Electro-optic components and systems

Laser Modulation

Choose from our line of modulators and driver electronics

Conoptics manufactures an extensive line of low voltage electro-optic light modulators, driver electronics, and associated components to satisfy your diverse requirements.

Your application will dictate which versions of modulator and driver electronics you need and what auxiliary components you should use. Just view that information on the technical tabs to learn the characteristics of standard products and their operating parameters.

Drive Electronics
In general, the first application requirements considered in the choice of modulation system components are the information bandwidth and waveform requirement. The driver output voltage achievable is a function of amplifier bandwidth and, while this system parameter is not isolated from others, such as aperture diameter, operating wavelength, etc., it is normally the limiting parameter of the system. Standard Conoptics products include four general purpose drivers: The Models 10, 25, 50 and 100 are dc coupled broadband amplifiers which require an input of 1 volt p-p into 50 ohms for full rated output. Their bandwidths are a function of the modulator used. Each model requires a different electrical configuration in the associated modulator. The Model 10 requires that the modulator be configured as a lumped capacitor. The Model 25 requires a 100 ohm balanced line; the Model 50, a 50 ohm balanced line; and the Model 100, a two segment (4 port) 50 ohm balanced line. The Model 302 is primarily intended for low signal bandwidth, long optical wavelength applications. It also offers cost advantages over higher frequency broadband drivers, especially since, due to its high voltage output, shorter capacitive modulators can be used. The bandwidth of the Model 302 ranges from 150 to 200 kHz depending on the modulator used. Input requirement is 4 volts p-p into 50 ohms. All models include a built in manual bias control.

Optical Modulators
All modulators listed in this data sheet are of the transverse field type, that is, the electric field produced by the applied signal voltage is perpendicular to the optical propagation direction. The voltage swing required by a given modulator at a given operating wavelength to transit between the full off state to the full on state is called the Half Wave Voltage (VÂ½). The transverse field structure allows reduction of VÂ½ by manipulation of the crystal length to aperture ratio to a level achievable by available driver electronics. VÂ½ is roughly proportional to wavelength and long wavelength devices usually require higher length to aperture ratios to accommodate existing driver output levels. Conoptics offers modulators constructed with three different crystal species: Ammonium Dihydrogen Phosphate (ADP), Potassium Dideuterium Phosphate (KD*P), and Lithium Tantalate (LTA). Models 370, 380, and 390 utilize ADP as the active element. The unique feature of these models is the virtual non-existence of piezoelectric resonances. Models belonging to the 360 series utilize LTA. LTA has the lowest intrinsic VÂ½ and the longest wavelength IR cutoff. Furthermore, it has a combination of high refractive index and relatively low dielectric constant which allows modulators to be designed which make full use of the intrinsic driver frequency response. Models in the 360 series exhibit piezoelectric resonances but they are discrete and very narrow. KD*P is used in Model 350 series modulators. In terms of optical transmission bandwidth and driver frequency response utilization, this series falls in between ADP and LTA versions.

Modulator Modifications
Any of the modulators listed here can be used as a phase modulator by simply rotating the input polarization direction by 45Â°. This procedure makes one of the modulator half segments essentially inactive and doubles VÂ½ (now the voltage required for a 180Â° phase shift). A factory modification can be made during construction which restores VÂ½ to its original value. This modification precludes use of the device as an intensity modulator, however, and is irreversible.

Auxiliary Components With the exception of 360 Series, modulators used at wavelengths longer than 2000nm, an integral Glan type polarizer (analyzer) is supplied with each model listed here. Operation at longer wavelengths requires polarizers of a different type and may be additional cost items. Other components such as quarter wave plates used in polarization rotators, are also available from Conoptics. The most commonly used auxiliary components are Automatic Bias Controllers (ABC's). The purpose of ABC's is to compensate the long term temperature induced drift of the bias voltage needed to position the applied signal baseline at the desired operating point on the modulator transfer characteristic. Three different versions are available. The first accommodates signal information flows which have a periodic â€œdead timeâ€ such as scanned data or that found in image recorders. Here, a sampling signal is injected by the ABC during the â€œdead timeâ€ and the resulting optical modulation is analyzed to produce an error signal. A feedback loop drives the operating point to the top or bottom of the transfer characteristic, as desired. The second option, used with continuous information flows, such as video disc mastering, samples both the modulated optical output and its reciprocal signal. It averages these samples and produces an error signal which drives the operating point to the midpoint of the transfer characteristic. The third option is similar to the second but is designed to control arbitrary duty cycle digital waveforms. All ABC versions are available with modulation systems incorporating ADP or KD*P modulators and Model 10, 25, 50 and 100 driver electronics. The inherent stability of 360 Series LTA modulators is sufficient in the majority of applications to avoid the need for an ABC. The addition of an ABC to a modulation system requires integration with both the driver electronics and the optical modulator and is a factory installed option.

Modulation Systems

The modulators and drivers listed in this data sheet can be used in various combinations to form high performance, cost effective modulation systems. Table II shows the key performance characteristics of various combinations of standard driver electronics and modulators. The high frequency -3dB points may be limited either by the driver or the modulator. Rise and fall times are normally calculated as 0.35 divided by the -3dB bandwidth but, due to the compression caused by the sine squared transfer characteristic over its full on to off range, the optical rise and fall times of these systems is approximately 20% less. Table 1 Modulator Specifications:

Table 1 Modulator Specifications:

Model No	*350-50*	*350-80*	*350-105*	*350-160*	*350-210*	*360-40*	*360-80*	*360-120*	*360-160*	*370*	*370 LA*	*380*	*390*
Crystal	*KD*P*	*KD*P*	*KD*P*	*KD*P*	*KD*P*	*LTA*	*LTA*	*LTA*	*LTA*	*ADP*	*ADP*	*ADP*	*ADP*
V 1/2 , volts @ 500 nm 830 nm 1064nm 2500nm	*455 757 NA NA*	*261 433 522 NA*	*226 376 482 NA*	*130 216 NA NA*	*113 188 NA NA*	*NA 312 400 NA*	*NA 143 183 430*	*NA 107 138 323*	*NA 71 92 215*	*184 306 NA NA*	*263 437 NA NA*	*92 153 NA NA*	*115 190 NA NA*
Aperture Diameter, mm	*3.1*	*2.7*	*3.1*	*2.7*	*3.1*	*2.7*	*2.7*	*2.7*	*2.7*	*2.5*	*3.5*	*2.5*	*3.5*
Useful Transmission Range, nm	*300 - 1100*	*300 - 1100*	*300 - 1100*	*300 - 1000*	*300 - 1000*	*700 - 4500*	*700 - 4500*	*700 - 4500*	*800 - 4500*	*300 - 750*	*300 - 750*	*300 - 750*	*300 - 750*
Resonances	*YES*	*YES*	*YES*	*YES*	*YES*	*YES*	*YES*	*YES*	*YES*	*NO*	*NO*	*NO*	*NO*
Contrast Ratio @ 633nm 1064nm	*500:1 700:1*	*500:1 700:1*	*500:1 700:1*	*300:1 NA*	*300:1 NA*	*NA 300:1*	*NA 200:1*	*NA 200:1*	*NA 100:1*	*500:1 NA*	*500:1 NA*	*500:1 NA*	*500:1 NA*
Length, mm with Polarizer	*106*	*137*	*162*	*215*	*268*	*95*	*137*	*174*	*215*	*158*	*158*	*253*	*272*

Note: All cells are 50mm diameter.

Table 2 Modulation System:

MODULATOR MODEL NUMBER	*10*	*25*	*50*	*100*	*200*	*302*	*302A*	*25D*
350-50	*	*	*	*	*1 to 200 MHz*	*DC - 200kHz 875nm*	*DC-1MHz*	*
350-80	*	*	*	*	*1 to 200 MHz*	*CD - 200kHz 1100nm*	*DC-1MHz*	*<8ns,>25MHz 354nm*
350-105	*	*	*	*	*1 to 140MHz*	*	*DC-1MHz*	*<8ns,>20MHz 430nm*
350-160	*DC - 12MHz 460nm*	*DC - 35MHz 460nm*	*	*	*1 to 100 MHz*	*	*DC-1MHz*	*<8ns,>20MHz 710nm*
350-210	*DC - 12MHz 530nm*	*DC - 30MHz 530nm*	*DC - 60MHz 400nm*	*DC - 120MHz 400nm*	*1 to 80MHz*	*	*DC-1MHz*	*<8ns,>20MHz 820nm*
360-40	*	*	*	*	*1 to 200 MHz*	*DC - 300kHz 2120nm*	*DC-1MHz*	*
360-80	*	*	*	*	*1 to 200 MHz*	*DC - 300kHz 4500nm*	*DC-1MHz*	*<8ns,>20MHz 1010nm*
360-160	*DC - 13MHz 1390nm*	*DC - 40MHz 1390nm*	*DC - 80MHz 1040nm*	*DC - 130MHz 1040nm*	*1 to 125 MHz*	*	*DC-1MHz*	*<8ns,>20MHz 2135nm*
360-120	*DC - 12MHz 2090nm*	*DC - 35MHz 2090nm*	*DC - 60MHz 1575nm*	*DC - 120MHz 1575nm*	*1 to 150 MHz*	*	*DC-1MHz*	*<8ns,>10MHz 3235nm*
370	*	*	*	*	*1 to 125 MHz*	*DC - 200kHz 850nm*	*DC-1MHz*	*<8ns,>20MHz 505nm*
370 LA	*	*	*	*	*1 to 125 MHz*	*DC - 200kHz 850nm*	*DC-1MHz*	*<8ns,>20MHz 355nm*
380	*DC - 10MHz 650nm*	*DC - 25MHz 650nm*	*DC - 50MHz 490nm*	*DC - 100MHz 490nm*	*1 to 80 MHz*	*	*DC-1MHz*	*<8ns,>20MHz 80nm (2)*
390	*DC - 10MHz 520nm*	*DC - 25MHz 520nm*	*DC - 50MHz 400nm*	*DC - 100MHz 400nm*	*1 to 80 MHz*	*	*DC-1MHz*	*<8ns,>10MHz 810nm*

Model 360-80
Calculates index dispersion and/or pulse elongation for several materials.

LTA average
A = 4.52118266929
B = .0848939034985
C = .0397341352617
D = 27.2917136782
E = 1156.32081918

Form is n^2=A+B/(L^2-C)+D*L^2/(L^2-E)

Lambda	n	dn/dL	d2n/dL2	d3n/dL3	d4n/dL4
.7000	2.16752	-.14286	+.62742	-4.11610	+34.23492
.7500	2.16109	-.11601	+.45775	-2.77728	+21.14312
.8000	2.15581	-.09620	+.34153	-1.93363	+13.58106
.8500	2.15139	-.08129	+.25956	-1.38243	+9.01732
.9000	2.14762	-.06987	+.20031	-1.01109	+6.15902
.9500	2.14436	-.06100	+.15656	-.75424	+4.31100
1.0000	2.14149	-.05403	+.12365	-.57246	+3.08275
1.0500	2.13893	-.04851	+.09848	-.44119	+2.24645
1.1000	2.13662	-.04409	+.07895	-.34470	+1.66473

PULSE ELONGATION IN FEMTOSECONDS vs WAVELENGTH FOR A 80mm LENGTH

Delta Lambda/Lambda

Lambda	0.1%	0.2%	0.4%	0.8%	1.6%	3.2%
.7000	82	164	328	657	1321	2695
.7500	69	137	275	550	1106	2256
.8000	58	117	233	467	939	1914
.8500	50	100	200	401	805	1641
.9000	43	87	173	347	697	1420
.9500	38	75	151	302	607	1236
1.0000	33	66	132	264	531	1082
1.0500	29	58	116	232	466	950
1.1000	25	51	102	204	410	836

Model 360-160

Calculates index dispersion and/or pulse elongation for several materials.

KD*Pe
A = 2.12538053178
B = .00886632607593
C = .00815373335291
D = 2.28110628422E+12
E = 3.78851499211E+14

Form is n^2=A+B/(L^2-C)+D*L^2/(L^2-E)

Lambda	n	dn/dL	d2n/dL2	d3n/dL3	d4n/dL4
.7000	1.46316	-.02115	+.07564	-.46711	+3.43939
.7500	1.46219	-.01789	+.05602	-.32773	+2.24331
.8000	1.46136	-.01545	+.04209	-.23552	+1.50647
.8500	1.46063	-.01362	+.03198	-.17284	+1.03763
.9000	1.45999	-.01221	+.02449	-.12919	+.73079
.9500	1.45940	-.01114	+.01885	-.09815	+.52493
1.0000	1.45887	-.01031	+.01454	-.07566	+.38375
1.0500	1.45837	-.00967	+.01119	-.05910	+.28500
1.1000	1.45790	-.00917	+.00856	-.04671	+.21470

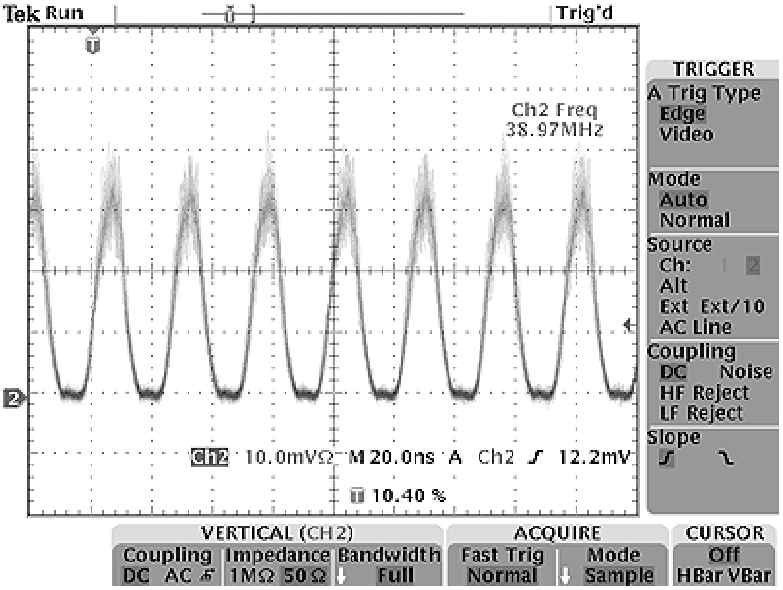
PULSE ELONGATION IN FEMTOSECONDS vs WAVELENGTH FOR A 160mm LENGTH

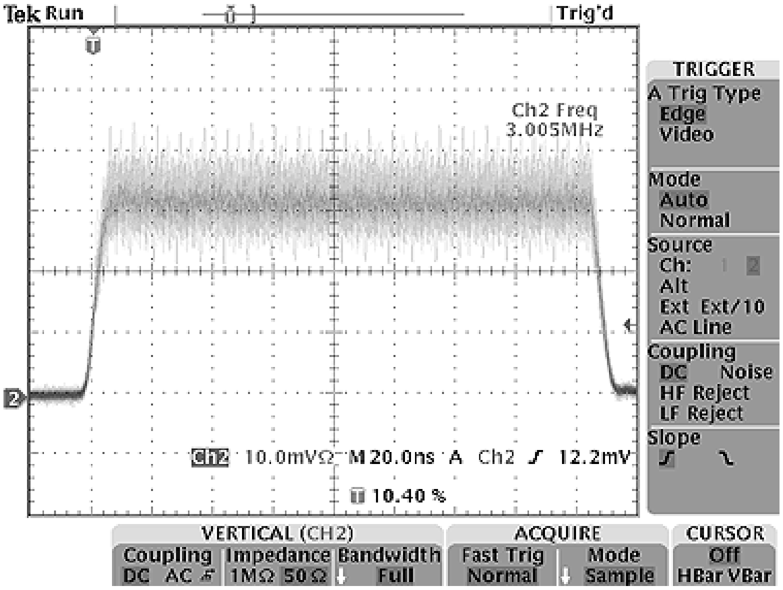
Delta Lambda/Lambda

Lambda	0.1%	0.2%	0.4%	0.8%	1.6%	3.2%
.7000	20	40	79	158	318	647
.7500	17	34	67	135	270	550
.8000	14	29	57	115	231	471
.8500	12	25	49	99	198	404
.9000	11	21	42	85	170	347
.9500	9	18	36	73	146	298
1.0000	8	16	31	62	125	255

1.0500	7	13	26	53	106	217
1.1000	6	11	22	44	89	182

M25D driving 350-160 detected @ 514nm





PHASE MODULATORS

The standard products 350, 360, 370, 380 and 390 series are built as intensity modulators with a polarizer aligned to the crystal axis.Â These standards can also be used as polarization rotators, voltage variable waveplates or phase modulators.Â However, when used as a phase modulator only half the cell is active, so the half wave voltage is twice as high as it should be.

Any product can be constructed with all the crystals in-line such that the full cell is active as a phase modulator, but it cannot be used as an intensity modulator (or polarization rotator, variable waveplate).

Please not that the product cannot be re-configured as an intensity modulator once it is built as a phase modulator.

MODEL NUMBER	**PHASE SENSITIVITY Mrad/volt @ 500nm**	**V FOR 1/2 WAVE PHASE MODULATOR**
350-50LA	3.85	815
350-50	7	450
350-80	12	261
350-105	14.7	225
530-160	24	130
350-210	29	113

ADP SERIES MODEL	**PHASE SENSITIVITY mrad/volt@ 500nm**	**V FOR ½ WAVE**
370LA	12	262
370	17	184
380	34	90
390	27	115

LTA SERIES MODEL	**PHASE SENSITIVITY mrad/volt @ 830nm**	**V FOR ½ WAVE**
360-40	13	242
360-80	26	120
360-120	39	80
360-160	52	60

PHASE MODULATOR ALIGNMENT

Linearly polarized light must be passed through the modulator so that that the plane of polarization is orthogonal* to the applied field (see figure 1)

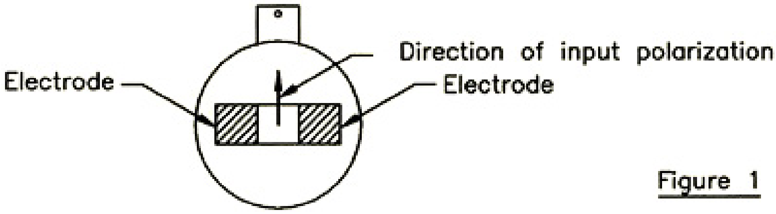


Figure 1

* For 350/370/380/390 Series
For 360 Series â€œplane of polarization is parallelâ€

To perform the alignment of the phase modulator, the optical setup must contain a polarized laser (or an input polarizer (P_1) if the laser is unpolarized) and an output polarizer (P_2) positioned so that its pass direction is orthogonal to the input (see figure 2)

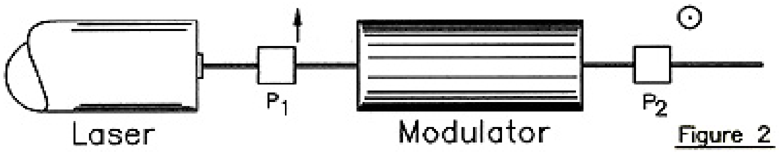


Figure 2

Align the phase modulator (with the connector vertical or parallel Â to the input polarization) so that the laser beam is centered on the input and the exit crystal faces. Rotate the modulator until a null is observed, after P_2. This will align the input polarization parallel to the induced index change. Then remove P_2

A suitable modulator support must be provided so that adjustments of the modulator can be made in roll, pitch and yaw. (see figure 3)

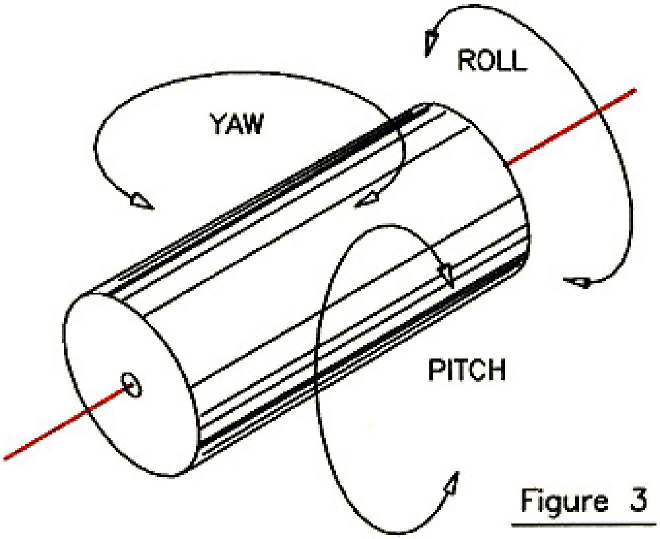
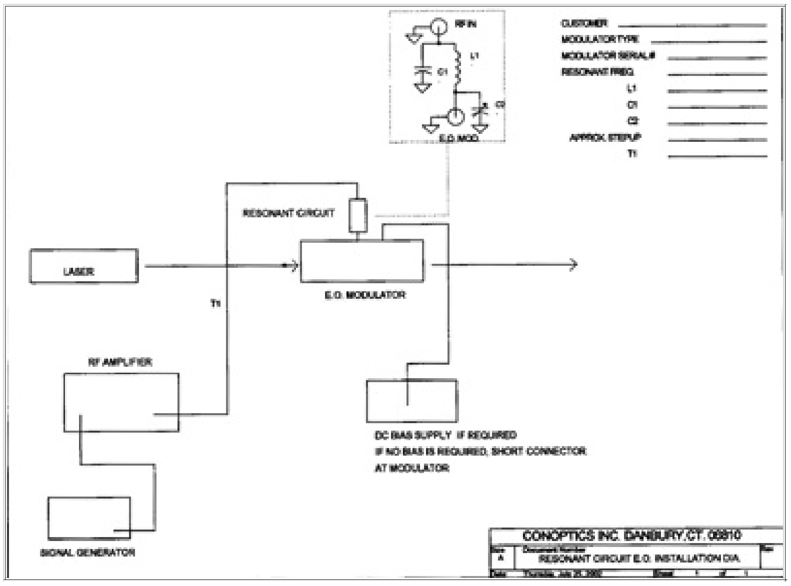


Figure 3

RESONANT CIRCUIT E.O. INSTALLATION DIAGRAM



(Click for larger view. »)

MODULATOR MOUNTING ASSEMBLY