Acousto-Optic Deflector

Instruction Manual
LS110 & LS110XY series

Precautions

NEVER EXCEED RATED RF INPUT POWER FOR THE DEFLECTOR

PLEASE READ BEFORE ATTEMPTING OPERATION
(I know, who needs manuals but make an exception !!)

Skip to page 5 if theory of operation is not of interest

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1. GENERAL

Both the single axis LS110 and dual axis LS110XY deflectors employ electronic beam steering. It may be helpful to review the basic concepts described in the following section.

2. AO Deflection, Overview.

An AO deflector output is scanned by varying the RF drive frequency. The power in the scanned beam is by controlled by varying the RF amplitude. An ideal acousto-optic deflector would generate a uniform and efficient scan response over the full deflection range. In practice this is difficult to achieve. The optimum laser input angle (or Bragg angle) is frequency dependent. This creates roll-off in the scanned beam efficiency as the drive frequency is swept across the device RF bandwidth to create the scan.

Bragg Angle

First order deflection efficiency is maximised when the laser beam input angle (θ) relative to the acoustic column axis satisfies the Bragg condition :

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

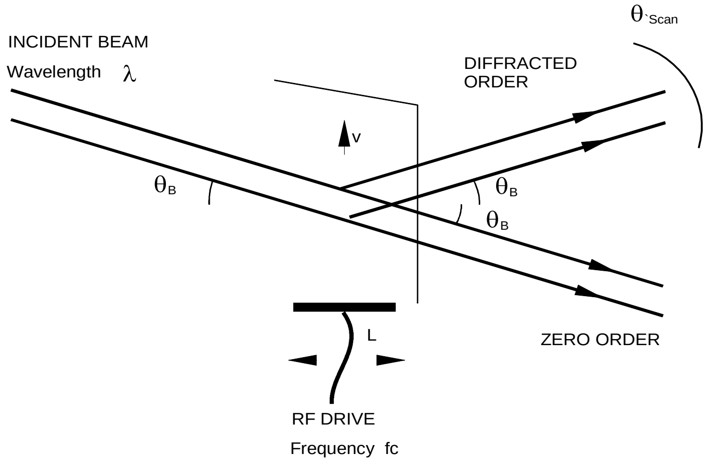
The output scan angle is given by a similar relationship:

$$\theta_{scan} = \frac{\lambda .(fc \pm f)}{v}$$

where :

λ = optical wavelength
v = acoustic velocity
fc = centre frequency
f = frequency

Bragg Diffraction

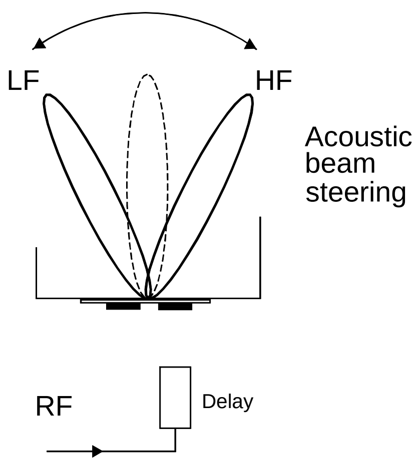


Bragg Angle $\theta_B = \lambda .fc / 2v$

The Bragg angle can only be exactly true for one chosen drive frequency (fc). However to create a scan, it is necessary to sweep the drive frequency (f) either side of the device centre frequency (fc). As a result, at frequencies away from fc, the efficiency of a normal (single electrode) AO device will degrade due to the increasing Bragg angle error.

To circumvent this difficulty, several techniques have been developed to 'steer' the acoustic wave in the AO material and thus track the optimum Bragg conditions over a wider range of frequencies. The goal is to create a uniform response over the broadest possible scan angle

The plot below gives illustrates the benefits of acoustic beam steering



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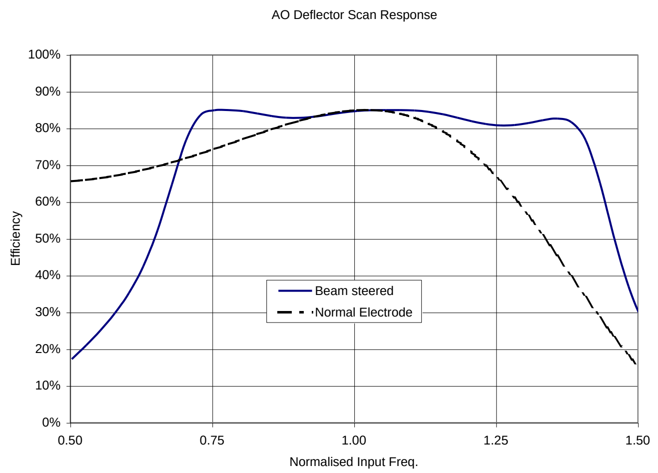
Electronic Beam Steering

The most reliable method uses an array of electrodes on the device transducer, each with an RF signal progressively time delayed.



The fixed delay results in a change in phase between electrodes proportional to the drive frequency. The result is to change the launch angle of the transmitted acoustic beam in the interaction material depending on the drive frequency. By using the correct delay/phase shift and electrode spacing, this active beam steering can be made to track the ideal Bragg angle.

This Beam steering technique is used in many Isomet AO deflectors including the LS110 series, 1250c-BS, 1209-BS and LS600 series deflectors.

We offer a range of compatible RF drivers with integrated power dividers and phase delays e.g.

- DA134-p-xxx Modulator/Deflector Driver with dual phase delayed outputs.
  (Requires an external frequency input)
- D333-2BS integrated VCO and driver with dual phase delayed outputs.
- iHSA-4 quad output, phase controllable synthesizer. .

The DA134 and D333-2BS drivers employ fixed delay lines to introduce the phase offset between the driver outputs. The delay value is determined at time of order and differs with the specification of the particular beam steered deflector.

The iHSA-4 employs a digital synthesizer and is fully programmable in frequency, amplitude and phase. No pre-set delay lines are required. An exact Bragg match can be achieved by programming the appropriate phase differential between the synthesizer outputs for each demanded frequency (scan angle).

For customers supplying their own RF drive source, an RF splitter / delay line assembly can be supplied with the deflector unit.

3. INSTALLATION AND ADJUSTMENT

The description below applies to a Single axis AOD or for the X-axis of an Dual axis deflector.

a. For the initial alignment, ensure the input RF power is set below the saturation power listed on the test data sheet. If the drive electronics are pre-adjusted, this will be indicated. Otherwise assume not.

b. Align the deflector head to insure that the incident light beam is centred in the active aperture of the deflector. The light beam polarization should be linear (perpendicular w.r.t. the LS110A base). The input aperture includes a quarter wave plate. This generates the circularly polarized light required for the orientation of the interaction material. The following explanation assumes the light beam is directed slightly toward the transducer (connector end) of the deflector. See page 11 for possible orientations.

c. Connect the two SMA inputs of the deflector to the RF outputs of the beam steered driver or amplifier, X1 and X2. The delayed output (X2 or 'DLY') should be connected to the SMA nearest the input aperture of the LS110A (J2).

For iHSA-4 configurations, please refer to the iHSA-4 user guide. Skip to paragraph f. below

The Initial Set-up is at a fixed frequency equal to the AOD Centre frequency

IT IS IMPORTANT to make the initial Bragg angle adjustment at a low RF power.
Unless specified or indicated, the RF amplifier / driver supplied will not be optimized for you specific AOD and wavelength.

d. Connect a suitable RF driver source to the 'Input' of the Driver / Amplifier
(or to the Delay line unit / RF splitter)

e. Tune the input frequency source to the mid-frequency point of the AO deflector bandwidth (100MHz or 110MHz for the LS110A Vis, 50MHz or 70MHz for the LS110A NIR).

f. Start be applying approximately half the required RF power (say total 0.5W for vis 1.0W for NIR) at the centre frequency.

For the Isomet DA134 / D333 series this is achieved by adjusting the pot 1/4 to 1/3 clockwise from the fully anti-clockwise position. Turn on DC power.

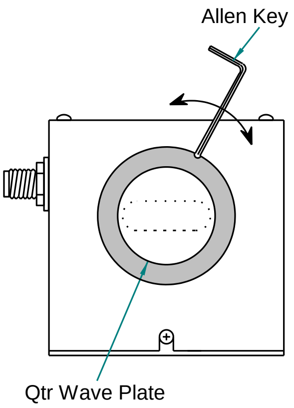
For iHSA-4 (using the Isomet GUI software), use the slider controls to set the Frequency to Fc MHz, Phase to 0 deg and Amplitude to less than half maximum (e.g. 40%)

Starting with the AOD face normal to the laser beam, slowly rotate the deflector clockwise until deflection of the light beam occurs. The deflection will occur in the horizontal plane. Select the diffraction spot to the right of the un-diffracted (zero order) beam and monitor the light intensity by using either a photodetector or a light power meter.

Adjust the Bragg angle for maximum deflected light intensity.
Note for some Beam steered AO deflectors (e.g. LS110), the correct position is the "second" maximum to occur at the first order position. Fine tuning of the incident light beam position may be necessary for optimum results.

g. Depending on the orientation of the Input beam linear polarization, it may be necessary to make an adjustment to the input quarter wave plate. Rotate carefully and slowly. Small holes in the rim of the plate holder will accept a small diameter drill or screwdriver. This will assist as a lever to aid rotation. Rotate to give the maximum diffraction efficiency.

Carefully rotate to maximize the diffraction efficiency



NOTE. For the **LS110 XY**, the waveplates are secured with locking screws. Remove cover to gain access.

h. Adjust the RF power level carefully to achieve best efficiency sweep at the minimum RF power necessary. Do NOT exceed the RF power level at which maximum efficiency is achieved (Psat). Excessive RF drive power will reduce the efficiency and may result in serious damage to the AO crystal.

Scanning Set-up with a swept or sequential frequency input

For the Isomet DA134 / D333BS series

h. To equalise deflection efficiency at the extremes of the scan, alternate between the minimum and maximum desired frequencies and adjust Bragg angle to give the same efficiency for both. (Note: the photo detector or light power meter will require repositioning for the two angles.) Sweeping the freq' input should result in a continuous deflected line output. If significant peaks and troughs are noted across the sweep, it is probable that the phased outputs are connected to the wrong inputs of the AO deflector.

For iHSA-4 based driver,

h. Load the appropriate image scan files and then initiate the internal data clock. This will create a repeating frequency sweep. (see iHSA-4 guide)

A sweeping frequency should result in a continuous deflected line output. If significant peaks and troughs are noted across the scan, it is probable that the phased output(s) is connected to the wrong input of the AO deflector.

Carefully adjust the Bragg angle to give peak the uniformity and scan efficiency

With the iHSA-4, it is possible to custom calibrate and optimize the scan for a very flat response. Please refer to iHSA-4 manual for Calibration routine.

i. The lead lengths between the two outputs of the driver/amplifier (or delay line assembly) and the beam steered deflector should be equal unless otherwise instructed. Unequal lengths of more than a 1cm would introduce a phase error.

For the Isomet D134A / D333-BS series

Within limits, small changes in the relative lead lengths can be used to fine tune the deflector sweep response, although this is not usually required. The Bragg angle would need re-adjustment.

DUAL AXIS

j. For dual axis deflectors such as model LS110A-XY, follow the above procedure initially for the X deflector only. Once adjusted set the deflection of the X axis to mid scan (mid frequency) and adjust the Y axis as above.

Note: For the LS110A-XY, the Y-axis adjuster is locked by 2 Allan head screws either side of the Y-axis pivot point (opposite face to the RF inputs). Slacken before making adjustments.

4. THERMAL EFFECTS

We must consider the thermal effects of this device - both due to optical and acoustic absorption. The majority of heat is generated by RF drive power. As the temperature of the material increases beyond the recommended level, undesired refractive index changes will occur in the material. This results in beam distortion. Ultimately, the crystal will crack due to thermal stresses, if excessive RF power is applied. (>3.0W for a typical visible AO deflector).

5. MAINTENANCE

6.1 Cleaning

It is of utmost importance that the optical apertures of the deflector optical head be kept clean and free of contamination. When the device is not in use, the apertures may be protected by a covering of masking tape. When in use, frequently clean the apertures with a pressurized jet of filtered, dry air.

It will probably be necessary in time to wipe the coated window surfaces of atmospherically deposited films. Although the coatings are hard and durable, care must be taken to avoid gouging of the surface and any residue from cleaning. It is suggested that the coatings be wiped with a soft ball of brushed (short fibres removed) cotton, slightly moistened with clean alcohol. Before the alcohol has had time to dry on the surface, wipe again with dry cotton in a smooth, continuous stroke. Examine the surface for residue and, if necessary, repeat the cleaning.

6.2 Troubleshooting

No troubleshooting procedures are proposed other than a check of alignment and operating procedure. If difficulties arise, take note of the symptoms and contact the manufacturer.

6.3 Repairs

In the event of deflector malfunction, discontinue operation and immediately contact the manufacturer or his representative. Due to the high sensitive of tuning procedures and the possible damage, which may result, no user repairs are allowed. Evidence that an attempt has been made to open the optical head will void the manufacturer's warranty.

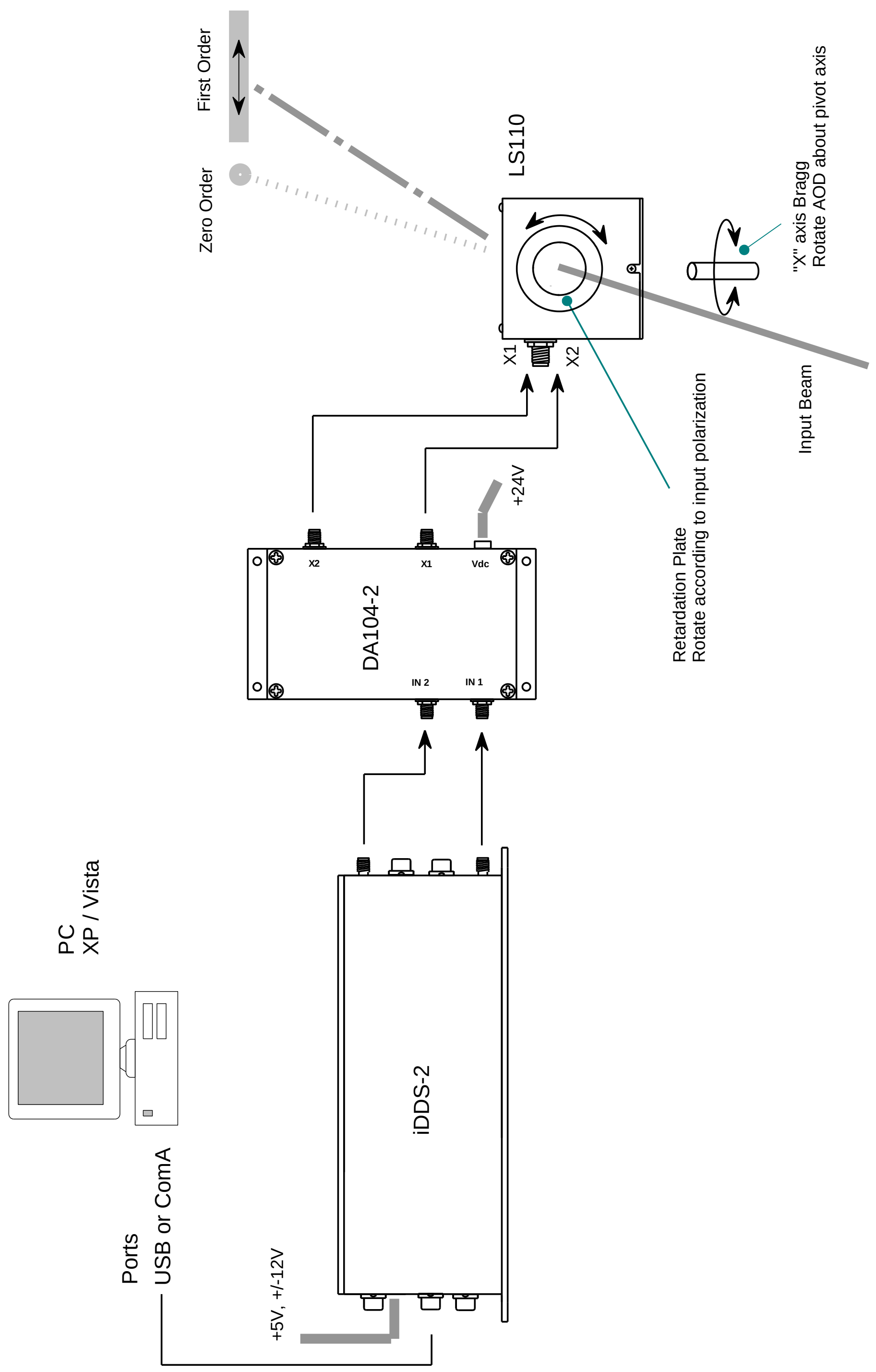


Figure 4a, LS110 Single axis AO deflector configuration

(Not in perspective. Input Beam directed towards RF connectors of AOD)

June2013: iDDS-2 and DA104-2 superseded with iHSA-2 / -4

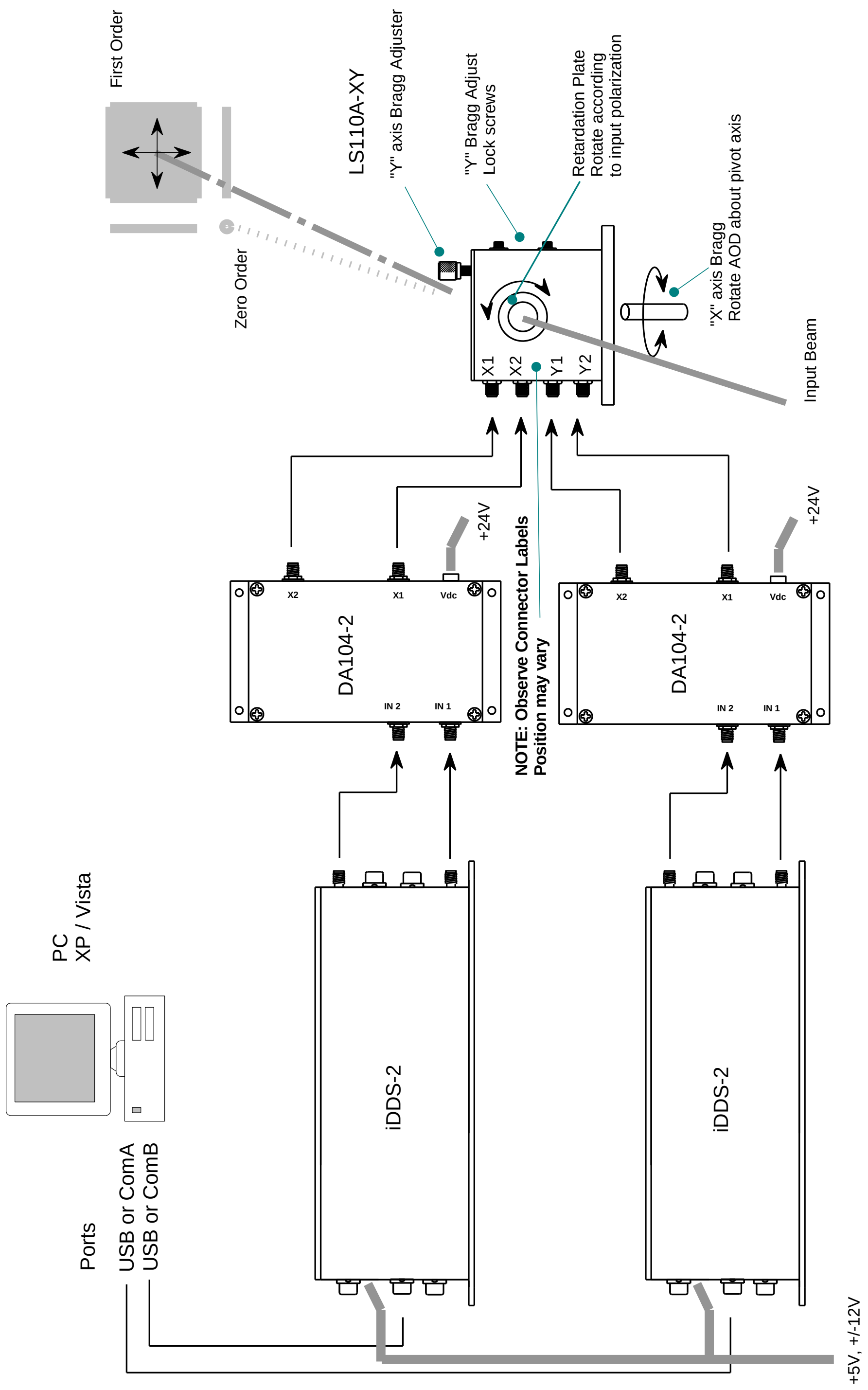
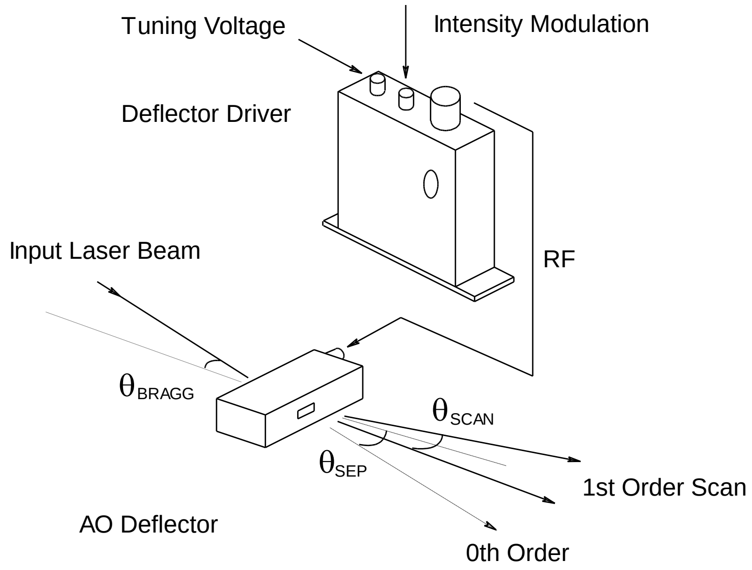


Figure 4b, LS110 Dual axis AO deflector configuration

(Not in perspective. Input Beam directed towards RF connectors of AOD)

June2013: iDDS-2 and DA104-2 superseded with iHSA-2 / -4

Schematic of a single electrode acousto optic deflector and tunable 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 and mid scan point of the first order is given by:

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

The first order scan angle is given by:

$$\theta_{SCAN} = \frac{\lambda . \delta f}{v}$$

The access time or time aperture is given by:

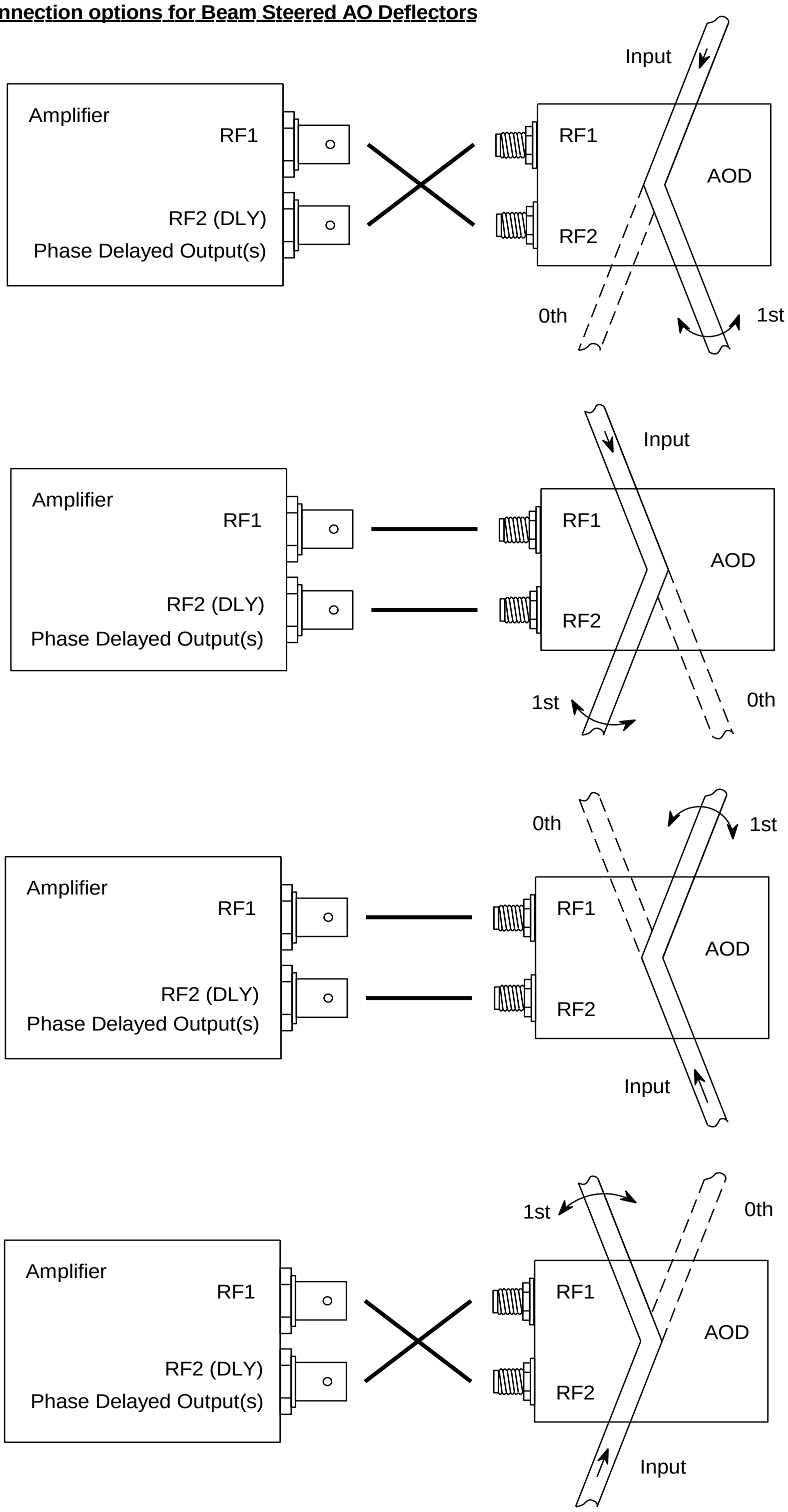
$$T_{acc} = d/v$$

where : λ = wavelength
δf = scan frequency bandwidth
fc = centre frequency
v = acoustic velocity of the crystal material
d = beam diameter

Figure 5, Basic AO Deflector Parameters

Alternative Orientations

Connection options for Beam Steered AO Deflectors



Correct orientation as viewed from top of AOD
(Connector identification may differ)