

Boulder Nonlinear Systems (BNS) designs, develops, and manufactures liquid crystal devices (LCDs) for modulating light in a number of ways. LCDs can be designed to completely turn off a beam of light (Optical Shutter), vary the intensity of a beam of light (Beam Attenuator), delay the time of flight of a beam of light (Variable Waveplate).

These technologies can also be extended from single, large apertures to segmented, or pixelated, apertures – also known as spatial light modulators (SLMs). With an SLM one can spatially vary the amount of modulation to create a variety of optical functions. For instance computer generated holograms can be implemented, wavefront errors can be corrected, atmospheric turbulence can be simulated, beams can be steered, pulses can be shaped, or coherent images can be implemented for optical processing.

The following pages describe our available Variable Waveplate technology. Please be aware that these are not off-the-shelf products, but instead are built to order. Therefore modifications and options are almost always possible for those applications with more demanding requirements. In addition, pricing and delivery times can only be determined after first establishing all customer-specific requirements

Table 1 - Typical Waveplate specifications for devices designed for the visible wavelength range. These specifications represent data gathered from a small sample of designs. Actual results will vary as a function of the final design.

<i>Variable Waveplates</i>	<i>Transmission</i>	<i>Polarization Purity</i>	<i>Maximum Switching Frequency</i>
<i>CV Series</i>	<i>80 – 90%</i>	<i>200:1</i>	<i>30 Hz</i>

Above specifications are subject to change without notice. Please contact Boulder Nonlinear Systems for additional updates.

CV Series of Variable Waveplates

The CV Series of Variable Waveplates offers continuously variable polarization rotation between two designed endpoints. This device is not suitable for many broadband applications as the rotation angle achieved will vary as a function of wavelength. The CV Series will give fast response times (typically < 100 us, drive voltage dependant) in one direction (unenergized to energized), while the other direction (energized to unenergized) will be quite a bit slower (typically 10’s of ms, depending on operating temperature and wavelength).

A stable output rotation angle can be held indefinitely, but will vary with changes in drive voltage or operating temperature. The drive signal must be ac, with zero dc offset to prevent damaging the device. Typically a 2 kHz square-wave is suitable. Varying the amplitude of the square-wave (while maintaining a zero dc offset) results in changing the rotation angle.

The CV Series can be designed to provide a variety of finite polarization rotation ranges, typical values might be 90°, 180°, or 360°. Resolution, or rotation step size, will depend only on the resolution of the drive voltage, however it will provide a nonlinear rotation as a function of voltage change.

Device Construction

The Variable Waveplates can be constructed using one of two types of substrates. If the transmitted wavefront distortion (TWD) must be optimized then the devices should be constructed of polished optical flats. Typically this approach will yield a TWD of $< \lambda/10$ at 632.8 nm. However, if thinner devices are required, or price is more of an issue than TWD, thin sheet glass substrates can be utilized in place of the polished optical flats.

Devices built with thin sheet glass substrates require silica spacer beads distributed throughout the clear aperture in order to maintain a uniform liquid crystal layer thickness. This approach may not be appropriate for applications requiring a high optical power density. If the clear aperture is very small, or the substrates are polished optical flats the silica spacer beads can be placed only in the perimeter glue seal.

Devices can be delivered either with or without anti-reflection (AR) coatings. Eliminating the AR coating will typically reduce the price; however it will also increase reflections and reduce the overall transmission accordingly (unless the device will be index matched to another optic – *requires a low-stress approach to avoid damaging the Variable Waveplate*).

Company Profile

Boulder Nonlinear Systems, Inc. (BNS) is an innovative technology company specializing in dynamic liquid crystal polarization control solutions for both laser-based and imaging systems. Company strengths in scientific research and development are leveraged into OEM and standard product offerings targeted for astronomy, biomedical, defense, microscopy, optical computing, optical storage, and telecommunications applications.

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The devices will typically have two short stranded wire leads attached with the free ends stripped of insulation.

Devices are usually not mounted in a housing, but housings can be designed and delivered upon request.

Optical Damage and Temperature

While BNS has not performed any optical damage threshold testing, some of our customers have provided us with their information. Permanent damage has been noted with pulsed lasers at a peak power density of 1 GW/cm². With CW lasers damage has been noted at an average power density of 150 W/cm².

It should be noted that at power densities lower than the permanent optical damage threshold the device performance will begin to change due to thermal effects. Heating a Variable Waveplate above room temperature will result in faster switching speeds, but can also result in poorer optical rotation performance. For the CV Series the total rotation range will decrease as temperature increases.

If the temperatures increase significantly the device will no longer operate until it is cooled down again. For the CV Series this isotropic temperature is approximately 90°C.

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