Application Note

ISOMET

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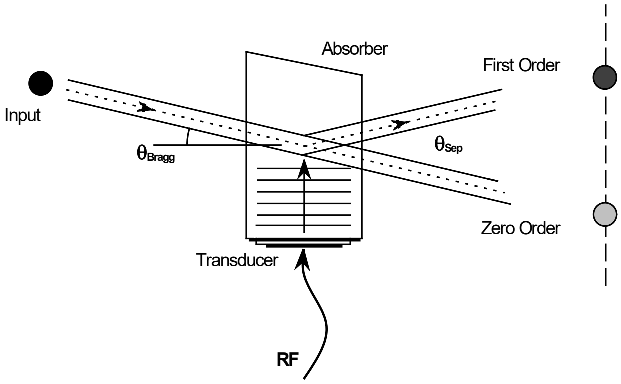
Maximizing AO Diffraction efficiency

Efficiency is typically defined as the ratio of the zero and first order output beams:



Diffraction Efficiency (DE) = $\dfrac{\text{First order (RF On)}}{\text{Zero order (RF Off)}}$

In addition the device exhibits insertion losses due to absorption in the bulk material and losses at the A.R coated surfaces.

Transmission (TX) = $\dfrac{\text{Zero order (RF Off)}}{\text{Input Power}}$

Or alternatively, the insertion Loss (IL) is specified, where IL = (1 - TX) %

The total throughput efficiency is a combination of the above: TE = DE x TX %

Maximum efficiency is achieved at the when the applied RF power is at the saturation value. This value is given by:

$$P_{sat} = \frac{k.\lambda^2.H}{2.L.M_2}$$

where :

v	= acoustic velocity	L	= interaction length
f_c	= RF centre frequency	λ	= wavelength
H	= electrode height	L	= electrode length
M_2	= AO Figure of Merit	k	= Conversion loss (1.2 typ.)

Psat figure will be stated in the AO test data sheet

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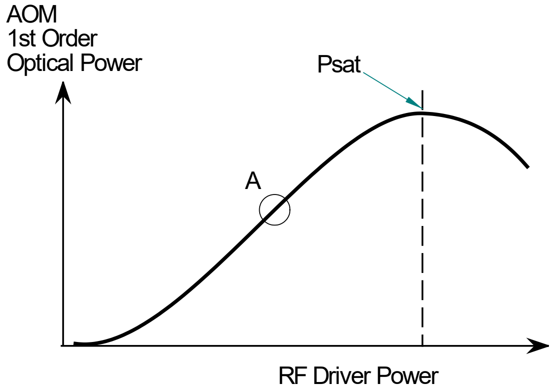
Drive Power Characteristic



As can be seen from the curve above, applying RF power in excess of Psat will cause a decrease in first order intensity (a false indication of insufficient RF power)

DO NOT operate beyond Psat. This will cause excessive thermal effects and may damage the AO device

It is important to set the input Bragg range and laser beam position correctly BEFORE optimizing the efficiency by adjusting the RF power.

The correct sequence is:

1: Align the beam position height in the active aperture

2: Adjust the Bragg Angle, whilst applying low RF drive power (<50% of 'Psat' RF drive power).

3: Peak the RF drive power (refer to note on page 5)

Specific values for beam height, Bragg angle and recommended RF drive powers are given in the appropriate AO device Test Data Sheet.

Isomet RF drivers are set to a nominal power level. This is stated in the respective Test Data Sheet. NOTE: It is **not** matched to any specific AO or operating wavelength.

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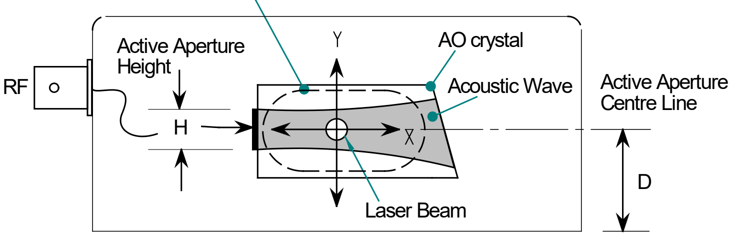
1: Beam Height and Position

Ensure beam is aligned along the acoustic axis and central to the aperture width.
The active aperture 'H' is defined by the electrode height on the transducer.
Most often this is symmetrical within the clear (cover) aperture height.

Diagram below shows a generic AO crystal outline and the acoustic column position.
Best results are achieved when the laser is placed over the AOM Bragg pivot point (this is usually above a dowel pin hole in the base) and at a height 'D' above the base, on the **active aperture** center line.



Input Beam Location
Y axis : Centre the beam in Active Aperture height H, on centre line D mm above base
X axis : Not critical but avoid clipping device cover

(See AO data sheet for dimension D)

2 : Bragg Angle adjustment

For accurate Bragg alignment set the initial RF power to a low level, so that the AOM is operating in the linear region (e.g. region 'A' in the Drive Power curve, page 2)

As a guide, use approximately half the drive power stated in the AO data sheet.

[Isomet RF drivers]
If uncertain of the RF drive power level, rotate the RF PWR ADJ pot anticlockwise until you hear "clicks", (~10 turns) or reach a stop. Then rotate clockwise until you see some diffraction. This should occur within 3 or 4 turns with a multi-turn adjuster or 1/3 of a turn for single turn adjusters. Refer to RF driver manual for control signals.

Maximize the efficiency by carefully rotating the AO device with respect to the input laser beam. The angular adjustment is sensitive.

The exact Bragg angle is given by:

$$\theta_B = \frac{\lambda . f_c}{2.v}$$

Diagram below shows the plus and minus Bragg angle rotations.
Unless stated, the input beam can be directed towards either optic face.

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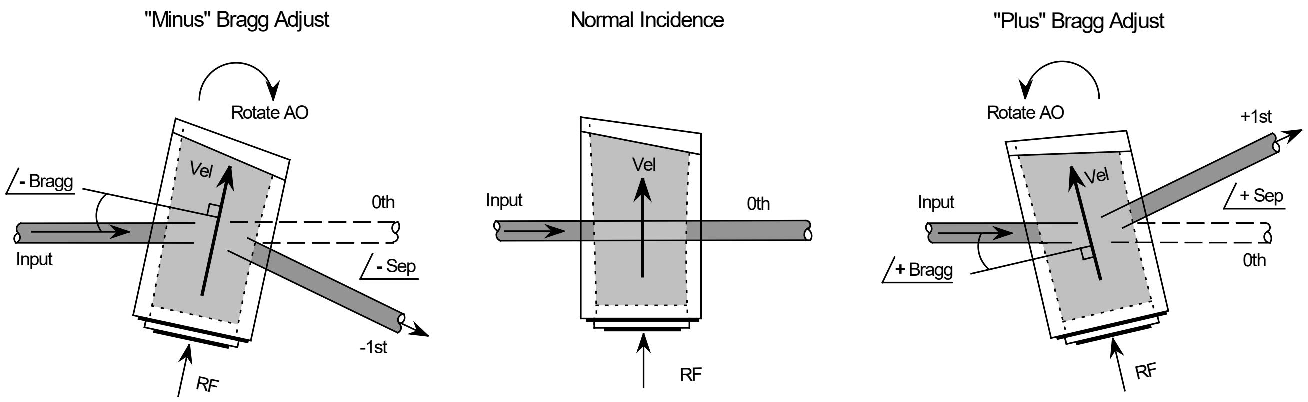
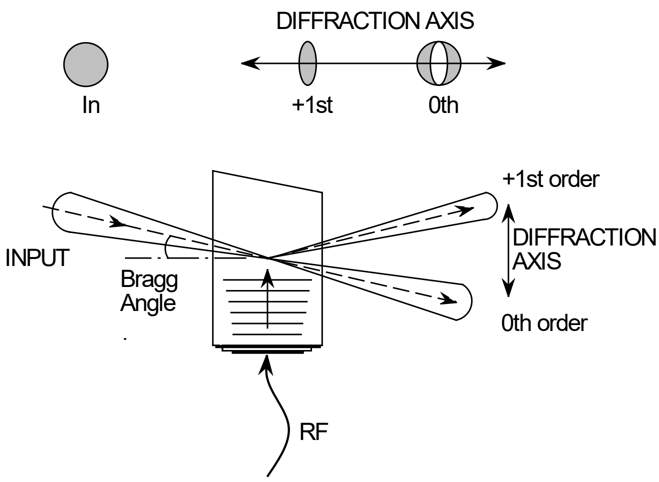


Beam Waist Considerations

To increase the modulation rate, it is necessary to focus the beam into the AO device.

As the beam is increasingly focussed, the efficiency and output beam circularity of the first (1st) order will degrade due to Bragg angle errors. As illustrated in the diagram below, the outer rays of the input cone of light are no longer at the same input angle than the core. The entire beam is not at the optimum Bragg angle and the extremities will not be diffracted as efficiently as the centre. This effect only occurs in the plane along the diffraction axis.



Hint:

The resultant dark line through the centre of the Zero (0th) order can be used as an aid to Bragg angle adjustment. Maximum efficiency is achieved when this line is near centre of the Zero order

3: RF power Set

AFTER the beam position and Bragg angle have been optimised, slowly increase the RF power (rotate PWR ADJ CW) until the first order laser intensity stops increasing and reaches the saturation power level; Psat.

For applications with a diverging or converging input beam in the AOM, the correctly adjusted RF power and Bragg angle condition is indicated when the zero order shows a characteristic dark line through the middle of the beam at or near the Psat RF drive level.

Note:

All AO devices are limited by the total average RF power dissipation.

The optimum RF drive power (Psat) increases with the wavelength squared (λ^2).

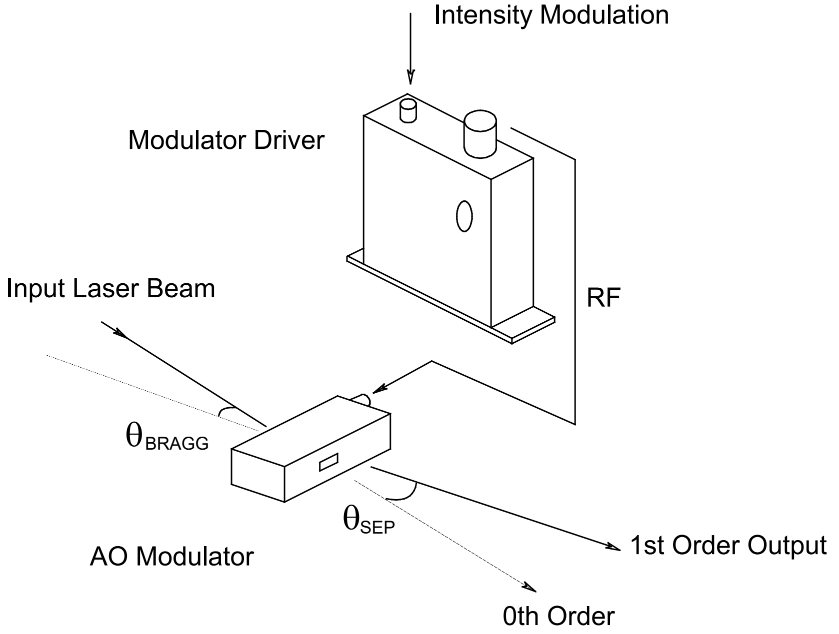
Particularly at NIR wavelengths, the Psat power level is higher than the safe operating maximum limit for the AO device. In such cases, the average or CW diffraction efficiency will be restricted.

For duty cycled operation, higher peak efficiency can still be achieved provided the average RF drive power is less that the maximum power rating.

Other factors:

- Check input laser polarization is appropriately aligned for the AO device.
- Beam diameter is less than the active aperture height (H) of the AO device.
- Laser beam mode TEM_{00} or a Laser Beam Quality factor (*M2*) much less than <2.
- Check the DC voltage supply for the RF driver has sufficient current rating.

Schematic of an acousto optic modulator and driver



The input Bragg angle, relative to a normal to the optical surface and in the plane of deflection, is given by:

$$\theta_{BRAGG} = \frac{\lambda . fc}{2.v}$$

The separation angle between the zeroth order first order outputs is given by:

$$\theta_{SEP} = \frac{\lambda . fc}{v}$$

Optical rise time for a Gaussian input beam is approximately:

$$t_r = \frac{0.65.d}{v}$$

where :	λ	=	wavelength
	fc	=	centre frequency
	v	=	acoustic velocity of interaction material
	d	=	$1/e^2$ beam diameter

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