USER'S GUIDE

Amplitude Modulators

Models 410X

New Focus™
A Newport Corporation Brand

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Warranty

Newport Corporation guarantees its products to be free of defects for one year from the date of shipment. This is in lieu of all other guarantees, expressed or implied, and does not cover incidental or consequential loss.

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Document Number 410412 Rev. G

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Theory and Operation

Introduction

The New Focus 410X series electro-optic amplitude modulators allow you to achieve deep amplitude modulation of your laser beam with a small input voltage, while maintaining large optical apertures. We offer two types of modulators:

- Broadband Amplitude Modulators (AM) for general-purpose applications.
- Resonant Amplitude Modulators (RAM) which are tuned to user-specified frequencies.

Benefits include low drive voltage, high modulation frequency, low insertion loss, good RF shielding, and high power handling capability. Specifications are show in the table on page 10. The 4101, 4102, 4103 and 4104 modulators are provided in lithium niobate. The user is free to define the modulation frequency of the resonant modulators.

Theory

The 410X series amplitude modulators require external polarizers at the input and output. Without the external polarizers, these amplitude modulators are actually voltage-variable waveplates. (Polarizers are not provided with the modulators so that you may vary the polarizers used according to your specific application.)

When the amplitude modulator is placed between crossed polarizers the output is given by the equation:

$$I_0 = I_i \, \mathrm{Sin}^2 \left\{ \frac{V_i}{V_\pi} \cdot \frac{\pi}{2} + \phi_0 \right\}$$

where I_i is the input intensity, ϕ_0 is any intrinsic or extrinsic state phase bias, V_i is the input drive voltage, and V_π is shown approximately in the specifications table on page 10. The extinction ratio depends on the quality of the polarizers. With high-quality polarizers, extinction ratios of 50:1 are achievable.
When the DC bias is set to $V_\pi/2$ the output intensity is given by:

$$I_0 = I_i \, \frac{1}{2} \cdot \left[1 + \sin \left\{ \frac{V_i}{V_\pi} \cdot \pi \right\} \right]$$

Performance of the amplitude modulators is defined by insertion loss, V_π, and the voltage standing wave ratio (VSWR).

Insertion Loss

Insertion loss is determined by the absorption and scatter in the electro-optic crystal, and by the quality of the anti-reflection coatings on the end faces. Low optical losses are critical in applications of the New Focus amplitude modulators, so great care is taken to ensure insertion loss is minimized.

Modulation Depth

This describes the magnitude of the amplitude modulation imposed on the input laser beam by the modulator. This depth is optimized by New Focus' resonant circuit design which drives the resonant modulator, and by optimizing the alignment of the input beam's polarization with the crystal active axis.

Voltage Standing Wave Ratio (VSWR)

The VSWR describes the level of impedance matching between the driving source and the amplitude modulator, which directly affects the power transfer into the device. Resonant amplitude modulators are designed to be very close to 50 Ω at resonance. Thus, they will have a greatly enhanced return loss at the specified resonant frequency. All New Focus resonant amplitude modulators are accurately tested for VSWR by looking at return loss vs. frequency around the modulation frequency. These results are provided at the rear of this manual.

Operation

Aligning the module to the optical beam:

1. Mount the module on an adjustable positioning device using the 1/4"-20 tapped hole on the base of the module. We recommend the New Focus Model 9071 tilt aligner because of its tilt and translation capabilities.
2. Turn on the optical beam. Orient the beam so it is vertically or horizontally polarized on the input aperture. The x- and z-crystal axes are oriented ±45° with respect to vertical. Polarizers are not provided with the amplitude modulators.
3. Position and align the module so that the beam passes through the 2-mm input and output apertures, clearing them without clipping. The beam should be collimated with a diameter of less than 2 mm, but such that the Rayleigh range is at least the length of the crystal. A good beam diameter is 200–500 μm.

Note: Since the optical alignment on any modulator can be disturbed by the drive cable, ensure that the cable does not place a significant force on the modulator.

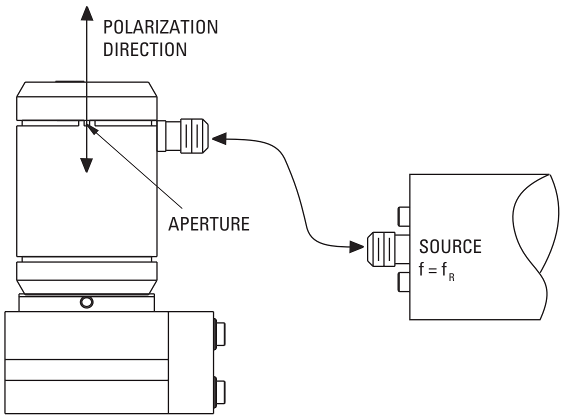

Figure 1: A high-frequency resonant modulator driven by a source tuned to f_R. The module is mounted on a Model 9071 tilt aligner.

Setting Up the Input Signal:

Using a cable with an SMA connector, connect the input port on the back of the module to a modulating source appropriate for the type of modulator you are using (resonant or broadband).

Resonant modulators are tuned to a specific frequency and require very low drive voltages, such as that from a simple crystal oscillator or a function generator that has an output impedance near 50 Ω. Resonant modulators have a greatly reduced return loss at the specified frequency compared to broadband modulators.

Broadband modulators require large drive voltages and have a bandwidth dependent on the impedance of the modulating source. With a 50-Ω source, the bandwidth will be approximately 200 MHz. The source must be able to drive an open circuit without causing damage to the source.

Linear Amplitude Modulation

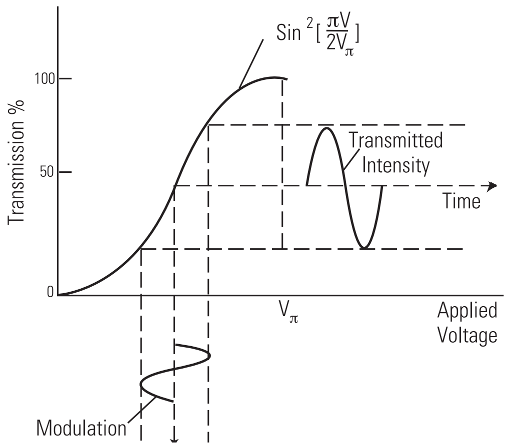

Figure 2:
The transfer function of an amplitude modulator between crossed polarizers is a sin² function.

Linear amplitude modulation can be achieved over a limited range by biasing the amplitude modulator at the quarter-wave point which is equivalent to the 50%-transmission point. This can be achieved either by applying a DC-bias voltage and a small RF signal to the modulator, or by including a quarter waveplate oriented either vertically or horizontally.

Specifications

	4101 **4103**	**4102** **4104**
Wavelength	500-900 nm (4101) 900-1600 nm (4003)	500-900 nm (4102) 900-1600 nm (4104)
Type	Resonant AM	Broadband AM
Operating Frequency*	.01 - 250 MHz (single frequency)	DC-200MHz
Max $V\pi$	16 V (532 nm) 30 V (1000 nm)	160 V (532 nm) 300 V (1000 nm)
Material	$LiNbO_3$	$LiNbO_3$
Max Optical Intensity**	0.5 W/mm^2 (532 nm) 1 W/mm^2 (1300 nm)	0.5 W/mm^2 (532 nm) 1 W/mm^2 (1300 nm)
Aperture	2 mm	2 mm
Insertion Loss***	<0.3 dB	<0.3 dB
RF Bandwidth	2-4 % of center frequency	200 MHz
Connector	SMA	SMA
Impedance	50 Ω	10 pF
Max. RF Power	1 W	10 W
Max VSWR	1.5	N/A

* Resonant modulators must be specified to a single frequency.
** In a 1 mm beam.
*** Insertion loss is wavelength dependent.

Customer Service

Technical Support

Information and advice about the operaion of any New Focus product is availabe from our applications engineers. For quickest response, ask for "Technical Support" and know the model number and serial number for your product.

Hours: 8:00–5:00 PST, Monday through Friday (excluding holidays).

Toll Free: 1-866-NUFOCUS (1-866-683-6287)
(from the USA & Canada only)

Phone: (408) 980-5903

Support is also available by fax and email:

Fax: (408) 987-3178

Email: techsupport@newfocus.com

We typically respond to faxes and email within one business day.

Service

In the event tht your modulator malfunctions or becomes damaged, please contact New Focus for a return authorization number and instructions on shipping the unit back for evaluation and repair.

Appendix I

Model Number: ______________________________

Serial Number: ______________________________

Frequency: ______________________________

Wavelength: ______________________________

Input RF Power: ______________________________

Return Loss: ______________________________

VSWR: ______________________________

Q: ______________________________