Laser Beam Attenuator, Standard Version

User Manual
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1. Introduction

Laser beam attenuator is continuously variable beam-splitter, which allows to attenuate laser beam continuously through the attenuation range.

While assembling or operating the attenuator, do not stare at the direct or scattered laser light even with safety goggles. All parts of the body must be kept away from the laser radiation. While adjusting laser beam through Watt Pilot, laser power must be kept as low as possible. Hazardous laser radiation can increase while optical components or instruments are used in combination with the attenuator. Appropriate eye protection must be worn at all times.

This user manual is designed to help to install and operate Laser beam attenuator. Before installing and operating the attenuator please read installation and operation instructions carefully. If you have any questions about contents of this manual please contact info@altechna.com. Altechna reserves right to update contents of this manual without notification.

2. Operation principle

Standard version of laser beam attenuator incorporates zero order waveplate of \( \lambda/2 \) phase retardation and one high energy polarizing beamsplitter cube. The cube separates s-polarized and p-polarized beams in orthogonal directions. The intensity ratio of these two beams is continuously tuned by rotating the waveplate without alteration of other beam/pulse parameters. The intensity of either exit beam, or intensity ratio between them, can be controlled over wide dynamic range.

P-polarization should be selected for maximum if maximum beam blocking is required, while s-polarization would provide maximum energy transmission of the attenuator. Proper functioning of attenuator requires optimal configuration of optical elements regarding to incident laser beam polarization contrast. Higher incident laser beam polarization contrast, leads to higher attenuation range.

![1 pic. Operation principle of attenuator.](image1)

Half-wave phase plate rotates incident beam polarization twice the rotation rate of the plate. This corresponds to the following attenuation dependence:

\[
T = \frac{I_{\text{out}}}{I_{\text{in}}} = \cos^2 2\Theta
\]

Where \( T \) is normalizer transmission, \( I_{\text{in}} \) is intensity at the input, \( I_{\text{out}} \) is intensity at the output, \( \Theta \) is angle between input polarization and waveplate fast axis.

This dependence with corresponding inspection results is illustrated in pic. 2.

![2pic. Transmitted power dependence on angle between waveplate fast axis and incident polarization.](image2)
3. Adjustment

3.1. Scale calibration

For convenient usage scale on the attenuator can be adjusted during usage. For instance if one wants “0°” on the scale to correspond to max blocking (or max transmission), scale can be calibrated during operation, however precautions must be taken just like during any adjustment during laser operation. Scale step-by-step calibration is show in pic 3.

This calibration need only to be done once and it provides convenient reference as “0°” permanently becomes minimum (or maximum) energy position.

3.2. Sensitivity to AOI

Attenuator comprises polarization dependent optics, which means, angle of incidence should be considered to obtain optimal performance.

First of all polarizing cube is designed to meet its specifications at normal incidence which corresponds to 45° AOI with polarizing coating on cube hypotenuse, but the best extinction ratio (and thus – attenuation range) might we laying in vicinity of few degrees, which means, that aiming for the widest attenuation range angle tuning might do quite a difference. However, angle tuning for polarizing plate introduces longer optical path in birefringent media, so with tilting its phase retardation value also changes, affecting polarization state of the beam after the plate.
Both factors affect the performance of the attenuator and the measured curves below illustrate the dependence of attenuator performance at tilted angles.

Graphs 4 and 5 represent attenuator transmittance versus tipping and tilting angles. Tilt and tip planes match with planes of incidence in polarizing cube. Tipping – attenuator adjustment in p-plane. Tilting – attenuator adjustment in s-plane. All measurements were taken at 532nm wavelength.

Tipping has symmetric angle dependence because it corresponds to symmetric angle adjustment around 45° AOI on the cube hypotenuse, while tilting (angle adjustment) because tilting ±10° actually corresponds to AOI ~35°-55° in polarizing coating of the cube. Tilting adjustment should be considered aiming for the best attenuation range. However, specifications of the attenuator are maintained within ±5° AOI which does not require precise positioning.

Sensitivity measurement results should be used only for reference as results may vary for every individual pair of optical components. The angular sensitivity is expected to be higher for UV wavelengths.

Tel. +370 527 25 738
Fax +370 527 23 707
sales@altechna.com

Mokslininkų st. 6A
Vilnius, Lithuania

www.altechna.com