Electro-Optic Modulators

Electro-Optic Modulator Family

Scientists and engineers rely on our optical modulators for exceptional performance, quality, ease of use, broad selection, and excellent value.

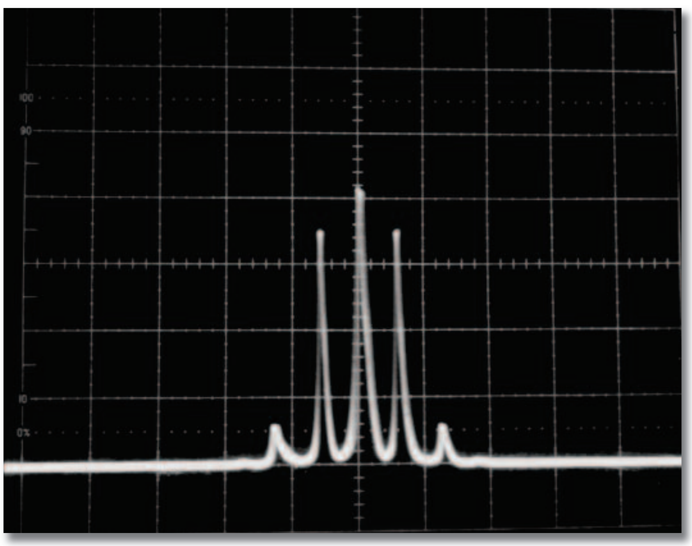
Simply Better™ Photonics

New Focus™
A Newport Corporation Brand

New Focus Simply Better Photonics

New Focus™ offers a broad line of optical modulators and drivers that are versatile, reliable and easy to use. All our optical modulators are based on the electro-optic or Pockels' effect—the linear dependence of the index of refraction on an applied electric field. Applying a voltage across the electrodes of an electro-optic crystal changes the effective refractive index and thus the phase of light as it passes through the crystal.

Our amplitude modulators span the frequency range from DC to 250 MHz while our phase modulators span an impressive frequency range from DC to 9.2 GHz, and feature low drive voltages, low insertion losses, and high maximum optical powers. They use lithium niobate (LiNbO3), magnesium-oxide-doped lithium niobate (MgO:LiNbO3), and KTP crystals which have large electro-optic coefficients minimizing required drive voltages. In addition, the small loss tangents at RF frequencies of LiNbO3 and KTP permit operation of these devices over a broad range of frequencies from DC to 9.2 GHz. LiNbO3 and KTP are also non-hygroscopic, and have high maximum optical-power limits and low optical insertion loss.



Transmitted intensity spectrum from a scanning Fabry-Perot optical spectrum analyzer. The 1.06-μm laser was phase modulated with a Model 4003 resonant phase modulator. The driving frequency was 7.94 MHz and the peak voltage was 3 V.

- Broad Selection
- Exceptional Performance and Quality
- Excellent Value
- Easy to use
- Easy Optical Alignment

Aligning our modulators is easy with the Model 9071 four-axis tilt aligner.

Electro-Optic Modulator Selection Guide

Standard Phase Modulators

- Phase modulators can generate frequency sidebands on a cw optical beam
- Frequency range from DC to 9.2 GHz
- Resonant designs offer very low drive voltages
- Blue, Visible, and IR Wavelengths

Modulator Series[1]	Wavelength Range	Type	Operating Frequency[2]	Modulation Depth	Max Optical Intensity[3]	Material
Standard Phase Modulators						
4002	500-900 nm	Broadband	DC-100 MHz	30 mrad/V @ 532 nm	2 W/mm² @ 532 nm	$MgO:LiNbO_3$
4004	900-1600 nm	Broadband	DC-100 MHz	15 mrad/V @1000 nm	4 W/mm² @ 1064 nm	$MgO:LiNbO_3$
4005	360-500 nm	Resonant	0.01-250 MHz	0.27 - 0.8 rad/V @ 364 nm	0.1 W/mm² @ 364 nm	$MgO:LiNbO_3$
4006	360-500 nm	Broadband	DC-100 MHz	40 mrad/V @ 364 nm	0.1 W/mm² @ 364 nm	$MgO:LiNbO_3$
4001NF	500-900 nm	Resonant	0.01-250 MHz	0.2 - 0.6 rad/V @ 532 nm	2 W/mm² @ 532 nm	$MgO:LiNbO_3$
4003NF	900-1600 nm	Resonant	0.01-250 MHz	0.1 - 0.3 rad/V @ 1000 nm	4 W/mm² @ 1064 nm	$MgO:LiNbO_3$
4425-01	360-500 nm	Resonant	0.25 - 0.75 GHz	0.14 - 0.28 rad/V @ 364 nm	0.1 W/mm² @ 364 nm	$MgO:LiNbO_3$
4421-01	500-900 nm	Resonant	0.25 - 0.75 GHz	0.094 - 0.19 rad/V @ 532 nm	2 W/mm² @ 532 nm	$MgO:LiNbO_3$
4423-01	900-1600 nm	Resonant	0.25 - 0.75 GHz	0.05 - 0.10 rad/V @ 1000 nm	4 W/mm² @ 1064 nm	$MgO:LiNbO_3$
4425-02	360-500 nm	Resonant	0.75 - 1.0 GHz	0.14 - 0.28 rad/V @ 364 nm	0.1 W/mm² @ 364 nm	$MgO:LiNbO_3$
4421-02	500-900 nm	Resonant	0.75 - 1.0 GHz	0.094 - 0.19 rad/V @ 532 nm	2 W/mm² @ 532 nm	$MgO:LiNbO_3$
4423-02	900-1600 nm	Resonant	0.75 - 1.0 GHz	0.05 - 0.10 rad/V @ 1000 nm	4 W/mm² @ 1064 nm	$MgO:LiNbO_3$
4425-03	360-500 nm	Resonant	1.0 - 2.0 GHz	0.14 - 0.28 rad/V @ 364 nm	0.1 W/mm² @ 364 nm	$MgO:LiNbO_3$
4421-03	500-900 nm	Resonant	1.0 - 2.0 GHz	0.094 - 0.19 rad/V @ 532 nm	2 W/mm² @ 532 nm	$MgO:LiNbO_3$
4423-03	900-1600 nm	Resonant	1.0 - 2.0 GHz	0.05 - 0.10 rad/V @ 1000 nm	4 W/mm² @ 1064 nm	$MgO:LiNbO_3$
4435-01	360-500 nm	Resonant	2.0 - 2.5 GHz	0.11 - 0.19 rad/V @ 364 nm	0.1 W/mm² @ 364 nm	$MgO:LiNbO_3$
4431-01	500-900 nm	Resonant	2.0 - 2.5 GHz	0.075 - 0.13 rad/V @ 532 nm	2 W/mm² @ 532 nm	$MgO:LiNbO_3$
4433-01	900-1600 nm	Resonant	2.0 - 2.5 GHz	0.04 - 0.07 rad/V @ 1000 nm	4 W/mm² @ 1064 nm	$MgO:LiNbO_3$
4435-02	360-500 nm	Resonant	2.5 - 4.6 GHz	0.11 - 0.19 rad/V @ 364 nm	0.1 W/mm² @ 364 nm	$MgO:LiNbO_3$
4431-02	500-900 nm	Resonant	2.5 - 4.6 GHz	0.075 - 0.13 rad/V @ 532 nm	2 W/mm² @ 532 nm	$MgO:LiNbO_3$
4433-02	900-1600 nm	Resonant	2.5 - 4.6 GHz	0.04 - 0.07 rad/V @ 1000 nm	4 W/mm² @ 1064 nm	$MgO:LiNbO_3$
4435-03	360-500 nm	Resonant	4.6 - 5.0 GHz	0.11 - 0.19 rad/V @ 364 nm	0.1 W/mm² @ 364 nm	$MgO:LiNbO_3$
4431-03	500-900 nm	Resonant	4.6 - 5.0 GHz	0.075 - 0.13 rad/V @ 532 nm	2 W/mm² @ 532 nm	$MgO:LiNbO_3$
4433-03	900-1600 nm	Resonant	4.6 - 5.0 GHz	0.04 - 0.07 rad/V @ 1000 nm	4 W/mm² @ 1064 nm	$MgO:LiNbO_3$
4855-06	360-500 nm	Resonant	6.3 - 7.5 GHz	0.11 rad/V @ 364 nm	0.1 W/mm² @ 364 nm	$MgO:LiNbO_3$
4851-02	500-900 nm	Resonant	6.3 - 7.5 GHz	0.075 rad/V @ 532 nm	2 W/mm² @ 532 nm	$MgO:LiNbO_3$
4853-04	900-1600 nm	Resonant	6.3 - 7.5 GHz	0.04 rad/V @ 1000 nm	4 W/mm² @ 1064 nm	$MgO:LiNbO_3$
4855-05	360-500 nm	Resonant	9.2 GHz	0.08 rad/V @ 364 nm, 7-7.5 GHz	0.1 W/mm² @ 364 nm	$MgO:LiNbO_3$
4851-01	500-900 nm	Resonant	9.2 GHz	0.056 rad/V @ 532 nm, 7-7.5 GHz	2 W/mm² @ 532 nm	$MgO:LiNbO_3$
4853-03	900-1600 nm	Resonant	9.2 GHz	0.03 rad/V @ 1000 nm, 7-7.5 GHz	4 W/mm² @ 1064 nm	$MgO:LiNbO_3$

Note: All modulators are built with universal mounting options

[1] More specifications available on the Newport website. Specifications are subject to change.

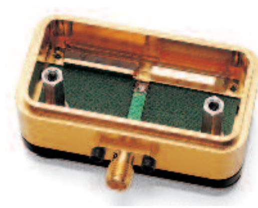
[2] Resonant modulators must be specified to a single frequency

[3] In a .05 mm beam

High Damage Threshold Phase Modulators

- High optical-damage thresholds—5x our LiNbO3 versions
- Covering frequency range from 10kHz to 2.0 GHz
- Resonant designs with large modulation depths
- Visible and IR wavelengths

Amplitude Modulators



- Used to create power fluctuations in signal
- Covering frequency range from DC to 250 MHz
- Can be used as electronically variable wave plates
- Visible and IR wavelengths

High Efficiency Phase Modulators

- High efficiency (2x standard) for high modulation depth
- Frequency range from 0.5 to 2.0 GHz
- Blue, Visible and IR wavelengths

Broadband and Resonant Modulator Drivers

- High-Voltage Amplifier for Driving Broadband Modulators
- Integral frequency source and power amplifier
- Provides high modulation depths at frequencies up to 2 GHz

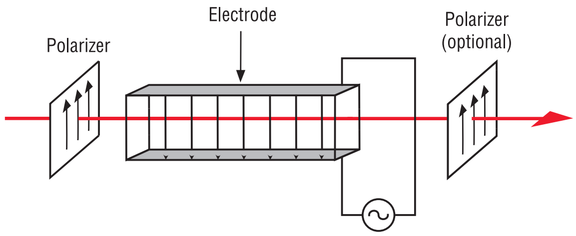
Modulator Series[1]	Wavelength Range	Type	Operating Frequency[2]	Modulation Depth	Max Optical Intensity[3]	Material
High Damage Threshold Modulators						
4062NF	500-900 nm	Broadband	DC-250 MHz	26 mrad/V @ 532 nm	10 W/mm² @ 532 nm	KTP
4064	1000-1600 nm	Broadband	DC-250 MHz	13 mrad/V @ 1000 nm	20 W/mm² @ 1064 nm	KTP
4061	500-900 nm	Resonant	0.1-250 MHz	0.16 - 0.3 rad/V @ 532 nm	10 W/mm² @ 532 nm	KTP
4063	1000-1600 nm	Resonant	0.1-250 MHz	0.08 - 0.16 rad/V @ 1000 nm	20 W/mm² @ 1064 nm	KTP
4461	500-900 nm	Resonant	0.6 - 2.0 GHz	0.094 - 0.19 rad/V @ 532 nm	10 W/mm² @ 532 nm	KTP
4463	1000-1600 nm	Resonant	0.6 - 2.0 GHz	0.05 - 0.1 rad/V @ 1000 nm	20 W/mm² @ 1064 nm	KTP
High Efficiency Phase Modulators						
4445	360-500 nm	Resonant	0.5 - 2.0 GHz	0.28 - 0.55 rad/V @ 364 nm	0.1 W/mm² @ 364 nm	$MgO{:}LiNbO_3$
4441	500-900 nm	Resonant	0.5 - 2.0 GHz	0.19 - 0.38 rad/V @ 532	2 W/mm² @ 532 nm	$MgO{:}LiNbO_3$
4443	900-1600 nm	Resonant	0.5 - 2.0 GHz	0.1 - 0.2 rad/V @ 1000 nm	4 W/mm² @ 1064 nm	$MgO{:}LiNbO_3$
Amplitude Modulators						
4102NF	500-900 nm	Broadband AM	DC-200 MHz	NA	0.5 W/mm² @ 532 nm	$LiNbO_3$
4104NF	900-1600 nm	Broadband AM	DC-200 MHz	NA	1 W/mm² @ 1300 nm	$LiNbO_3$
4101NF	500-900 nm	Resonant AM	0.01-250 MHz	NA	0.5 W/mm² @ 532 nm	$LiNbO_3$
4103	900-1600 nm	Resonant AM	0.01-250 MHz	NA	1 W/mm² @ 1300 nm	$LiNbO_3$

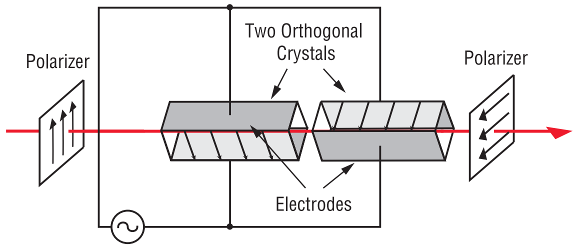
Note: All modulators are built with universal mounting options
[1] More specifications available on the Newport website. Specifications are subject to change.
[2] Resonant modulators must be specified to a single frequency
[3] In a 1 mm beam

Phase Modulators

Phase modulators are used to vary the phase of an optical beam. When driven sinusoidally, phase modulators can generate frequency sidebands on a cw optical beam. Sinusoidal phase modulation at a frequency Ω generates frequency sidebands at multiples of Ω about the central optical frequency.

Given a sinusoidal phase modulation at frequency Ω and a peak phase modulation m, the phase variation is $\phi(t)=m\sin(\Omega t)$. The electric field of the optical beam after passing through the modulator can be seen below.





Left: When a phase modulator is used, the laser beam should be well collimated and its polarization should be oriented vertically to within 1°. For an unpolarized laser, the polarizer should have an extinction ratio greater than 100:1. We recommend our Glan-Thompson polarizers or our low-cost sheet polarizers.

Right: In our amplitude modulators, we mount the crystals at 45°. The input beam should be either vertically or horizontally polarized.

NOTE: *Polarizers are available separately.*

Amplitude Modulators

A bulk electro-optic amplitude modulator consists of a voltage-tunable wave plate followed by a polarizer. †Thus, the modulation of the intensity is a $\sin^2$ function. If the input polarization is oriented at 45° to the crystal axes, the applied voltage will produce a variable phase delay between the ordinary and extraordinary field components.

New Focus simplifies your optical setup by mounting the crystal at 45°. Thus, the input polarization can be either vertical or horizontal. In order to suppress birefringence variations due to temperature changes, we use two matched crystals arranged in series with their applied electric fields oriented at 90° relative to each other.

† We do not recommend using a general-purpose phase modulator as an amplitude modulator. This will result in a slowly varying amplitude modulation, due to the temperature-dependent birefringence of the phase-modulator crystal.

Broadband Versus Resonant Modulators

Our modulators are available in both broadband and resonant configurations. Broadband modulators can be driven over a range of frequencies, while resonant modulators operate at a single customer-specified frequency.

The advantage of the broadband devices is that they can be operated from DC to 100 MHz (200 MHz for the Model 4104 amplitude modulator), making them appropriate for applications where modulation over a broad frequency range is required. However, since the input drive voltage is applied directly across the crystal electrodes, these devices require a relatively high drive voltage, making it difficult to achieve large modulation depths.

For applications requiring modulation at a single frequency, resonant modulators are preferred because much higher modulation can be achieved with a given drive voltage.

Phase and Amplitude Modulator Definitions of Characteristics

Maximum Optical Intensity
The maximum optical intensity of a 1-mm-diameter beam that can be passed through the crystal without causing photorefractive damage. Note that this optical damage threshold is strongly wavelength dependent.

Maximum RF Power
The maximum recommended RF drive power. Above this power, the electronic components will saturate or thermal effects in the crystal (such as thermal lensing) will become a problem.

Maximum Vπ
The voltage required to achieve a π phase shift at a given wavelength. It is proportionately smaller at shorter wavelengths. The Vπ is much smaller for resonant devices because the resonant circuit provides significant voltage enhancement.

Modulation Depth (only for Phase Modulators)
The resulting phase change when 1 V is applied to the modulator. The modulation depth is much larger for resonant phase modulators because the resonant circuit provides voltage enhancement when operating on resonance.

Frequency
The range of electrical frequencies over which a modulator can operate. For resonant modulators, the specific resonant frequency can be chosen anywhere within this range when ordering the modulator.

VSWR
The voltage standing-wave ratio (VSWR) is defined as the ratio between the maximum and minimum voltages along a standing wave that results from electrical reflections due to an impedance mismatch. A VSWR value of 1 indicates a perfectly matched system.

Wavelength
The wavelength range of the crystal's AR coating.

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Newport Corporation, Irvine, California and Franklin, Massachusetts; Evry and Beaune-La-Rolande, France and Wuxi, China have all been certified compliant with ISO 9001 by the British Standards Institution. Santa Clara, California is DNV certified.

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