Acousto Optic Theory

Basic Theory

As shown in Figure 1 (a) and (b), acousto optic devices operate by Bragg diffraction of an incident light beam from a moving acoustic wavefront. The intensity of light diffracted into the output beam is dependent on the power of the acoustic beam which is in turn dependent on the modulation signal input to the driver. The modulation signal to optical output transfer function is monotonic but non-linear. This is unimportant for digital modulation.

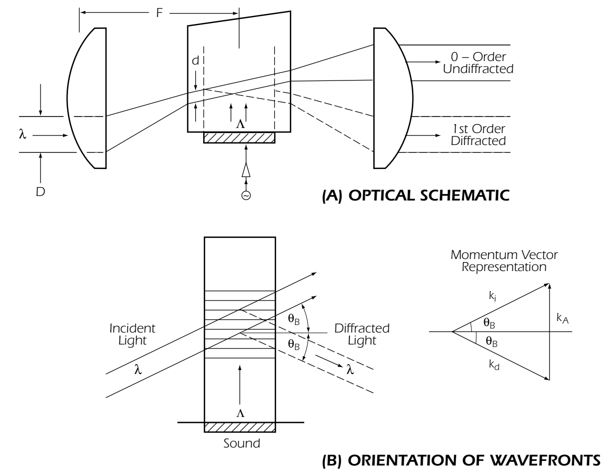

Figure 1. Modulator Configuration

Alignment

For proper modulator operation, the optical beam and sound beam must interact with the proper relationship. This requires several conditions be met simultaneously.

First, the acoustic beam (modulator housing) must be slightly rotated off perpendicular to the optical beam so that the Bragg angle condition is met as shown in Figure 1. This can be accomplished either side of perpendicular with only a slight difference in performance as described later. The proper Bragg angle for each device is tabulated on the individual data sheets.

Second, the modulator must be translated vertically so the optical beam passes through the acoustic beam. This adjustment is more critical for the high-performance (wideband) units which have acoustic beams of very small height. In fact, a slight design compromise is made in these units to avoid having this adjustment be excessively critical. An estimate of the required precision and stability of this adjustment is 25% of the "active aperture", as tabulated on the data sheets, e.g. ~.001" for Model 3350.

Third, the focusing lens for the incident optical beam must be positioned longitudinally so that the optical beam focus (beam waist) is located at the acoustic column. If the beam waist location is determined in air before the modulator is introduced, then the lens should be moved away from the modulator location to account for the increased optical path length inside the modulator crystal. This increment is ~6.2 mm for Models 3080 and 3110, and ~1.7 mm for Model 3200.

To obtain the proper optical beam waist diameter (d) stipulated in the device data sheets requires the following relationship:

$$d = \frac{1.27F\lambda}{D}$$

Where: D = Input laser beam, diameter ($1/e^2$ intensity points)
F = Focal length of input focusing lens
λ = Light wavelength

A single-element, plano-convex lens, oriented as shown, will give satisfactory results.

Finally, in the case of the Model 3350, the optical beam should be positioned close to the acoustic transducer to minimize effects of acoustic attenuation and acoustic beam spreading from diffraction.

Figure 2 is included as an aid in obtaining correct adjustments. The images are shown as outputs without the recollimating optics. However, they should not be viewed directly, but as reflections from a diffuse surface such as a 3 x 5-inch file card. The zero and first orders are point for point complementary (sum = 1). The missing area in the zero order beam corresponds to light diffracted into the first order. In practice, the zero order may be easier to interpret, particularly if the laser power can be reduced to avoid eye saturation.

It should be noted that there is a slight variation in diffraction efficiency with the polarization of the incident optical beam. Polarization perpendicular to the mounting surface of the modulator is usually preferred in TeO_2 devices.

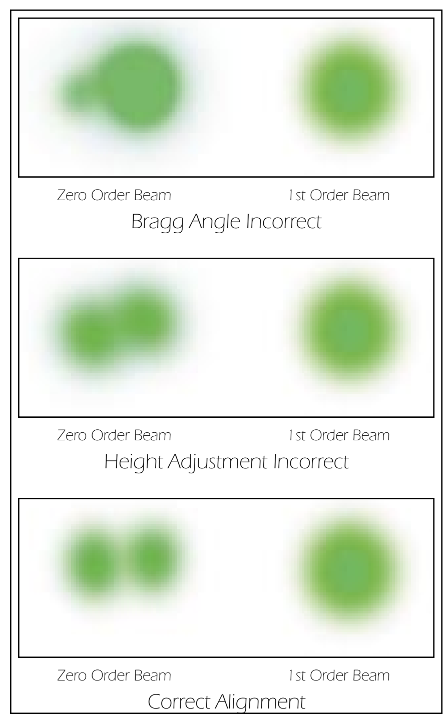

Figure 2. Alignment Beam Patterns