to Enlarge
Top View Showing Power Range Adjustment Switches



Click to Enlarge

The LCC3112H and LCC3113H have two selection switches at the top of the case, which are used to select the input power range. When the low/high power switch is set to "LOW", the input power range can be set from 1 mW to 30 mW; when the status switch set to "HIGH", the input power range can be set from 100 mW to 500 mW. The other noise eater models have only one selection switch.

The LCC3111x and LCC3112x noise eaters use a Silicon detector as part of the feedback loop, while the LCC3113H noise eater uses a Germanium detector. The responsivity of the detectors is different for different wavelengths, and so the power settings on the selector only correspond to the design wavelength of the detector (635 nm for LCC3111x, 780 nm for LCC3112x, 1550 nm for the LCC3113H). The power range at a given wavelength is inversely proportional to the responsivity (a higher responsivity value will result in a lower power range value). The graph to the right shows the relative responsivity of both detectors

at a range of wavelengths. The tables below show a rough estimate of the power settings at various wavelengths for each model.

The noise eater operates by varying how much of the signal is attenuated in order to reach the target output power and attenuate the noise. Since the noise eater can attenuate the signal but not amplify it, the clean output beam can only have a power as high as the minimum power level of the noisy signal. In practice, to remove all noise without unnecessarily attenuating the signal power, the output power level should be set to slightly lower than the minimum power of the noisy signal. See the operating manual on the *Documents* tab for more information.

## Max Powers at Various Wavelengths

The tables below list the maximum input powers for each noise eater, specified for a variety of input wavelengths and switch settings. Please note that these maximum power levels correspond to the feedback electronics of the noise eater, and in some cases, the actual maximum input power is instead limited by the damage threshold of the noise eater. For the high power noise eaters (LCC3111H, LCC3112H, and LCC3113H), this damage threshold is 8 W/cm$^2$, which corresponds to a maximum input power of 1 W if the input power is distributed evenly across the Ø4 mm clear aperture. For the low power noise eater (LCC3111L), the damage threshold is 0.8 W/cm$^2$, which corresponds to a maximum input power of 100 mW if the input power is again distributed evenly across the Ø4 mm clear aperture.

| LCC3111L Max Power at Various Wavelengths | | | |
|---|---|---|---|
| **Switch Status** | **Max Power at 450 nm** | **Max Power at 550 nm** | **Max Power at 635 nm** |
| 1 mW | 2 mW | 1.5 mW | 1 mW |
| 3 mW | 6 mW | 4.5 mW | 3 mW |
| 10 mW | 20 mW | 15 mW | 10 mW |
| 30 mW | 60 mW | 45 mW | 30 mW |

| LCC3111H Max Power at Various Wavelengths | | | |
|---|---|---|---|
| **Switch Status** | **Max Power at 450 nm** | **Max Power at 550 nm** | **Max Power at 635 nm** |
| 100 mW | 200 mW | 150 mW | 100 mW |
| 300 mW | 600 mW[a] | 450 mW | 300 mW |
| 500 mW | 1000 mW[a] | 750 mW[a] | 500 mW |

- The maximum power levels specified here are for the feedback electronics, but the maximum input power at these settings is limited by the damage threshold of the liquid crystal retarder, which is 8 W/cm$^2$. See the section "Max Powers at Various Wavelengths," above, for details.

| LCC3112H Max Power at Various Wavelengths | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Switch Status** | | **Max Power at 650 nm** | **Max Power at 700 nm** | **Max Power at 780 nm** | **Max Power at 900 nm** | **Max Power at 1000 nm** | **Max Power at 1100 nm** |
| Low | A | 1.2 mW | 1.1 mW | 1 mW | 0.9 mW | 0.9 mW | 3.3 mW |
| Low | B | 3.5 mW | 3.3 mW | 3 mW | 2.6 mW | 2.7 mW | 10.0 mW |
| Low | C | 11.8 mW | 11.1 mW | 10 mW | 8.8 mW | 8.9 mW | 33.3 mW |
| Low | D | 35.5 mW | 33.3 mW | 30 mW | 26.3 mW | 26.8 mW | 100 mW |
| High | A | 120 mW | 111 mW | 100 mW | 86.0 mW | 89.3 mW | 333 mW |
| High | B | 355.5 mW | 333 mW | 300 mW | 258.0 mW | 268 mW | 999 mW[a] |
| High | C | 600 mW[a] | 500 mW | 500 mW | 430.0 mW | 446.6 mW | 1650 mW[a] |

- The maximum power levels specified here are for the feedback electronics, but the maximum input power at these settings is limited by the damage threshold of the liquid crystal retarder, which is 8 W/cm$^2$. See the section "Max Powers at Various Wavelengths," above, for details.

| LCC3113H Max Power at Various Wavelengths | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Switch Status** | | **Max Power at 1050 nm** | **Max Power at 1150 nm** | **Max Power at 1250 nm** | **Max Power at 1350 nm** | **Max Power at 1450 nm** | **Max Power at 1550 nm** | **Max Power at 1650 nm** |
| Low | A | 1.9 mW | 1.6 mW | 1.5 mW | 1.2 mW | 1 mW | 1 mW | 1.6 mW |
| Low | B | 5.8 mW | 4.8 mW | 4.1 mW | 3.5 mW | 3.1 mW | 3 mW | 4.8 mW |
| Low | C | 19.2 mW | 16 mW | 13.7 mW | 11.7 mW | 10.4 mW | 10 mW | 16 mW |
| Low | D | 57.6 mW | 48 mW | 41.1 mW | 35.1 mW | 31.3 mW | 30 mW | 48 mW |
| High | A | 190 mW | 160 mW | 137 mW | 117 mW | 104.7 mW | 100 mW | 160 mW |
| High | B | 500 mW | 480 mW | 411 mW | 351 mW | 313.4 mW | 300 mW | 480 mW |
| High | C | 835 mW[a] | 800 mW[a] | 685 mW[a] | 585 mW[a] | 520 mW[a] | 500 mW | 800 mW[a] |

- The maximum power levels specified here are for the feedback electronics, but the maximum input power at these settings is limited by the damage threshold of the liquid crystal retarder, which is 8 W/cm$^2$. See the section "Max Powers at Various Wavelengths,"

above, for details.

Hide Noise Eaters for 425 - 650 nm or 475 - 650 nm

## Noise Eaters for 425 - 650 nm or 475 - 650 nm

- LCC3111L is a Low-Power Noise Eater (0.5 mW to 60 mW) with a Modulation Input
- LCC3111H is a High-Power Noise Eater (30 mW to 1000 mW) with a Modulation Input

| Part Number | Description | Price | Availability |
|---|---|---|---|
| LCC3111L/M | Customer Inspired!Noise Eater / EO Modulator for 425 - 650 nm, Metric | $1,550.00 | Today |
| LCC3111H/M | Customer Inspired!High-Power Noise Eater / EO Modulator for 475 - 650 nm, Metric | $1,800.00 | Today |
| LCC3111L | Customer Inspired!Noise Eater / EO Modulator for 425 - 650 nm | $1,550.00 | Today |
| LCC3111H | Customer Inspired!High-Power Noise Eater / EO Modulator for 475 - 650 nm | $1,800.00 | Today |

Hide Noise Eater for 650 - 1050 nm

## Noise Eater for 650 - 1050 nm

- LCC3112H is a Switchable Low/High-Power Noise Eater (0.5 mW to 60 mW and 50 mW to 1000 mW) with a Modulation Input

| Part Number | Description | Price | Availability |
|---|---|---|---|
| LCC3112H/M | Customer Inspired!High-Power Noise Eater / EO Modulator for 650 - 1050 nm, Metric | $2,010.00 | Lead Time |
| LCC3112H | Customer Inspired!High-Power Noise Eater / EO Modulator for 650 - 1050 nm | $2,010.00 | Lead Time |

Hide Noise Eater for 1050 - 1620 nm

## Noise Eater for 1050 - 1620 nm

- LCC3113H is a Switchable Low/High-Power Noise Eater (0.5 mW to 57.6 mW and 50 mW to 835 mW) with a Modulation Input

| Part Number | Description | Price | Availability |
|---|---|---|---|
| LCC3113H/M | Customer Inspired!High-Power Noise Eater / EO Modulator for 1050 - 1620 nm, Metric | $2,220.00 | Today |
| LCC3113H | Customer Inspired!High-Power Noise Eater / EO Modulator for 1050 - 1620 nm | $2,220.00 | Today |

Visit the *Noise Eaters / Laser Amplitude Stabilizers* page for pricing and availability information:
https://www.thorlabs.com/newgrouppage9.cfm?objectgroup_id=6107