Application Note ***AN4925***

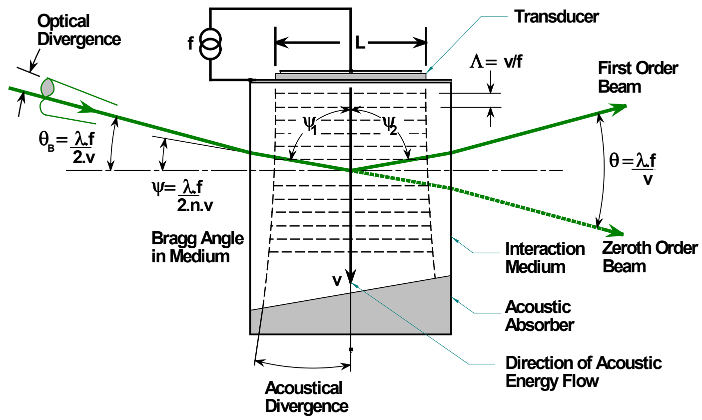
ISOMET

Off-axis AO Deflectors

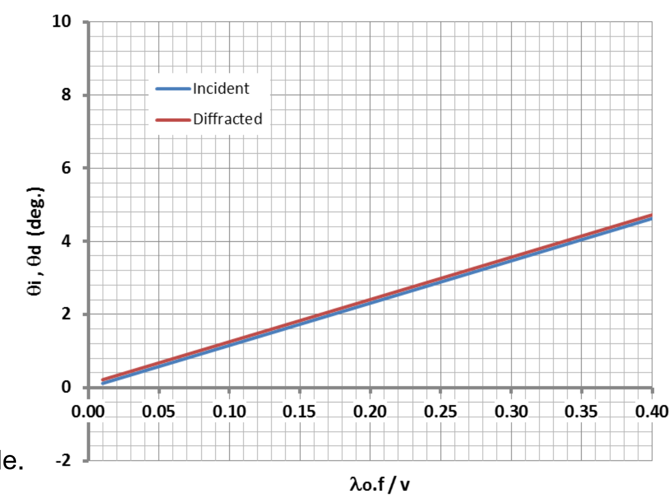
The interaction of sound (RF) and light waves in most AO modulators, frequency shifters and deflectors is defined as Isotropic. The acoustic wave is longitudinal mode. To aid explanation of off-axis deflectors, we will first start with a brief explanation of Isotropic Interaction

Recap: Isotropic Interaction

For isotropic diffraction, the refractive indices for the incident (n_i) and diffracted (n_d) light beams are the same and the relationship between the incident beam θ_i, diffracted beam θ_d and Bragg angle θ_{Bragg} is constant.



A plot of incident and diffracted angles illustrates isotropic phase matching (Bragg angle) is always sensitive to the incident angle regardless of wavelength (λ_o), frequency (f) or velocity (v).

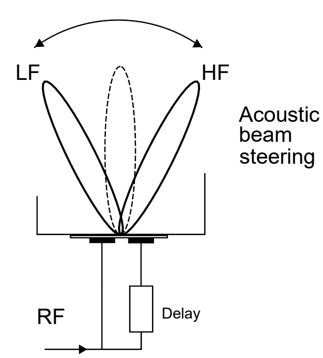


General isotropic device characteristics:

- Easier to fabricate.
- Wider choice of AO crystal materials and thus wavelength/power options.
- Input and output apertures interchangeable.
- Choice of +Bragg or -Bragg orientations.
- Diffracted polarization = Input polarization.
- Polarization insensitive (not all crystals and wavelengths).
- Relatively high acoustic velocities. (large scan angles require wide RF bandwidths)

Acoustic Beam Steering in AO Deflectors

When the RF drive frequency is tuned, the incident angle should be changed in proportion to maintain optimal phase matching (Bragg angle) and produce maximum efficiency into the diffracted first order.



For wide band AO deflector applications, phased array transducers and acoustic beam steering techniques are employed to compensate for this Bragg angle sensitivity. Such methods can generate highly uniform and efficient diffraction characteristics across a wide frequency tuning range.

For more details See App note AO-BeamSteer AN0424

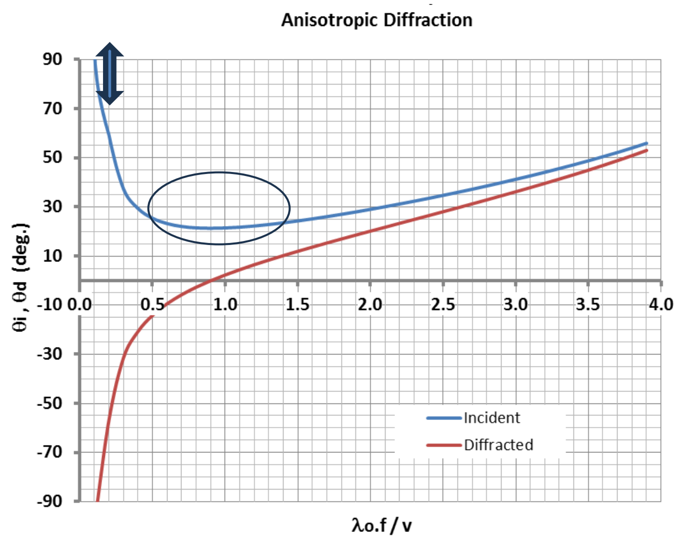
Off-axis AO Deflectors

The interaction of sound (RF) and light waves in off-axis AO modulators, frequency shifters and deflectors is defined as Anisotropic. The acoustic wave is shear mode.

Anisotropic Interaction

Off-axis AO devices exploit the birefringence properties of anisotropic materials in which the refractive indices for the incident (n_i) and diffracted (n_d) beams are different.

The 'Dixon' equations describe the angles of incidence and diffraction for interaction in birefringent materials. These are plotted below:



There are two significant regions:

For AO deflector use

- The first region is about the turning point of the 'Incident' curve (circled). This is an attractive operating point for AO deflectors i.e. a small change in incident 'Bragg' angle over a relatively large change in drive frequency = diffracted beam angle.

  This is an ideal characteristic for wide bandwidth AO deflectors where large scan angles require large frequency tuning ranges. The very low sensitivity to input Bragg angle results in a flat efficiency response for the diffracted beam without employing beam steering techniques described in previously.

For AOTF use

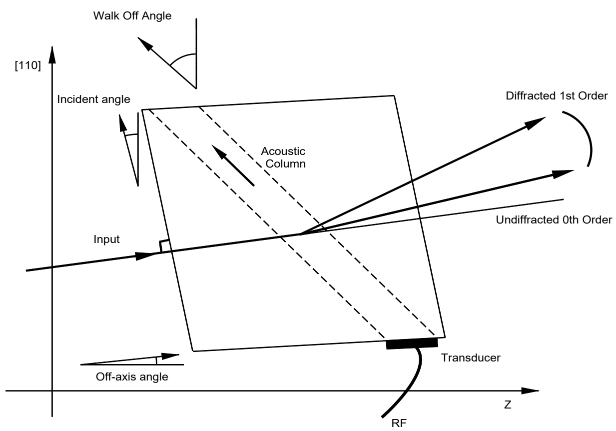
- The second significant region applies to AOTF operation (arrowed).
  This area corresponds to high sensitivity and thus selectivity where diffraction only exists over a very narrow frequency-wavelength range. This region also permits a large acceptance window θ_i for a very narrow change in frequency, ideal for non-laser applications.

General anisotropic, off-axis characteristics:

- More complex to fabricate.
- Limited choice of AO crystals. In practice, TeO_2(s)
- Device orientation is defined by the design.
- Diffracted polarization is rotated 90°with respect to the input (and zero order) polarization.
- Sensitive to input polarization
- Relatively slow acoustic velocity (= large scan angles).

Typical Off-axis devices and orientations

Case 1: Off-axis deflector schematic, orientation A



Case 2: Off-axis modulator/deflector, orientation B