CHAPTER 3

PHOTONICS

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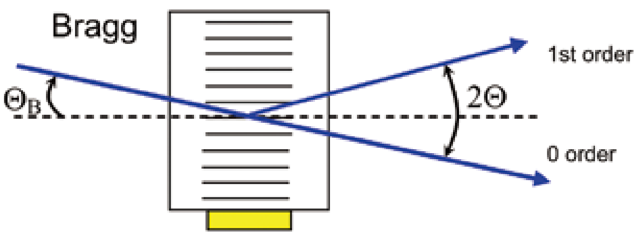
AN IMTRODUCTION TO ACOUSTO-OPTIC

1- AO HISTORY

Brillouin predicted the light diffraction by an acoustic wave, being propagated in a medium of interaction, in 1922.
In 1932, **Debye and Sears,** Lucas and Biquard carried out the first experimentations to check the phenomena.
The particular case of diffraction on the first order, under a certain angle of incidence, (also predicted by Brillouin), has been observed by **Rytow** in 1935.
Raman and Nath (1937) have designed a general ideal model of interaction taking into account several orders.
This model was developed by **Phariseau** (1956) for diffraction including only one diffraction order.
At this date, the acousto-optic interaction was only a pleasant laboratory experimentation. The only application was the measurement of constants and acoustic coefficients.
The laser invention has led the development of acousto-optics and its applications, mainly for deflection , modulation and signal processing. Technical progresses in both crystal growth and high frequency piezoelectric transducers have brought valuable benefits to acousto-optic components ‘ improvements.

2- GLOSSARY

Bragg cell:
A device using a bulk acousto-optic interaction (eg. deflectors, modulators, etc...).
“Zero” order,”1st” order:



The zero order is the beam directly transmitted through the cell. The first order is the diffracted beam generated when the laser beam interacts with the acoustic wave.

Bragg angle (ΘB):
The particular angle of incidence (between the incident beam and the acoustic wave) which gives efficient diffraction into a single diffracted order. This angle will depend on the wavelength and the RF frequency.

Separation angle (Θ):
The angle between the zero order and the first order.

RF Bandwidth (ΔF):
For a given orientation and optical wavelength there is a particular RF frequency which matches the Bragg criteria. However, there will be a range of frequencies for which the situation is still close enough to optimum for diffraction still to be efficient. This RF bandwidth determines, for instance, the scan angle of a deflector or the tuning range of an AOTF.

Maximum deflection angle (ΔΘ):
The angle through which the first order beam will scan when the RF frequency is varied across the full RF bandwidth.

Rise time (T_R):
Proportional to the time the acoustic wave takes to cross the laser beam and, therefore, the time it takes the beam to respond to a change in the RF signal. The rise time can be reduced by reducing the beam’s width.

Modulation bandwidth (ΔFmod):
The maximum frequency at which the light beam can be amplitude modulated. It is related to the rise time - and can be increased by reducing the diameter of the laser beam.

Efficiency (h):
The fraction of the zero order beam which can be diffracted into the “1st” order beam.

Extinction ratio:
The ratio between maximum and minimum light intensity in the “1st” order beam, when the acoustic wave is “on” and “off” respectively.

Frequency shift (F):
The difference in frequency between the diffracted and incident light beams. This shift is equal to the acoustic frequency and can be a shift up or down depending on orientation.

Resolution (N):
The number of resolvable points, which a deflector can generate - corresponding to the maximum number of separate positions of the diffracted light beam - as defined by the Rayleigh criterion.

RF Power (P_{RF}):
The electrical power delivered by the driver.
Acoustic power (Pa):
The acoustic power generated in the crystal by the piezoelectric transducer. This will be lower than the RF power as the electro-mechanical conversion ratio is lower than 1.

3- PHYSICAL PRINCIPLES MAIN EQUATIONS

An RF signal applied to a piezo-electric transducer, bonded to a suitable crystal, will generate an acoustic wave. This acts like a “phase grating”, traveling through the crystal at the acoustic velocity of the material and with a acoustic wavelength dependent on the frequency of the RF signal. Any incident laser beam will be diffracted by this grating, generally giving a number of diffracted beams.

3-1 Interaction conditions

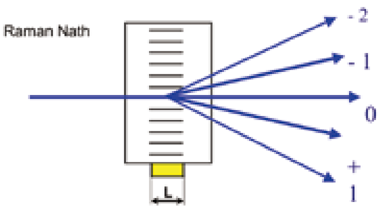
A parameter called the “quality factor, Q”, determines the interaction regime. Q is given by:

$$Q = \frac{2\pi\lambda_0 L}{n\Lambda^2}$$

where λ_0 is the wavelength of the laser beam, n is the refractive index of the crystal, L is the distance the laser beam travels through the acoustic wave and L is the acoustic wavelength.

Q<<1 :This is the Raman-Nath regime. The laser beam is incident roughly normal to the acoustic beam and there are several diffraction orders (...-2 -1 0 1 2 3...) with intensities given by Bessel functions.

Q>>1 : This is the Bragg regime. At one particular incidence angle *B, only one diffraction order is produced - the others are annihilated by destructive interference.



In the intermediate situation, an analytical treatment isn’t possible and a numerical analysis would need to be performed by computer.

Most acousto-optic devices operate in the Bragg regime, the common exception being acousto-optic mode lockers and Q-switches.

3-2 Wave vectors constructions

An acousto-optic interaction can be described using wave vectors. Momentum conservation gives us :

$$\vec{K}_d = \vec{K}_i +/- \vec{K}$$

Ki = 2pni/λ_0 – wave vector of the incident beam.
Kd = 2pni/λ_0 – wave vector of the diffracted beam.
K = 2pF/v – wave vector of the acoustic wave.

Here F is the frequency of the acoustic wave traveling at velocity v. ni and nd are the refractive indexes experienced by the incident and diffracted beams (these are not necessarily the same).

Energy conservation leads to : Fd = Fi +/- F

So, the optical frequency of the diffracted beam is by an amount equal to the frequency of the acoustic wave. This “Doppler shift” can generally be neglected since F<<Fd or Fi, but can be of great interest in heterodyning applications.

Acousto-optic components use a range of different materials in a variety of configurations. These can be heard described by terms such as longitudinal- and shear-mode, isotropic and anisotropic. While these all share the basic principles of momentum and energy conservation, these different modes of operation have very different performances - as shall be seen.

3-3 Characteristics of the diffracted light

Isotropic Interactions

An isotropic interaction is also referred to as a longitudinal-mode interaction. In such a situation, the acoustic wave travels longitudinally in the crystal and the incident and diffracted laser beams see the same refractive index. This is a situation of great symmetry and the angle of incidence is found to match the angle of diffraction. There is no change in polarization associated with the interaction.
These interactions usually occur in homogenous crystals, or in birefringent crystals cut appropriately.

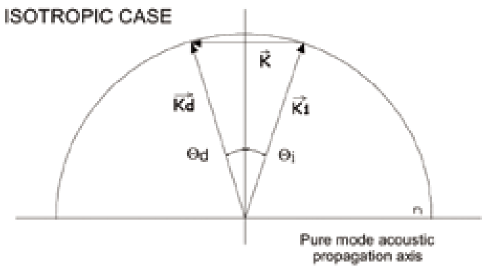
In the isotropic situation, the angle of incidence of the light must be equal to the Bragg angle, QB:

$$\theta_B = \frac{\lambda F}{2v}$$

where l = λ_0/n is the wavelength inside the crystal, v is the acoustic velocity and F is the RF frequency.

The separation angle Q between the first order and zero order beams is twice the angle of incidence and, therefore, twice the Bragg angle.

$$\theta = \frac{\lambda F}{v}$$



The diffracted light intensity I_1 is directly controlled by the acoustic power P:I

$$I_1 = I_0 \sin^2 \sqrt{\eta} \qquad \text{with} \quad \eta = \frac{\pi^2}{2\lambda_0^2} M_2 \frac{L}{H} P$$

Here λ_0 is the incident light intensity, M_2 is the acousto-optic figure of merit for the crystal and H and L are the height and length of the acoustic beam. I_0 is the wavelength of the incident beam.
Diffraction efficiency (relative) is the ratio I_1/I_0:

$$\frac{I_1}{I_0} = \sin^2 \frac{\pi}{2} \sqrt{\frac{P}{P_0}} \qquad \text{with} \quad P_0 = \frac{\lambda_0^2}{2M_2} \frac{H}{L}$$

For a given orientation, if the RF frequency is slightly different from that required to match the Bragg criterion, diffraction will still occur. However, the diffraction efficiency will drop. The situation is shown in the figure below, where the acoustic wave-vector, K, is longer than the ideal "Bragg" wave-vector, K_0.

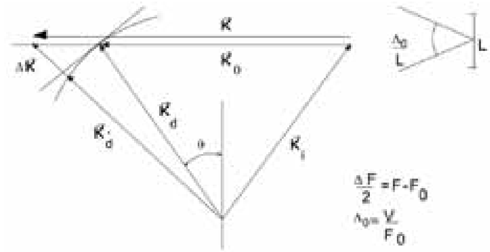
A complicated analysis leads to the result:

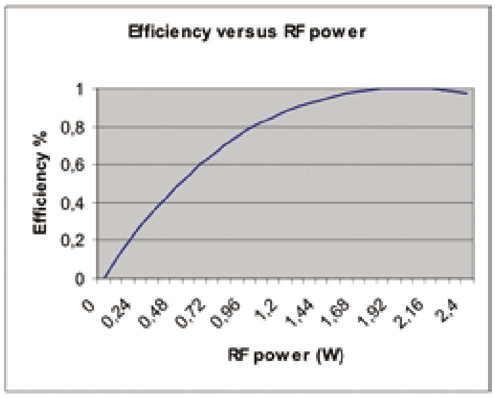
$$\boxed{\frac{I_0}{I_1} = \eta \operatorname{sinc}^2 \sqrt{\eta + \frac{\Delta\phi^2}{4}}}$$

where $\Delta\Phi = \Delta K.L$ and is called the "phase asynchronism".
In the isotropic case :

$$\Delta\phi = \frac{\pi\lambda}{v} \frac{\Delta F}{2} \frac{L}{\Lambda_0}$$

At the correct Bragg frequency, $\Delta\Phi = 0$ (F=Fo) and efficiency is maximum
When $\Delta\Phi$ increases, diffraction efficiency decreases and will continue to decrease down to zero.
If there is a lower limit on the acceptable diffraction efficiency, then this puts a limit on $\Delta\Phi$. This, in turn, implies a maximum DF - and defines the RF bandwidth for the device.
To increase this RF bandwidth, the ratio Λ_0/L (the acoustic divergence) can be increased.
As the RF frequency varies, the diffracted beam's direction changes. This is the basis behind acousto-optic deflectors.



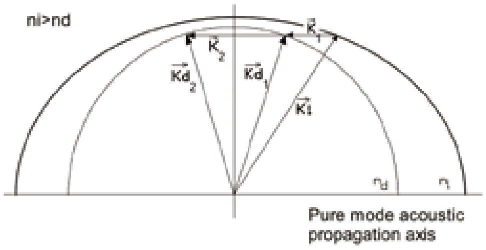


Anisotropic interaction

In an anisotropic interaction, on the other hand, the refractive indexes of the incident and diffracted beams will be different due to a change in polarization associated with the interaction. This can be seen in the figure below where the acoustic wave vector K1 connects the index curves of the incident and diffracted waves. (K2 simply represents a similar interaction at a very different RF frequency).

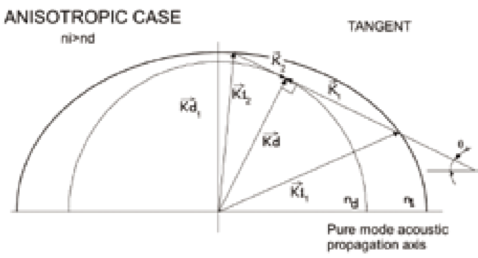
The same asymmetry which causes the difference in refractive indexes also causes the acoustic wave to travel in a "shear-mode" and, in the particular example of tellurium dioxide, this results in a drastic reduction in the acoustic velocity.

ANISOTROPIC CASE



Anisotropic interactions generally offer an increase in efficiency and in both acoustic and optical bandwidth. They are used almost universally in large aperture devices. The reduction in the acoustic velocity, seen in shear-mode tellurium dioxide, lends this material to be used in high resolution deflectors.

The increased bandwidth available from shear-mode devices can be seen most immediately in the figure below where the interaction configuration is chosen so that the acoustic wave-vector lies tangential to the diffracted beam's index ellipse.



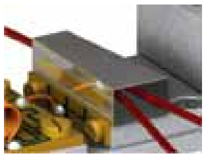
This means that the length of the acoustic wave-vector can vary quite grossly while only producing small changes in the length of the diffracted beam's wave-vector. So, in this situation, ΔK (and, hence, $\Delta \Phi$) is quite insensitive to changes in RF frequency.

Shear-mode interactions are very much more complex to analyze, requiring detailed information on crystal cut, refractive indexes, orientation. However, these interactions have a lot of advantages and most deflectors and all AOTFs will use shear-mode interactions. The reduced acoustic velocity makes these devices very much slower than longitudinal-mode units and this can be seen as a disadvantage in some circumstances.

5- CONSTITUTION OF A BRAGG CELL

Although acoustic interactions can be observed in liquids, practical devices use crystals or glasses as the interaction medium, with RF frequencies in the MHz to GHz range.

A piezo-electric transducer generates the acoustic wave when driven by an RF signal.

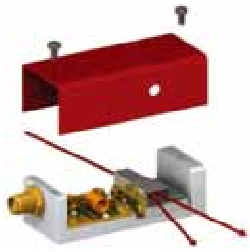


The transducer is placed between 2 electrodes. The top electrode determines the active limits of the transducer.
The ground electrode is bonded to the crystal.

The transducer thickness is chosen to match the acoustic frequency to be generated. The height of the electrode H depends on the type of application, and must exceed the laser beam diameter. For a deflector, it is selected in order to collimate the acoustic beam inside the crystal during propagation.
The electrode length L is chosen to give the required bandwidth and efficiency.
The shape of the electrode can be varied for impedance matching or to "shape" the acoustic wave.
An "apodization" of the acoustic signal can be obtained by optimizing the shape of the electrode.

An impedance matching circuit is added to couple the transducer to the driver. Indeed, this circuit is necessary to adapt the Bragg cell to the impedance of the RF source (in general 50 Ohms), to avoid power returned losses. The RF power return loss is characterized with the VSWR of the AO device.

The crystal will generally be AR coated to reduce reflec-tions from the optical surfaces. Alternatively, the faces can be cut to Brewster's angle for a specific wavelength.A variety of different materials can be used. All have their own advantages and disadvantages.



CHAPTER 3 PHOTONICS

MODULATORS & FIXED FREQUENCY SHIFTERS

Acousto-optic modulators are used to vary and control laser beam intensity. A Bragg configuration gives a single first order output beam, which intensity is directly linked to the power of RF control signal. The rise time of the modulator is simply deduced by the necessary time for the acoustic wave to travel through the laser beam. For highest speeds the laser beam will be focused down, forming a beam waist as it passes through the modulator. The first order beam of a modulator is frequency shifted by the amount of the RF carrier frequency : it acts like as fixed frequency shifter.

Model	Material	Wavelength nm	Aperture mmxmm	Freq(Shift) MHz	Polarisation	Rise Time ns	Modul.BW MHz(Am)	Efficiency %
MQ200-A1.5-244.266-B	Fused silica	244-266	1.5 x 2	200	Linear	60	8	85
MQ180-A0.3-244.266-B	Fused silica	244-266	0.3 x 1 1	80	Linear	12	40	85
MQ200-A1.5-266.300	Fused silica	266-300	1.5 x 2	200	Linear	60	8	85
MQ180-A0.2-266.300	Fused silica	266-300	0.2 x 1	180	Linear	10	48	85
MQ180-A0,2-UV	Fused silica	325-425	0.2 x 2	180	Linear	10	48	80
MQ110-A1-UV	Fused silica	25-425	1 x 2	110	Linear	15	32	85
MQ110-A3-UV	Fused silica	325-425	3 x 3	110	Linear	50	10	90
MQ240-A0.15-UV	Fused silica	325-425	0.15 x 1	240	Linear	6	80	70
MTS130-A3-400.442	TeO2	400-442	3 x 3	130	Linear	1000	0,4	85
MQ180-A0.2-VIS	Fused silica	440-650	0.2 x 1	180	Linear	10	48	70
MT350-A0.2-VIS	TeO2	450-700	0.2 x 1	350	Linear	5	96	80
MT250-A0.5-VIS	TeO2	450-700	0.5 x 2	250	Linear	6	80	80
MT200-A0,5-VIS	TeO2	450-700	0.5 x 2	200	Linear	8	60	85
MT110-A1-VIS	TeO2	450-700	1 x 2	110	Linear	15	32	85
MT110-A1.5-VIS	TeO2	450-700	1.5 x 2	110	Linear	50	9	85
MT80-A1-VIS	TeO2	450-700	1 x 2	80	Linear	23	21	85
MT80-A1.5-VIS	TeO2	450-700	1.5 x 2	80	Linear	50	9	85
MTS110-A3-VIS	TeO2	458-670	3 x 3	110	Linear	1000	0.4	85
MTS40-A2.5-VIS	TeO2	458-670	2.5 x 2.5	40	Linear	1000	0.4	85
MTS40-A2.5-IR	TeO2	780-900	2.5 x 2.5	40	Linear	1000	0.4	85
MT110-A1.5-IR-Hk (Ti:sa)	TeO2	690-1064	1.5 x 2	110	Linear	50	9	80
MT350-A0.2-IR	TeO2	700-1100	0.2 x 1	350	Linear	5	96	80
MT250-A0.5-IR	TeO2	700-1100	0.2 x 2	250	Linear	6	80	80
MT200-A0,5-IR	TeO2	700-1100	0.5 x 2	200	Linear	8	60	85
MT110-A1-IR	TeO2	700-110	1 x 2	110	Linear	15	32	85
MT110-A1.5-IR	TeO2	700-1100	1.5 x 2	110	Linear	50	9	85
MT80-A1-IR	TeO2	700-1100	1 x 2	80	Linear	23	21	85
MT80-A1.5-IR	TeO2	700-1100	1.5 x 2	80	Linear	50	9	85
MT200-A0.4-1064	TeO2	1000-1100	0.4 x 1	200	Linear	8	60	80
MT200-A0.2-1064	TeO2	1000-1100	0.2 x 1	200	Linear	8	60	80
MT110-A1-1064	TeO2	1000-1100	1 x 2	110	Linear	15	32	85
MT80-A1-1064	TeO2	1000-1100	1 x 2	80	Linear	23	21	85
MT80-A1.5-1064	TeO2	1000-1100	1.5 x 2	80	Linear	50	9	85
MTS80-A3-1064Ac	TeO2	1064	3 x 3	80	Linear	500	1	85
MQ40-A3-L1064-W	SiO2	1064	3 x 3	40	Linear	120	4	80
MQ40-A3-S1064-W	SiO2	1064	3 x 3	40	Random	180	2.5	80
MGAS40-A1	Dopped Glass	1300-160	1 x 2	40	Random	50	10	85
MGAS80-A1	Dopped Glass	1300-1600	1 x 2	80	Random	50	10	85
MGAS110-A1	Dopped Glass	1300-1600	1 x 2	110	Random	25	20	85
MG40-A6-9300	germanium	9300	6 x 10	40	Linear	120	4	75
MG40-A8-9300	germanium	9300	8 x 10	40	Linear	120	4	75
MG40-A6-10600	germanium	10600	6 x 10	40	Linear	120	4	75
MG40-A8-10600	germanium	10600	8 x 10	40	Linear	120	4	75

FIXED FREQUENCY DRIVERS

These drivers based on quartz oscillators, produce a fixed RFfrequency signal. Drivers can be provided at any frequency from 10 to 3 GHz. All models use crystal controlled oscillators.
The RF output can be externally modulated. The settling time varies from 2 ns to 100 ns depending on the fixed frequency and RF power.

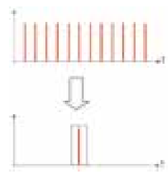
Model	Carrier Frequency	Max RF Power	Rise Fall/Time	Video In	Exctinction Ratio	Power Supply	Class
MODA40-1W/2W	40 MHz	1 or 2 W /50 Ω	< 20 ns	0-5 V / 50 Ω	45dB	24 VDC or 110/230 VAC	A
MODA40-50W	40 MHz	50 or 70 W / 50 Ω	< 50 ns	0-5 V / 50 Ω	45dB	24 VDC or 110/230 VAC	A
MODA80-1W/2W	80 MHz	1 or 2 W /50 Ω	< 10 ns	0-5 V / 50 Ω	45dB	24 VDC or 110/230 VAC	A
MODA80-4W/10W	80 MHz	4 or 10 W /50 Ω	< 10 ns	0-5 V / 50 Ω	45dB	24 VDC or 110/230 VAC	A
MODA110-1W/2W	110 MHz	1 or 2 W /50 Ω	< 8 ns	0-5 V / 50 Ω	45dB	24 VDC or 110/230 VAC	A
MODA110-4W/10W	110 MHz	4 or 10 W /50 Ω	< 8 ns	0-5 V / 50 Ω	45dB	24 VDC or 110/230 VAC	A
MODA180-1W/2W	180 MHz	1 or 2 W /50 Ω	< 5 ns	0-1 V / 50 Ω	45dB	24 VDC or 110/230 VAC	A
MODA180-4W/10W	180 MHz	4 or 10 W /50 Ω	< 5 ns	0-1 V / 50 Ω	45dB	24 VDC or 110/230 VAC	A
MODA200-1W/2W	200 MHz	1 or 2 W /50 Ω	< 3 ns	0-1 V / 50 Ω	45dB	24 VDC or 110/230 VAC	A
MODA250-1W/2W	250 MHz	1 or 2 W /50 Ω	< 3 ns	0-1 V / 50 Ω	45dB	24 VDC or 110/230 VAC	A
MODA350-1W/2W	350 MHz	1 or 2 W /50 Ω	< 3 ns	0-1 V / 50 Ω	45dB	24 VDC or 110/230 VAC	A

MULTI CHANNEL AOMs

Model	Material	Number of channels	Wavelength nm	Aperture mmxmm	Freq(Shift) MHz	Polarisation	Rise Time ns	Modul.BW MHz(AM)	Efficiency %
MT65-B20A1.5-1064-4x	TeO2	4	1064	1.5 x 1.5	65	Linear	160	3	85
MT200-A0.5-VIS-5x	TeO2	5	450-700	0.5 x 1	200	Linear	10	48	85
MQ200-A0.5-UV-16x	Fused silica	16	355	0.5 x 1	200	Linear	36	13	85

Pulses Pickers

A pulse picker is an electrically controlled optical switch used for extracting single pulses from a fast pulse train.



TeO2 General purpose Pulse Pickers

Model	Wavelength nm	Aperture mmxmm	Polarisation	Beam diameter mm	Rise Time ns	Max Repetition rate with Duty cycle < 1/10 MHz	Separation angle (0-1) mrd	Efficiency %
MT200-A0.5-800	700-950	0.5 x 1	Linear	0.06 - 0.3	10 - 48	3.3 - 0.69	38 @800nm	75 - 85
MT200-A0.5-1064	980-1100	0.4 x 1	Linear	0.09 - 0.3	15 - 48	2.2 - 0.69	50.6 @1064nm	75 - 85
MT250-A0.12-800	700-950	0.12 x 1	Linear	0.04 - 0.1	6 - 16	5.5 - 2	47.6 @800nm	70 - 85
MT250-A0.12-1064	980-1100	0.12 x 1	Linear	0.05 - 0.1	8 - 16	4.1 - 2	63.3 @1064nm	70 - 85

SiO2 High Damage Threshold Pulse Pickers

Model	Wavelength nm	Aperture mmxmm	Polarisation	Beam diameter mm	Rise Time ns	Max Repetition rate with Duty cycle < 1/100 KHz	Separation angle (0-1)	Efficiency %
MQ80-A0.7-1064	1000-1100	0.7 x 1	Linear	0.3 - 0.5	33 - 55	100 - 60	4.3 @1064nm	75 - 85
MQ150-A0.3-1064	1000-1100	0.3 x 1	Linear	0.08 - 0.2	9 - 22	370 - 150	26.8 @1064nm	50 - 70
MQ80-A0.7-1064	1000-1100	0.7 x 1	Linear	0.3 - 0.5	33 - 55	100 - 60	4.3 @1064nm	75 - 85
MQ150-A0.3-1064	1000-1100	0.3 x 1	Linear	0.08 - 0.2	9 - 22	370 - 150	26.8 @1064nm	50 - 70

CHAPTER 3 PHOTONICS

AN INTRODUCTION TO AO DEFLECTORS

Deflectors

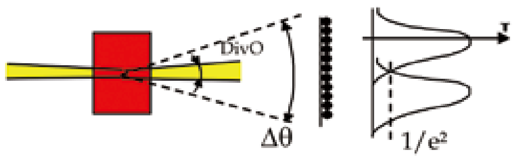
This component is used to deflect the light beam.

In most applications, a high resolution is requested. For this purpose, one uses large-sized crystals (up to 30 mm or more) in order to work with large beam diameters, decrease optical divergence and increase resolution.

Resolution

Static resolution N

Static Resolution of an AOD is defined as the number of distinct directions that can have the diffracted beam.



$$N = \frac{\Delta\theta}{DIVO}$$

The center of two consecutive points will be separated by the laser beam diameter (at 1/e²) in the case of a TEM00 beam.

ΔΘ: deflection angle range

DIVO: laser beam divergence

$$Q = \frac{2\pi\lambda_0 L}{n\Lambda^2}$$

for a TEM_{00} laser beam

ΔF: AO frequency range

Φ: beam diameter (1/e²)

V: acoustic velocity

Access time $$T_a = \frac{\phi}{V}$$

Ta is called access time of the deflector. It corresponds to the necessary time for the acoustic wave to travel through the laser beam and thus to the necessary time for the deflector to commutate from one position to another one.

A deflector is often characterized with the time x bandwidth product T_a x ΔF.

Dynamic resolution Nd

When the field of the frequencies does not consist any more of discrete values but of a continuous sweeping, it is necessary to define the dynamic resolution, which takes account of the " gradient " of frequencies.

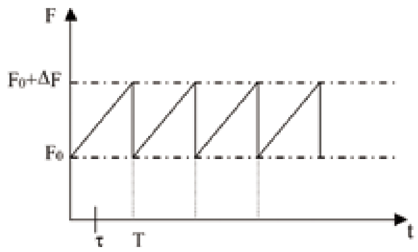
In the case of a linear frequency sweeping:

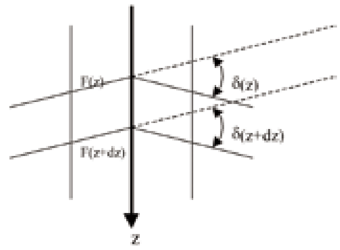
In Z=O (at the crystal's entry), the frequency F is equal to:

$$Q = \frac{2\pi\lambda_0 L}{n\Lambda^2}$$

In Z, the frequency is equal to

$$F = F_0 + \frac{\Delta F}{T}t - \frac{\Delta F}{T}\frac{Z}{V}$$





The angle of deviation (δ) is now a function of the distance (z) and of time (t).

$$\delta = \delta(Z,t) = \frac{\lambda F}{V} = \frac{\lambda}{V}\left(F_0 + \frac{\Delta F}{T}\left(t - \frac{Z}{V}\right)\right)$$

$$d\delta = \frac{\lambda}{V}\left(\frac{\partial F}{\partial t}dt + \frac{\partial F}{\partial Z}dZ\right)$$

In z and z+dz, the angle of deviation is not the same one. There is focusing, in only one plan, of the diffracted beam. It is significant to notice this effect of cylinder lens, inter-vening during sequential sweeping (television with raster scan, print-ing…).

Equivalent cylindrical focal length:

$$F_{Cyl} = \alpha^2 \frac{V}{\lambda \frac{dF}{dt}}$$

-dF/dt: frequency modulation slope

-V: acoustic velocity

-a: parameter depending on beam profile

(=1 for rectangular shape, about 1.34 for TEM_{00})

The dynamic resolution translates a consecutive reduction in the number of points resolved for this purpose.
It can be written versus static resolution as:

$$N_d = N(1 - \frac{T_a}{T}) + 1$$

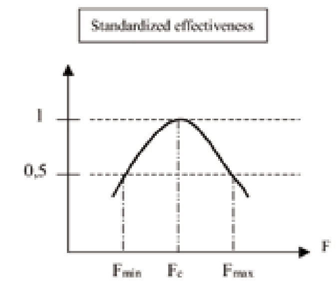
- Nd: dynamic resolution
- N : static resolution
- Ta : access time
- T : sweeping time from Fmin to Fmax

Examples:

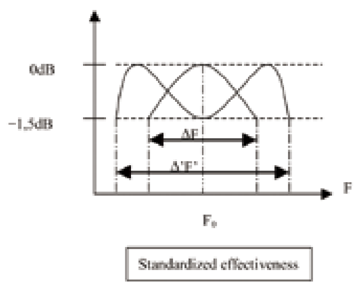
N	Ta (ms)	T (ms)	Nd
1000	10	50	800
2500	50	50	1

Efficiency and bandwidth

The bandwidth is limited to an octave to avoid the overlap of orders 1 and 2.
The efficiency curve versus frequency has the following shape for isotropic interaction:

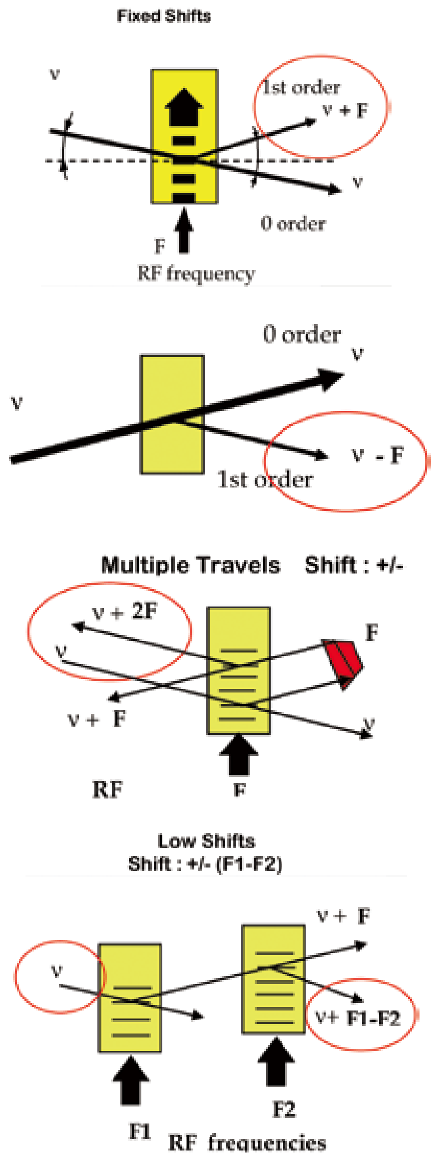


Some applications require a quasi-constant efficiency on all the bandwidth. This can be obtained by decreasing width (l) of the ultrasonic beam, but with the detriment of the maximum efficiency.
Particular case of anisotropic interaction: the bandwidth of the anisotropic interaction can be increased compared with isotropic interaction.
With specific interaction angles, there can be two synchronism frequencies to match the Bragg conditions, so that the deflection angle range can be broaden with good efficiency



Frequency Shifters

These components use the modification of frequency of the diffracted light. (Fd=Fi+/-F) All the applications using optical heterodyning or Doppler effect are using this property.
Note : the frequency shifter is also a modulator as well as a deflecto



CHAPTER 3 PHOTONICS

DEFLECTORS & VARIABLE FREQUENCY SHIFTERS

A Bragg configuration gives a single first order output beam, which intensity is directly linked to the power of RF control signal, and which angle is directly linked to the RF frequency. By varying the frequency, the output laser beam angle is modified. A deflector is used to scan a laser beam over a range of angles, or to control with accuracy the output angle of the laser beam.

By varying the frequency, the first order beam is also frequency shifted by the amount of the RF carrier frequency : it acts like a variable frequency shifter.

The main parameters to qualify a deflector are 1.Deflection angle range and 2.Resolution. The deflection angle range is the maximum angle variation of the laser beam : it is linked to the frequency range of the device.

The resolution of a deflection is the number of distinct directions which can be ad-dressed by the deflector : it is linked to the deflection angle range and laser divergence.

Two deflectors can be used in series and at right angles to give full two-dimensional scanning.

APPLICATIONS

Model	Material	Wavelength nm	Aperture mmxmm	Freq(Shift) MHz	Polarisation	Resolution	Deflecion range	Efficiency %
DTSX-250	TeO2	350-1600	4.5 x 4.5	f(λ)	Linear	300@633nm	48@633nm	> 70
DTSX-400	TeO2	350-1600	7.5 x 7.5	f(λ)	Linear	500@633nm	48@633nm	> 70
DTSXY-250	2 Axis TeO2	350-1600	4.5 x 4.5	f(λ)	Linear	300x300@633nm	41 x 41@532nm	> 45
DTSXY-400	2 Axis TeO2	350-1600	7.5 x 7.5	f(λ)	Linear	500x500@633nm	41 x 41@532nm	> 45
DT230-B120A0.5-UV	TeO2	400-450	0.5 x 17.5	230+/-60	Linear	500	11.4@400nm	> 50
DT230-B120A0.5-VIS	TeO2	450-670	0.5 x 17.5	230+/-60	Linear	500	15@532nm	> 50

Model	Material	Wavelength nm	Aperture mmxmm	Freq(Shift) MHz	Polarisation	Resolution TΔF	Deflecion angle range	Efficiency %
MQ110-B50A1-266.300	Fused Silica	266-300	1 x 2	110+/-25	Linear	16	2.2@226nm	> 60
MQ110-B50A1-UV	Fused Silica	325-425	1 x 2	110+/-25	Linear	16	3@355nm	> 60
MT225-B50A0.5-400.442	TeO2	400-442	0,5 x 2	200+/-25	Linear/random	23	5.4 @458nm	> 80
MT200-B100A0.5-VIS	TeO2	450-700	0,5 x 2	200+/-50	Linear/random	47	12.6@532nm	> 60@633nm
MT110-B50A1-VIS	TeO2	450-700	1 x 2	110+/-25	Linear/random	23	6.3@532nm	> 60@633nm
MT110-B50A1.5-VIS	TeO2	450-700	1,5 x 2	110+/-25	Linear/random	23	6.3@532nm	> 60@633nm
MT80-B30A1-VIS	TeO2	450-700	1 x 2	80+/-15	Linear/random	14	3.8@532nm	> 65
MT80-B30A1.5-VIS	TeO2	450-700	1,5 x 2	80+/-15	Linear/random	14	3.8@532nm	> 65
MT225-B100A0.5-800	TeO2	750-850	0,5 x 2	225+/-50	Linear/random	47	18.6 @785nm	> 60
MT200-B40A1-IR	TeO2	700-1100	1 x 2	200+/-20	Linear/random	19	7.4 @800nm	> 70@785nm
MT350-B120A0.2-IR	TeO2	700-1100	0,2 x 1	350+/-60	Linear/random	28	22.8@800nm	> 60
MT250-B100A0.5-IR	TeO2	700-1100	0,5 x 2	250+/-50	Linear/random	47	19@800nm	> 60
MT200-B100A0.5-IR	TeO2	700-1100	0,5 x 2	200+/-50	Linear/random	47	19@800nm	> 60@785nm
MT110-B50A1-IR	TeO2	700-1100	1 x 2	110+/-25	Linear/random	23	9.5@800nm	> 60@785nm
MT110-B50A1.5-IR	TeO2	700-1100	1,5 x 2	110+/-25	Linear/random	23	9.5@800nm	> 60@785nm
MT80-B30A1-IR	TeO2	700-1100	1 x 2	80+/-15	Linear/random	14	5.7@800nm	> 70@785nm
MT80-B30A1.5-IR	TeO2	700-1100	1,5 x 2	80+/-15	Linear/random	14	5.7@800nm	> 70@765nm
MT200-B100A0.4-1064	TeO2	980-1100	0,4 x 2	200+/-50	Linear/random	47	25.3@1064nm	> 35
MT200-B100A0.2-1064	TeO2	980-1100	0,2 x 1	200+/-50	Linear/random	47	25.3@1064nm	> 60
MT110-B50A1-1064	TeO2	980-1100	1 x 2	110+/-25	Linear/random	23	12.6@1064nm	> 55
MT110-B30A1.5-10064	TeO2	960-1100	1,5 x 2	110+/-15	Linear/random	14	7.6@1064nm	> 60
MT80-B30A1-1064	TeO2	980-1100	1 x 2	80+/-15	Linear/random	14	7.6@1064nm	> 65
MT80-B30A1.5-1064	TeO2	980-1100	1,5 x 2	80+/-15	Linear/random	14	7.6@1064nm	> 65

ASSOCIATED RF DRIVERS FOR DEFLECTORS & AGILE FREQUENCY SHIFTERS

VCO and DDS based

VCO drivers

(Voltage Controlled Oscillator)

These drivers are suitable for general purpose applications (raster scan, or random access...).The VCO can be modulated (amplitude) from an external signal.

The frequency is externally controlled by an analog signal. An external medium power amplifier will be required to generate the RF power levels required by the AO device.

VCO DRIVERS

Model	Frequency Range	Max RF Power	Sweeping Time	Video In	Frequency Control	Frequency Step	Power Supply
DRFA10Y-XX	40-100 MHz 60-150 MHz 80-200 MHz 140-300 MHz 190-350 MHz Other on request	Nom 0 dBm	1 µs	analog 0-5 V 50 Ω*	analog 0-10 V / 1 Kohms	continuous	24 VDC or 110/230 VAC

ULTRA FAST VCO DRIVER

Model	Frequency Range	Max RF Power	Sweeping Time	Video In	Frequency Control	Frequency Step	Power Supply
DRFA1.5Y-XX	85-135 MHz	Nom 0 dBm	150 ns	analog 0-5 V 50 Ω***	analog 0-10 V / 1 Kohms	continuous	24 VDC or 110/230 VAC

DDS drivers

(Direct Digital Synthesizer)

To get a high resolution driver with fast switching time, We are has designed direct digital synthetisers based on monolithic IC circuits. 3 models have already been released, and different units can be designed to specific requirements.

These models offer high frequency accuracy and stability and extremely fast switching times, generally of a few tens of nanoseconds. The DAC circuits have been designed with utmost care to obtain clean RF signals, with minimum spurious noise.

ULTRA FAST VCO DRIVER

Model	Frequency Range	Max RF Power	Sweeping Time	Video In	Frequency Control	Frequency Step	Power Supply
DRFA1.5Y-XX	85-135 MHz	Nom 0 dBm	150 ns	analog 0-5 V 50 Ω***	analog 0-10 V / 1 Kohms	continuous	24 VDC or 110/230 VAC

Model	Control Mode	Interface	Designed for	AM Control	Power supply
USB-CTRL-DDS	USB	Windows XP/NT	1 or 2 DDSA 15 to 31 bits	Analog or Digital	Through USB

Power amplifiers

Our acousto-optic amplifiers are linear with large bandwidth and medium power. The models below cover a variety of bandwidths from 1MHz to 3 GHz. Output powers up to 80 W are available.Each amplifier is supplied with its heat sink and all are stable and reliable under all conditions.For High power amplifiers, we propose models up to 500 W CW.

Model	Frequency Range	Gain nom	Output power	Flatness	Power Supply
AMPA-B-30	20-450 MHz	34 dB	1 Watt	+/- 0.5 dB	24 VDC
AMPA-B-33	20-600 MHz	40 dB	2 watts	+/- 0.5 dB	24 VDC
AMPA-B-36	20-210 MHz	40 dB	4 watts	+/- 1 dB	24 VDC
AMPA-B-40	20-210 MHz	41 dB	10 watts	+/- 1 dB	24 VDC

CHAPTER 3 PHOTONICS

POWER AMPLIFIERS & VARIABLE FREQUENCY SOURCES

RF Power amplifiers

AA's acousto-optic amplifiers are linear with large bandwidth and medium power.he models below cover a variety of bandwidths from 1MHz to 3 GHz. Output powers up to 80 W are available. Each amplifier is supplied with its heat sink and all are stable and reliable under all conditions.For High power amplifiers, AA proposes models up to 500 W CW.

Model	Frequency Range	Gain nom	Output Power	Flatness	Power Supply
AMPA-B-30	20-450 MHz	34 dB	1 watt	+/- 0.5 dB	24 VDC
AMPA-B-34	20-300 MHz	36 dB	2.5 watts	+/- 0.75 dB	24 VDC
AMPA-B-36	20-210 MHz	40 dB	4 watts	+/- 1 dB	24 VDC
AMPA-B-40	20-210 MHz	41 dB	10 watts	+/- 1 dB	24 VDC
AMPA-B-43	60-105, 110-150 150-210 MHz	44 dB	20 watts	+/- 0.75 dB	24 VDC
AMPA-B-47	35-45 MHz	48 dB	50 watts	+/-0.75 dB	24 VDC

USB controller for DDSPA

This simple tool allows user to control its DDS driver thanks to its computer with a USB link.

The provided software allows user to set manually frequency and power (option 8 bits) to the corresponding synthesizer.

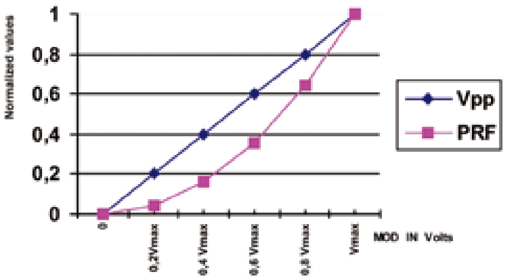
CHAPTER 3 PHOTONICS

AN INTRODUCTION TO RF DRIVERS

Output RF power

The output RF power PRF through a 50 W load (R) is related to the peak to peak signal amplitude Vpp by the relation :

$$P_{RF} = \frac{V_p^2}{8R} = \frac{V_p^2}{400}$$



VSWR (voltage stationary wave ratio)

This parameter gives an information on the reflected and transmitted RF power to a system.
In order to have the best matching between an acousto-optic device and a radio frequency source/amplifier, one will have to optimize both impedance matching on the source and the driver. Generally, input impedance of an acousto-optic device is fixed to 50 Ohms as well as the output impedance of the driver/amplifier.

VSWR	Reflected POWER
1.002 /1	0.0001 %
1.068 / 1	0.1 %
1.15 / 1	0.5 %
1.22 / 1	1 %
1.5 / 1	4 %
2 / 1	11 %
2.5 / 1	18 %
3 / 1	25 %

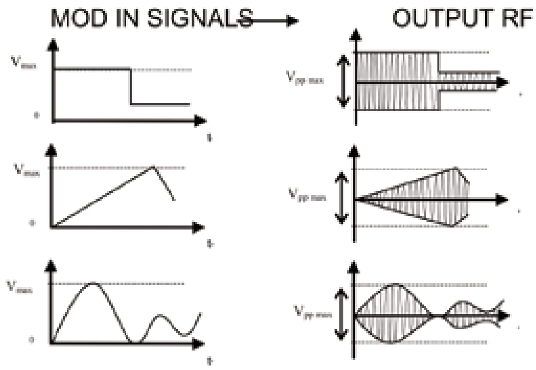
Amplitude Modulation

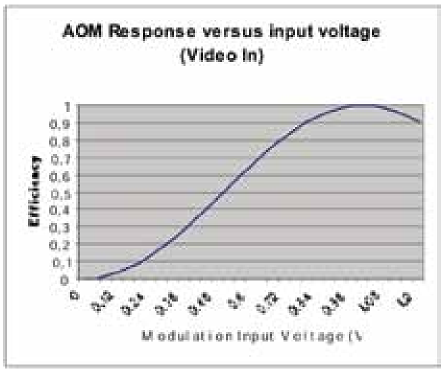
ANALOG MODULATION (0-Vmax)
The analog modulation input of your driver controls linearly and continuously the output RF amplitude of the signal from 0 to maximum level.
When applying 0 V on “MOD IN”, no output signal When applying Vmax on “MOD IN”, maximum output signal level

The output RF waveform is a double-sideband amplitude modulation carrier.
Vmax can be adjusted at factory from 1 V to 10 V.

Amplitude Modulation

ANALOG MODULATION (0-Vmax)
The analog modulation input of your driver controls linearly and continuously the output RF amplitude of the signal from 0 to maximum level.
When applying 0 V on “MOD IN”, no output signal
When applying Vmax on “MOD IN”, maximum output signal level
The output RF waveform is a double-sideband amplitude modulation carrier.
Vmax can be adjusted at factory from 1 V to 10 V.



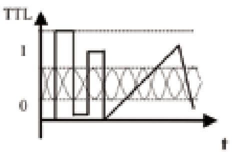


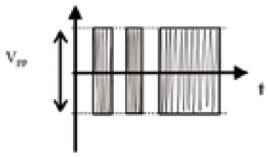
TTL MODULATION (ON/OFF)

The TTL modulation input of your driver is compatible with standard TTL signals. It allows the driver to be driven ON and OFF.

- When applying a “0” level (< 0.8 V) on “MOD IN”, no output signal.
- When applying “1” level (> 2.4 V) on “MOD IN”, maximum output signal level.

It will be noted that a TTL modulation input can be piloted with an analog input signal.



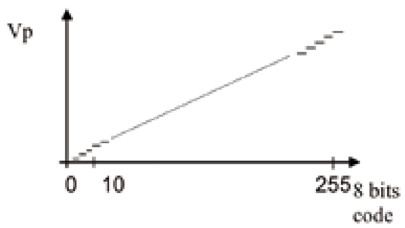


Digital 8 bit AMPLITUDE MODULATION

A byte (8 bit //) controls the amplitude of the output RF signal. A D/A converter converts the 8 bits command (N) on an analog signal which controls linearly the output amplitude.

256 levels are available

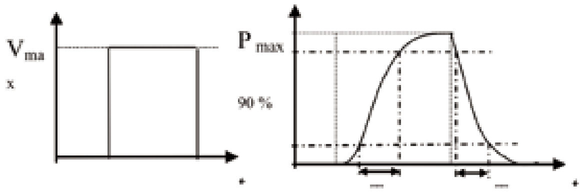
- When N=00000000, no output RF signal
- When N=11111111, maximum output level



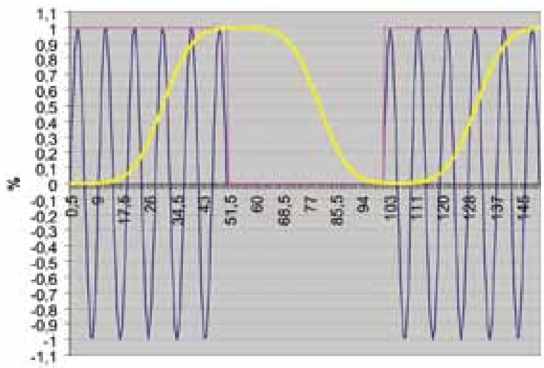
Rise and Fall Time

The rise time Tr and fall time Tf of your driver specified in your test sheet corresponds to the necessary time for the output RF signal to rise from 10 % to 90 % of the maximum amplitude value, after a leading edge front. This time is linked to carrier frequency and RF technology.

The class A drivers from AA, offer the best rise/fall time performances.



AO Modulator temporal response



EXTINCTION RATIO

The extinction ratio of your driver specified in the test sheet is the ratio between the maximum output RF level (MOD IN = max value) with the minimum output level (MOD IN = MIN value).

A bad modulation input signal can be responsible for the extinction ratio deterioration.

$$Extinction\ ratio = 10\log(\frac{P_{max}}{P_{min}}) = 20\log(\frac{V_{pp\,max}}{V_{pp\,min}}) \quad (dB)$$

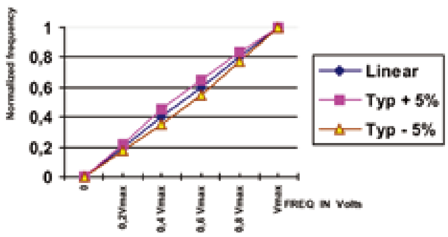
FREQUENCY CONTROLS

ANALOG CONTROL (0-Vmax)

The analog frequency control input of your driver controls linearly and continuously the output RF frequency of the signal from Fmin (minimum frequency) to Fmax (maximum frequency).
The minimum and maximum frequencies are set at factory, and can be slightly adjusted with potentiometers “OFF-SET” and “GAIN”.
The typical linearity of the frequency versus input command for standard VCOs is typically +/- 5%.

Sweeping time (VCO)

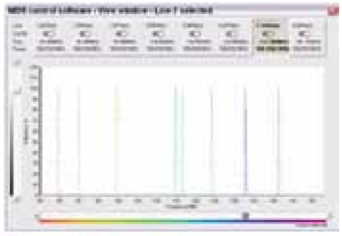
This is the maximum necessary time to sweep frequency from minimum to maximum, or maximum to minimum.
This value will be taken as the maximum random access time, though it depends on the frequency step.
When applying 0 V on “FREQ IN”, Frequency = F min
When applying Vmax on “FREQ IN”, Frequency = F max
(Standard frequency control input : 0-10 V / 1KW).



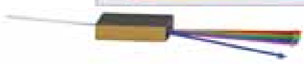
8 BITS FREQUENCY CONTROL (15, 23, 31b)

A byte (8 bit //) controls the frequency of the output RF signal. A D/A converter converts the 8 bits command (N) on an analog signal which controls linearly the output frequency.
256 steps are available : refer to your test sheet for pin connexions.
- When N=00000000, RF signal frequency = F minimum
- When N=11111111, RF signal frequency = F maximum

POLYCHROMATIC MODULATORS & ASSOCIATED RF DRIVERS



The AOTFnC is a special acousto-optic tunable filter which uses the anisotropic interaction inside a tellurium dioxidecrystal to ontrol independently or simultaneously different lines from an incoming UV or VISIBLE laser light (White laser, Ar+, Kr+, HeNe, DPSS, Dye...).
Up to 8 distinct lines can be mixed and separately modulated in order to generate different colorimetric patterns.
The specific crystal cut of the AOTF.nC produces good diffraction efficiency (> 90%), narrow resolution (1-2 nm), a low cross-talk between lines, and high extinction ratio.



The large separation angle between 0 and 1st orders, as well as the excellent output chromatic colinearity (<0.2 to <0.3 mrd) make this AOTF a powerful tool for free space or fiber pigtailed applications.Its associated thermal stabilisation maintains stable diffraction efficiency and reduces dramatically beam drift with single mode fiber pigtailing. This is a major advantage for high sensitivity applications.

AOTFnC*	UV	VIS	VIS Low Res	Low -VIS
Number of channels / Lines	4	8	4	8
Acoustic velocity (nom)	675 m/s	650 m/s	650 m/s	660 m/s
Optical wavelength range	350-430 nm	450-700 nm	450-700 nm	400-650 nm
Transmission	> 80 % -nom 90%	> 95 %	> 95 %	> 90 %
AO interaction type	Birefringent	Birefringent	Birefringent	Birefringent
Selected order	+1	-1	-1	-1
Input Light polarization	Linear parallel	Linear orthogonal	Linear orthogonal	Linear orthogonal
Output Light polarization	Linear orthogonal	Linear parallel	Linear parallel	Linear parallel
Drive frequency range	110-180 MHz	80-153 MHz	80-153 MHz	74-158 MHz
Active aperture	2 x 2 mm²	3 x 3 mm²	3 x 3 mm²	3 x 3 mm²
Spectral resolution (FWHM)	nom 1-2 nm	nom 1-2 nm	nom 4-9 nm	nom 1-4 nm
Separation angle (orders 0-1)	> 4.2 degrees	> 4.6 degrees	> 4.6 degrees	> 4 degrees
Chromatic colinearity (order 1)	< 0.2 mrd @351+363 nm	< 0.2 mrd	< 0.2 mrd	< 0.3 mrd
Temperature stabilization	TN	TN	TN	TN
AO Efficiency	>=90%	>= 90 % /line	>= 90 % /line	>= 90 % /line
Rise time	980 ns / mm	1010 ns / mm	1010 ns / mm	1000 ns /mm
Max accepted RF power	< 1 W all lines	< 1 W all lines	< 1 W all lines nom	1 W all lines
Electrical impedance	50 Ohms	50 ohms	50 ohms	50 ohms
VSWR	< 2/1	< 2/1	< 2/1	< 2/1
Size	70 x 36.6 x 35.8 mm	370 x 3.66 x 35.8 mm	3 70 x 36.6 x 35.8 mm3	70 x 36.6 x 35.8 mm3
Operating temperature	10 to 40 °C	10 to 40 °C	10 to 40 °C	10 to 40 °C

*Available as fiber pigtailed versions

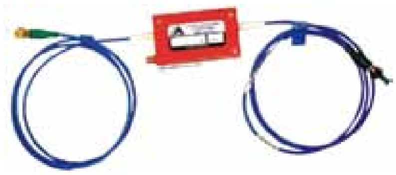
Power Supply	OEM version : 24 VDC - nom 085 A
	Laboratory version: 110/230 VAC - 50Hz60 Hz
Extinction ratio @ 125 MHz	MOD IN > 80dB typ 90 dB
	BLK > 70 dB typ 80 dB
	MOD IN + BLK > 90 dB typ 100 dB
Output RF power	22 dBm per channel [up to 36 dBm]
Output Impedance	50 W
V.S.W.R. Nom	< 1.5/1
Input/Output connectors	DB25 / SMA (DB9 for RS232)
Size	OEM version : 207 x 127 x 20.2 mm 3
	Laboratory version : Rack 19'',1U
Weight	OEM version : nom 1 kg
	Laboratory version : nom 4 kg
Heat exchange	OEM version :Conduction
	Laboratory version : stand alone
Operating temperature	10 to 40 °C
Maximum case temperature	OEM version : 50 °C

Number of channels
1, 4, 8
Frequency range
Will be adapted to AO up to 200 MHz
Frequency stability
+/- 2 ppm / °C
Frequency accuracy
< 1 KHz
Frequency step
Nom 1 KHz
Frequency control
Remote Control or USB, Option : RS232
Rise Time / Fall Time (10-90 %)
< 50 ns
Modulation Input Control
Analog 0-5 V / 10 KW or Analog 0-10 V / 10 KW
Blanking input Control
Analog 0-5 V or Analog 0-10 V / 10 KW (optionTTL)

MDS - MULTI DIGITAL SYNTHESIZER

The associated driver MDSnC, based on DDS (Direct Digital Synthesizer), has been specially designed in order to exploit the best of the AOTFnC features.
Its compact design with single power supply, low RF emissions and ease of use will satisfy the most demanding of applications, where accuracy and flexibility are key requirements.
Thanks to its complete digital design and integrated micro- controller setting up is fast, simple and repeatable.
Access to and adjustments of functions is simple with either a bright LCD display (with remote control adjustment) or through a RS232 serial link (with computer control) or USB communication.
All parameters are stored in an EEPROM and are automatically loaded after each switch on.
Each line is externally controlled by a distinct modulation input signal which can be TTL or analog. Additionally, all lines can be simultaneously controlled by a blanking signal which produces smooth effects without modifying the colorimetric balance.
The combination of the modulation input and blanking signals provides the best extinction ratio performance (> 100 dB).

FIBER PIGTAILED AO MODULATORS



FIBER PIGTAILED AOTF

Model	Fibre	Wavelength nm	Polarization	Resolution nm -3dB	Losses dB
AOTFnC-VIS-FIO	PM (IN + OUT)	450-700	Linear	1-2	4.5
AOTFnC-VIS-FI	PM (IN + OUT)	450-700	Linear/	1-2	2
AOTFnC-400.650-FIO	PM (IN + OUT)	400-650	Linear	1-4	4.5
AOTFnC-400.650-FI	PM (IN + OUT)	400-650	Linear	1-4	2
AOTFnC-400.650-4FIO	PM (4 INPUTS + 1 OUT)	400-650	Linear	1-4	8

Modulators / Q-Switches / Frequency Shifters

These fiber pigtailed devices can be used depending on the models as modulators, fixed frequency shifters or Q-switches. Our standard versions are proposed with a single mode fiber with polarization maintaining, However on request,
we can offer different types of fibers or connectors.These devices are dedicated for telecommunication applications, as well as for printing, microscopy, Q-switching or any other application

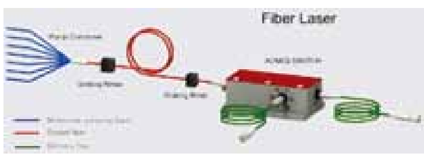
Model	Wavelength nm	Fiber in/out	Connectors	Rise/FallTime ns	Frequency shift MHz	Amplitude Modulation Bandwidth MHz	Insertion Losses db	Max CW Laser power	Diver model
MT200-B9-FIO	400-480	SM, PM	Super FC/PC, FC/APC	9	200	53	Nom 4 dB	0,1 W	AA.MOD. 200-1W
MT200-BG9-FIO	480-630	SM, PM	Super FC/PC, FC/APC	9	200	53	Nom 3 dB	0.5 W	AA.MOD. 200-1W
MT200-R9-FIO	630-700	SM, PM	Super FC/PC, FC/APC	9	200	53	Nom 3 dB	0.5 W	AA.MOD. 200-2W
MT200-R13-FIO	630-700	SM, PM	Super FC/PC, FC/APC	13	200	36	Nom 2.5 dB	0.5 W	AA.MOD. 200-2W
MT110-IR20-FIO	1000-1100	SM, PM	Super FC/PC, FC/APC	20	110	24	Nom 2.5 dB	0.5 W or 5 W	AA.MOD. 110-2W
MT80-IR60-FIO	1000-1100	SM, PM	Super FC/PC, FC/APC	60	80	24	Nom 1.5 dB	0.5 W or 5 W	AA.MOD. 80-2W
MT110-1550-20-FIO	1550	SM, PM	Super FC/PC, FC/APC	20	110	24	Nom 3 dB	0.5 W or 5 W	AA.MOD. 110-2W
MT80-1550-60-FIO	1550	SM, PM	Super FC/PC, FC/APC	60	80	24	Nom 2.5 dB	0.5 W or 5 W	AA.MOD. 80-2W

A fiber laser or fibre laser is a laser in which the active gain medium is an optical fiber doped with rare-earth elements such as erbium, ytterbium, neodymium, dysprosium, praseodymium, and thulium. Fiber nonlinearities, such as Stimulated Raman Scattering or Four Wave Mixing can also provide gain and thus serve in effect as gain media. Unlike most other types of lasers, the laser cavity in fiber laser is constructed monolithically by fusion splicing the different types of fibers; most notably fiber Bragg gratings replace here conventional dielectric mirrors to provide optical feedback.

To pump fiber lasers, semiconductor laser diodes or other fiber lasers are used almost exclusively. Fiber lasers can have several kilometer-long active regions and provide very high optical gain. They can support kilowatt level of continous output power because the fiber's high surface area to volume ratio allows efficient cooling. The fiber waveguiding properties reduce or remove completely thermal distortion of the optical path thus resulting in typically diffraction-limited high-quality optical beam. Fiber lasers also feature compact layout compared to rod or gas lasers of comparable power, as the fiber can be bent to small diameters and coiled. Other advantages include high vibrational stability, extended lifetime and maintenance-free turnkey operation.

FIBER LASERS

Many high-power fiber lasers are based on doubleclad fiber. The gain medium forms the core of the fiber, which is surrounded by two layers of cladding. The lasing mode propagates in the core, while a multimode pump beam propagates in the inner cladding layer. The outer cladding keeps this pump light confined. This arrangement allows the core to be pumped with a much higher power beam than could otherwise be made to propagate in it, and allows the conversion of pump light with relatively low brightness into a much higher-brightness signal. As a result, fiber lasers and amplifiers are occasionally referred to as «brightness converters.»

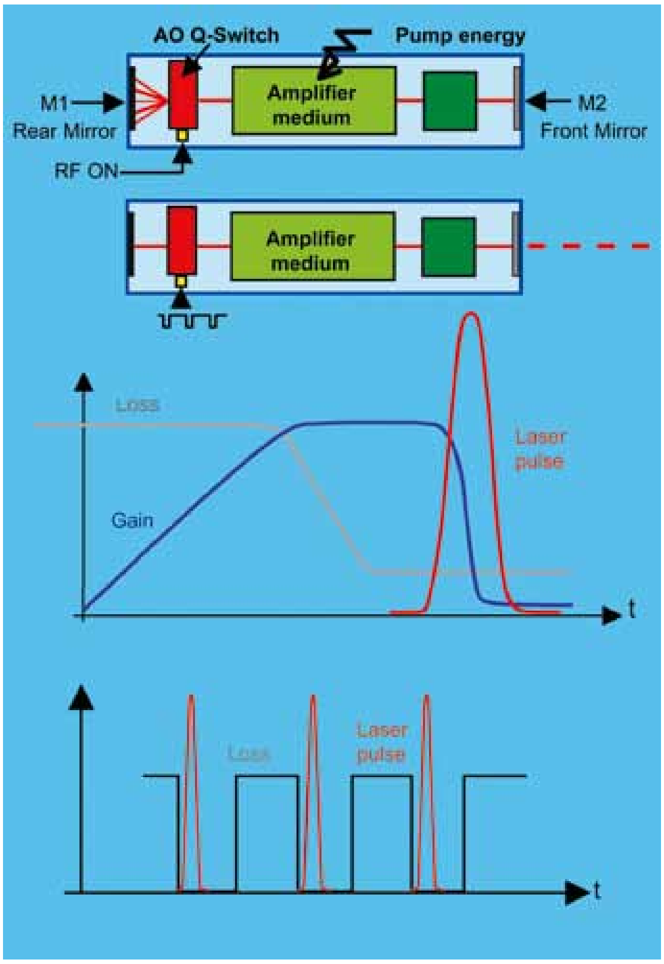


Applications include: Material processing,telecommunications,spectroscopy, and medicine.

Generation of optical pulses

Pulsed lasers have some advantages versus continuous lasers:
In some applications, such as optical communications, pulses convey information
Short pulses are used to achieve very large peak powers.
All the emitted energy is compressed into very short pulses, so as to reach very large peak powers
Some applications rely on optical pulses to take snap-shots of very rapidly occurring process, such as fast chemical reactions, or electronic processes in semiconductors.
Lasers can produce flashes of light that are many orders of magnitude shorter and brighter than ordinary flashlight
In some circumstances, it is the laser excitation mechanism itself that restricts the laser to pulsed mode operation, to reduce unwanted thermal load on the laser

A simple way to generate pulsed output is to put an optical switch (AO modulator for instance) at the output of a continuous wave laser (CW). By turning on and off, user can get pulses of light. For some applications, this is not efficient and this is preferable to use a switch (Q-Switch) inside the laser cavity.
This has at least two advantages:
When the switch is closed, the laser cannot operate. This means the pump energy is not lost but stored in the active material in the form of excited atoms, or in the cavity in the form of light
When the switch is abruptly opened all the stored energy may be regained in a short pulse, generating peak powers that are many times higher than the average (CW) power.



Q-Switching

The Q or Quality factor of a laser cavity describes the ability of the cavity to store light energy in the form of standing waves. The Q factor is the ratio of energy contained in the cavity divided by the energy lost during each round trip in the cavity:

$$Q = 2\pi \frac{\text{Energy stored in the cavity}}{\text{Energy lost in a cycle}}$$

This means that a cavity with high losses dissipates a lot of energy per cycle hence it has a low Q value. A high Q cavity means the energy loss per cycle is small in the given cavity.
By inserting a device in the cavity which is capable of controlling the loss of a cavity, we are effectively controlling the Q of the cavity. This device acts as an optical shutter or switch inside the cavity, which, when closed, absorbs or scatters the light, resulting in a lossy, low Q cavity. When the shutter is open, the cavity becomes low loss, high Q. This switch is called a Q-SWITCH.

Acousto-optic Q-Switches

A Q-switch is a special modulator which introduces high repetition rate losses inside a laser cavity (typ 1 to 100 KHz). They are designed for minimum insertion loss and to be able to withstand very high laser powers. In normal use an RF signal is applied to diffract a portion of the laser cavity flux out of the cavity. This increases the cavity losses and prevents from oscillation. When the RF signal is switched off, the cavity losses decrease rapidly and an intense laser pulse evolves.

It is essential in Q-switching to correlate the timing sequence of the optical pumping mechanism with the Q-switching. This means the following :
Assume that at the time when the laser pumping is turned on, the Q of the cavity is low. The high loss prevents laser action occurring so the energy from the pumping source is deposited in the upper laser level of the medium At the instant, when the population inversion is at its highest level, the switch is suddenly open to reduce the cavity loss Because of the very large built up population difference, laser oscillations will quickly start and the stored energy is emitted in a single giant pulse
The lasing stops because the pulse quickly depopulates the upper lasing level to such an extent that the gain is reduced to below threshold.
This operation is periodically repeated in order to obtain the operating regime.

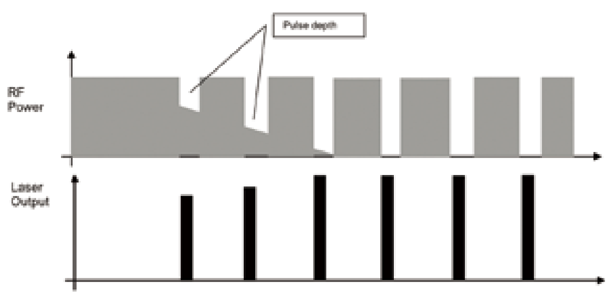
The associated RF driver in combination with the convenient Q-switch is a key component for an efficient Q-switching application. This one must be a class A driver with the fastest fall time in order to get an optimum falling slope of the cavity losses and to get the shortest and highest energy in each pulse.
A synchrone driver can be essential for some applications where synchronism pulse to pulse is critical. Phase locked drivers are also available in case of use of multi Q-switches in the same cavity.
The triggered signals or control signals of the driver may be chosen to have the opportunity to shape the Q-switch losses in time and perform the Q-switching effect safely and efficiently.
The thermal security interlock is essential to protect the Q-switch from overheating and to improve its lifetime. Other securities such as VSWR control or disconnection protection can facilitate the task of the user and make the use of the system more safe.
Depending on space and available resources, the choice of the driver will oriented towards an air, conduction through baseplate or water cooling driver, an OEM compact version or a 110/230 VAC version.

Giant Pulses

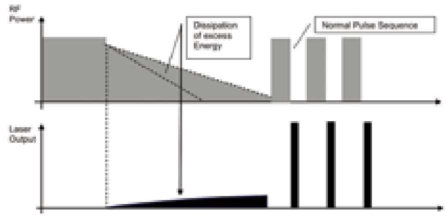
It is very common in high repetition rate Q-switched lasers, to observe a "giant first pulse" after a certain time of non operation. This giant pulse with excess of energy can create irreversible damages on the intra cavity optics.
Moreover, this undesirable increase of energy for the first pulses will lead to a non uniform peak power which may affect badly the application (different marking intensity for instance).
For this reason, user may have to dissipate or suppress the excess of energy of the first pulses. This can be achieved in controlling with a special sequence the Q-switch thanks to the provided RF driver.

General methods to suppress Giant First Pulse

FPS: First Pulse Suppression
With this method, the pulse depth of the Q-Switch is controlled and limited so as to not open completely the cavity, and thus allow limited Energy to get out of the cavity.
The amount of Losses is decreased progressively so as to obtain the permanent Q-switch regime. It needs typically few pulses to get constant pulses.



PPK: PRE PULSE KILLING
With this method, the excess of energy inside the cavity is dissipated before starting the pulse sequence. As the excess of energy is eliminated prior starting pulse sequence, then the pulse sequence can start normally.



AA Drivers : Methods of control

Basic Pulse control (DPC Input)
For all AA drivers, the Laser pulses are triggered by a TTL signal (Digital Pulse Control).
This input allows to control the Q-swicth with two states :
- No losses (TTL=0)= No RF power applied on Q-switch = Laser pulse can evolved
- Full Losses (TTL=1)= Full RF Power applied on Q-switch = Laser Cavity Blocked

Analog Power control (FAC input)
AA provides a supplementary analog input in order to control the RF power level. This input is pulled down (Typ 0-5Volts) – it means, that if it is not connected, then signal is ramped to 0, then output power is disabled. The analog FAC signal controls linearly the RF amplitude of the output signal.
Note that the analog power control is combined with TTL pulse control (DPC) as follows:
Output RF power ~ TTL (DPC) X Analog (FAC)
- If TTL (DPC) = 0 a Output RF Power = 0 whatever is FAC input (0 or 5 V)
- If TTL (DPC) = 1 a Output RF Power = 0 if FAC = 0V
  Maximum if FAC = 5V, Xx versus FAC input

Pulse Analog Control (PAC / RF OFF Analog Control)
The PAC input is an alternative analog input, which controls the RF OFF level of the driver.
This input (analog 0-5V typ) is pulled up. It means that when it is not connected, the signal ramped up to 5 Volts, and the driver can operate normally.
The analog PAC signal controls linearly the RF OFF amplitude of the output signal. It controls the threshold of leak-age.
Note that the PAC Amplitude control is combined with TTL pulse control (DPC) as follows:
RF POWER OUTPUT ~ TTL (DPC) + Analog (PAC)
- If TTL (DPC) = 0 a Output RF Power = 0 if PAC=0V
  Maximum if PAC = 5V, Xx versus PAC input
- If TTL (DPC) = 1 a Output RF Power = Max whatever is PAC input (0 or 5 V)

CHAPTER 3 PHOTONICS

Q-SWITCHES

Carrier Frequency MHz	Max RF Power W	Rise Fall/ Time ns	Controls	Exctinction Ratio dB	Security Measurement	Power Supply	Class
 **QMODP0xx** - Reliable Basic Solution up to 20 Watts							
27.12 40.68 68 80	10 20	< 20	TTL + FAC (0-5V)	45	NO	24 VDC 2.3-2.9 A	A
 **QMODP1xx** - Compact Solution 20, 30, 70 Watts							
27.12 40.68 68 80	20 30 70	< 30 < 30 < 50	TTL (R) + FAC (0-5V)	45	Output Power Return Power Thermal (QST + Driver)	15 VDC	A
 **QMODP2xx** - Ultra Compact Solution 20, 30, 70 Watts							
27.12 40.68 68 80	5 10 20	< 10 < 20 < 30	TTL	40	NO	24 VDC 3-6 A	A
 **QMODP3xx** - High power solution 100-120 Watts							
27.12 40.68	120	< 50	TTL (R) + FAC (0-5V)	45	Output Power Return Power Thermal (QST + Driver)	24 VDC 12 A	A
 **QMODP4xx** - DUAL OUTPUTS solution (2 synchronized outputs)							
27.12 40.68 68 80	2 x 30 2 x 60	< 50	TTL (R) + FAC (0-5V)	45	Output Power Return Power Thermal (QST + Driver)	24 VDC 6-12 A	A

Model	Material	Polarization	Carrier Freq. MHz	Aperture mm x mm	Loss%	Optional Length mm
QS80-A0.7-L1064	Fused silica	Linear	80	0.7 x 1	> 60	20
QS40-A0.8-L1064	Fused silica	Linear	40.68	0.8 x 1	> 80	32
QS80-A0.7-L1064	Fused silica	Linear	80	0.7 x 1	> 80	32
QS40-A1-L1064	Fused silica	Linear	40.68	1 x 2	> 80	32
QS80-A1-L1064	Fused silica	Linear	80	1x 2	> 80	32
QCQ40-A1.5-L1064	QUARTZ	Linear	40.68	1.5 x 2	> 80	32
QCQ80-A1.2-L1064	QUARTZ	Linear	80	1.2 x 2	> 80	32

Water-cooled Q-Switches Solutions for high gain cavities. Water cooling for heat dissipation

Model	Material	Polarization	Carrier Freq. MHz	Aperture mm x mm	Loss %	Optional Length mm
QS27-A2-L1064-W	Fused silica	Linear	27.12	2 x 2	> 80	46
QS27-A2-S1064-W	Fused silica	random	27.12	2 x 2	> 60	46
QS27-A3-L1064 -W	Fused silica	Linear	27.12	3 x 3	> 80	46
QS27-A3-S1064-W	Fused silica	Random	27.12	3 x 3	> 70	46
QS40-A2-L1064-W	Fused silica	Linear	40.68	2 x 2	> 80	46
QS40-A2-S1064-W	Fused silica	Random	40.68	2 x 2	> 60	46
QS40-A3-L1064-W	Fused silica	Linear	40.68	3 x 3	> 80	46
QS40-A3-S1064-W	Fused silica	Random	40.68	3 x 3	> 60	46

AA propose a complete line of Acousto-optic Q-switches and associated RF drivers, for a wide range of applications. They are manufactured from the highest quality materials, with optimized hard coatings for high damage threshold and long term operation. All AA Q-switches are designed so as to optimize heat dissipation and beam stability with a unique glueing and mechanical technology which reduces stress during operation.

CHAPTER 3 PHOTONICS

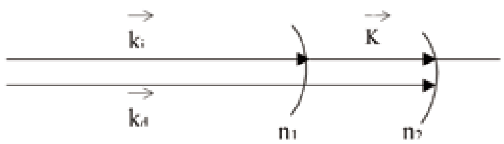
AN INTRODUCTION TO AOTF- TUNABLE FILERS

The extraction of a spectral component of an incoming light source can be carried out by the acousto-optic interaction.

The angle of deflection of an acousto-optic deflector is pro-portional to the optical wavelength. It is thus possible to extract a particular wavelength. The spectral resolution is then limited by diffraction due to finished dimension (D) of the light beam. The limit of the spectral width can be deduced as:

$$\Delta\lambda_0 = \frac{\lambda_0 V}{D}\frac{1}{F}$$

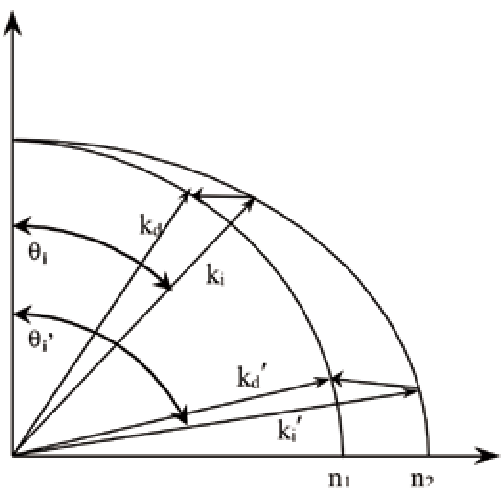
A good resolution (λ0/Δλ0 high) imposes a large dimension (D) of the light beam. The numerical aperture of such systems is thus obligatorily very low and thus their utilization is very limited. The collinear anisotropic interaction makes it possible to tune the filter by simple variation of the acoustic frequency, under significant numerical aperture:



$$\eta \approx \eta_0 \operatorname{sinc}^2\left(\frac{\Delta k L}{2\pi}\right)$$

(collinear AOTF efficiency)

The non collinear anisotropic interaction, is also usable under a high angle of incidence (Θi >10°). This last configuration allows the use of materials with high figure of merit coefficients. (TeO_2)



One can show that a large angular aperture is possible as long as the tangents at the point of incidence and synchronism are parallel (the light rays are then parallel in the crystal)

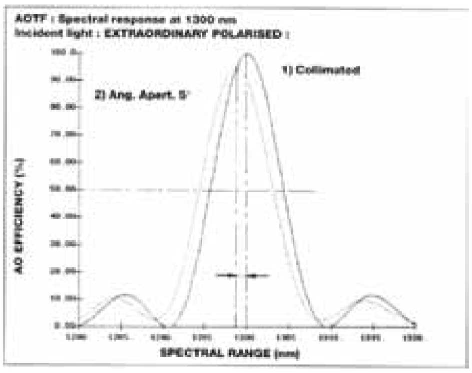
A wide length of interaction (L) and an adequate configuration of the wave vectors (synchronism on a small range of K) guarantee obtaining a low bandwidth and thus a low spectral width (Δλ).

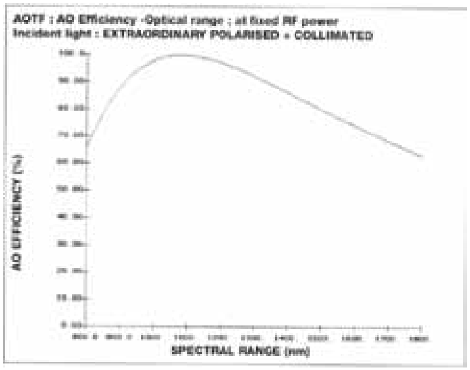
$$\lambda = a\frac{\Delta n(\lambda)}{F} \qquad \Delta\lambda = b\frac{\lambda^2}{L}$$

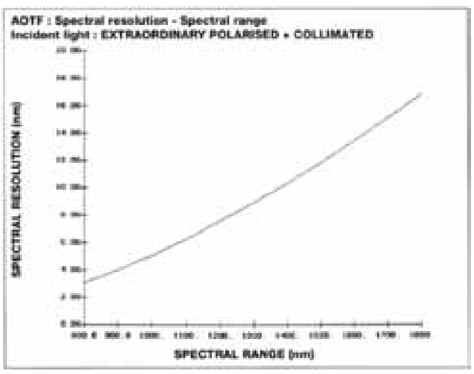
Dn: birefringence(=|n2-n1|)

a and b are parameters which depends of Θi and Θa

Examples:







Application example

Confocal Microscopy

Confocal microscopy is an imaging technique used to in-crease micrograph contrast and/or to reconstruct three-dimensional images by using a spatial pinhole to eliminate out-of-focus light or flare in specimens that are thicker than the focal plane. This technique has been gaining popularity in the scientific and industrial communities. Typical applications include life sciences and semiconductor inspection.

CONFOCAL LASER SCANNING MICROSCOPY

Confocal laser scanning microscopy (CLSM or LSCM) is a valuable tool for obtaining high resolution images and 3-D reconstructions. The key feature of confocal microscopy is its ability to produce blur-free images of thick specimens at various depths. Images are taken point-by-point and reconstructed with a computer, rather than projected through an eyepiece. The principle for this special kind of microscopy was developed by Marvin Minsky in 1953, but it took another thirty years and the development of lasers for confocal microscopy to become a standard technique toward the end of the 1980s.

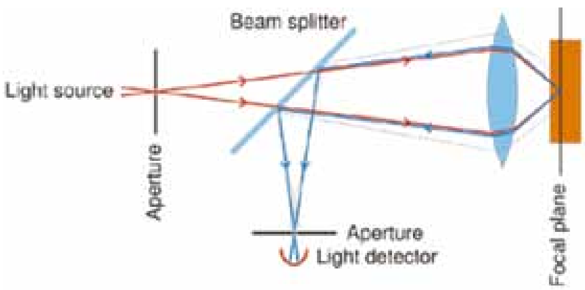


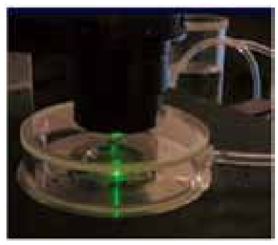
IMAGE FORMATION

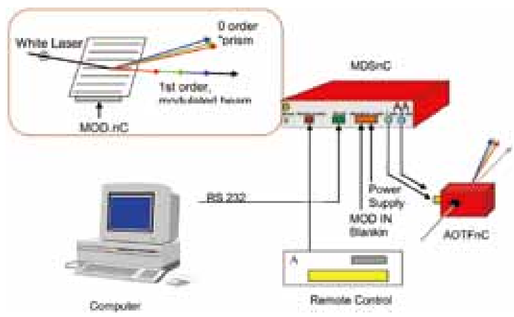
In a laser scanning confocal microscope a laser beam passes a light source aperture and then is focused by an objective lens into a small (ideally diffraction-limited) focal volume within a fluorescent specimen. A mixture of emitted fluorescent light as well as reflected laser light from the illuminated spot is then recollected by the objective lens. A beam splitter separates the light mixture by allowing only the laser light to pass through and reflecting the fluorescent light into the detection apparatus. After passing a pinhole the fluorescent light is detected by a photodetection device (photomultiplier tube (PMT) or avalanche photodiode) transforming the light signal into an electrical one which is recorded by a computer.

The detector aperture obstructs the light that is not coming from the focal point, as shown by the dotted grey line in the image. The out-of-focus points are thus suppressed: most of their returning light is blocked by the pinhole. This results in sharper images compared to conventional fluoresence microscopy techniques and permits one to obtain images of various z axis planes (z-stacks) of the sample.

The detected light originating from an illuminated volume element within the specimen represents one pixel in the resulting image. As the laser scans over the plane of interest a whole image is obtained pixel by pixel and line by line, while the brightness of a resulting image pixel corresponds to the relative intensity of detected fluorescent light. The beam is scanned across the sample in the horizontal plane using one or more (servo-controlled) oscillating mirrors. This scanning method usually has a low reaction latency and the scan speed can be varied. Slower scans provide a better signal to noise ratio resulting in better contrast and higher resolution. Information can be collected from different focal planes by raising or lowering the microscope stage. The computer can generate a three-dimensional picture of a specimen by assembling a stack of these two-dimensional images from successive focal planes.

In addition, confocal microscopy provides a significant improvement in lateral resolution and the capacity for direct, non-invasive serial optical sectioning of intact, thick living specimens with an absolute minimum of sample preparation. As laser scanning confocal microscopy depends on fluorescence, a sample usually needs to be treated with fluorescent dyes to make things visible. However, the actual dye concentration can be very low so that the disturbance of biological systems is kept to a minimum. Some instruments are capable of tracking single fluorescent molecules. Additionally transgenic techniques can create organisms which produce their own fluorescent chimeric molecules. (such as a fusion of GFP, Green fluorescent protein with the protein of interest).





AOTF

ACOUSTO-OPTIC TUNABLE FILTERS

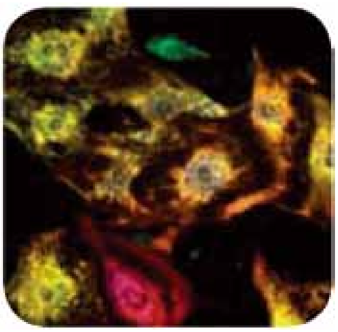
An AOTF is a solid-state, electronically tunable bandpass filter,which uses the acousto-optic interaction inside an anisotropic medium. These filters can be used with multi-lines sources (mixed gas lasers, Laser diodes...) or with broadband light sources (Xenon, Halogen lamps...). They allow to select and transmit a single wavelength from the incoming light.

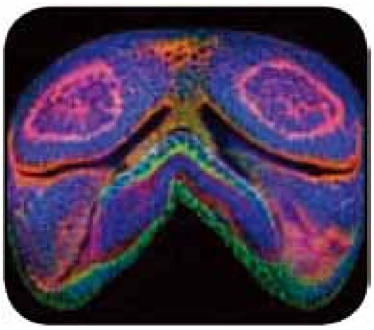
The main advantage of this technique is the total absence of any moving part which leads to a reliable, stable and fast technique for wavelength tuning. The RF frequency applied on the AOTF transducer controls the transmitted (filtered in 1st order) wavelength. A complete spectrum analysis can be done by varying the frequency corresponding to the wavelength range. The RF amplitude level applied on the transducer allows to adjust the transmitted (filtered) light intensity level.

This is a unique feature that can provide the AOTF. It is fast (several µs), accurate and procures high extinction ratio.

We propose a whole range of AOTFs based on TeO2 with shear acoustic mode. The filters are designed so as to get the best performances in each wavelength range and to satisfy most of the applications: resolution down to 1 nm, Field of view up to 20 degrees, apertures up to 10 mm...In most cases, the filtered output from the tunable filter is made colinear to make easier the use of these devices, and to satisfy fiber pigtailing conditions. A random input polarization will be separated into two orthogonal polarizations (order -1 and +1).

Model	Source	Wavelength nm	Aperture mmxmm	Field of View degrees	Tuning Time µs	Polarization	Resolution nm-3dB	Efficiency
AOTFnC-UV	Laser	350-430	2 x 2	1	<4.5	Linear	1-2	85
AOTF1	Lamp	350-600	5 x 5	7	<7.5	Linear/Random	5-35	80
AOTF2	Laser/Lamp	360-530	2 x 2	1	<3	Linear/Random	1,5-5	85
AOTFnC-400.650	Laser	400-650	3 x 3	1	<4.5	Linear	1-4	85
AOTFnC-VIS	Laser	450-700	3 x 3	1	<4.5	Linear	1-2	85
AOTF3-LR	Laser/Lamp	400-700	6 x 6	4	<9	Linear/Random	5-25	85
AOTF3-MR	Lamp	400-700	4 x 4	4	<6	Linear/Random	3.5-17	85
AOTF3-HR	Lamp	400-700	3,5 x 3,5	3	<5	Linear/Random	2.5-12	85
AOTF5	Lamp	480-620	5 x 5	8	<7.5	Linear/Random	3-10	80
AOTF6	Laser/Lamp	500-850	5 x 5	3	<7.5	Linear/Random	11-3	80-60
AOTF7	Laser/Lamp	600-900	5 x 5	4	<7.5	Linear/Random	<4	70
AOTF10	Lamp	1250-2500	3 x 3	20	<4.5	Linear/Random	2-10	70-30
AOTF11	Laser	1520-1560	2 x 3	3	<3	Linear/Random	1.5	70
AOTF13	Lamp	690-1064	3 x 3	1	<4.5	Linear/Random	nov-34	85





PULSE SELECTOR AND REGEN SWITCH

Synchronized switching systems ensure optimum performance Conoptics provides a family of products specifically tailored for pulse selection or regenerative amplifier switching systems. Each system consists of an optical modulator, a modulator driver, and synchronization electronics. The low voltage design approach taken here reduces modulator drive levels by an order of magnitude compared to other methods. This feature makes switching rates to tens of MHz readily achievable and virtually eliminates EMI effects.

Pulse Selection Systems

SYSTEM		DRIVER PARAMETERS		MODULATOR PARAMETERS			
DRIVER	MODULATOR	MINIMUM PULSE WIDTH	MAXIMUM REP RATE	MINIMUM WAVELENGTH	MAXIMUM WAVELENGTH FOR 100% DYNAMIC SWING	APERTURE mm	DYNAMIC SWING AT MAXIMUM OPERATING WAVELENGTH
25D	350-160	18 / variable	20MHz	350nm	700nm	2.7	80%@1000nm
25D	360-80	18 / variable	20MHz	600nm	1000nm	2.7	37%@2500nm
25D	360-120	18 / variable	20MHz	600nm	1350nm	2.7	56%@2500nm
25D	360-160	18 / variable	20MHz	600nm	2000nm	2.7	93%@2500nm
307A	350-50	18 / variable	50KHz	350nm	850nm	3.1	95%@1000nm
307A-1	350-50	18 / variable	5KHz	350nm	850nm	3.1	95%@1000nm
307A	360-40	18 / variable	50KHz	700nm	2000nm	2.7	95%@2000nm
307A-1	360-40	18 / variable	5KHz	700nm	2000nm	2.7	95%@2000nm

Please contact the factory for special configurations. Typical static insertion loss is 6%

Regen Switching Systems

SYSTEM	RISE TIME NSEC	MAXIMUM REP RATE	APERTURE mm	MAXIMUM WAVELENGTH SINGLE PASS	MAXIMUM WAVELENGTH DOUBLE PASS	PULSE WIDTH
307 / 350-50	5	50KHZ	3.1	880nm	1000nm	40 to 500 nsec
307/ 350-50LA	5	50KHz	5.7	450nm	900nm	40 to 500 nsec
25D / 350-105	8	20MHz	3.1	400nm	800nm	18 nsec to dc

CHAPTER 3 PHOTONICS

E-O MODULATOR

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.

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 (V½). The transverse field structure allows reduction of V½ by manipulation of the crystal length to aperture ratio to a level achievable by available driver electronics. V½ 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 V½ 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. Table 1 below provides the specifications our ADP (240-to-800nm), KD*P (240-to-1100nm) and LTA (700-2000nm) series modulator product line.

	Model Number	V ½ wave @ 500nm	V ½ wave @ 830nm	V ½ wave @1064nm	V½ wave @2500nm	Aperture Diameter	Resonances	Contrast Ration @ 633nm and 1064nm	Length w/ Polarizer
ADP Crystal eries Wavelength Limits (240 to 800nm)*	M370	184	--	--	--	2.5mm	No	500:1,N/A	158mm
	M370 LA	263	--	--	--	3.5mm	No	500:1, N/A	158mm
	M380	92	--	--	--	2.5mm	No	500:1, N/A	253mm
	M390	115	--	--	--	3.5mm	No	500:1, N/A	272mm
KD*P Crystal Series Wavelength Limits **(240 to 1100nm)***	M350-50	455	757	970	--	3.1mm	Yes	500:1, 700:1	106mm
	M350-80	261	433	522	--	2.7mm	Yes	500:1, 700:1	137mm
	M350-80LA	360	600	720	--	3.5mm	Yes		137mm
	M350-105	226	376	472	--	3.1mm	Yes	500:1, 700:1	162mm
	M350-160	130	216	275	--	2.7mm	Yes	300:1, 500:1	215mm
	M350-210	113	188	240	--	3.1mm	Yes	300:1, 500:1	268mm
LTA Crystal Series Wavelength Limits (700 to 2000nm)	M360-40	--	312	400	950	2.7mm	Yes	N/A, 200:1	95mm
	M360-80	--	143	183	430	2.7mm	Yes	N/A, 100:1	137mm
	M360-120	--	107	138	323	2.7mm	Yes	N/A ,100:1	174mm
	M360-160	--	71	92	215	2.7mm	Yes	N/A, 100:1	215mm

Special Notes

- Special Order wavelengths below 400nm are available, please contact sales@conoptics.com
- Special Clamped version available to minimize Piezo-electric resonances
- To determine the ½ wave voltage at your operating wavelength, compute the voltage listed and multiply it by the ratio of the wavelengths. (i.e. M350-50 @ 700nm = 455 x 700 / 500 = 637 Volts)
- The last digits of the Model Number for the 350 and 360 Series designate the total crystal path length in millimeters.

Modulator Modifications

Any of the modulators listed here can be used as a phase modulator by simply rotating the input polarization direction by 45°. This procedure makes one of the modulator half segments essentially inactive and doubles V½ (now the voltage required for a 180° phase shift). A factory modification can be made during construction which restores V½ to its original value. This modification precludes use of the device as an intensity modulator, however, and is irreversible.

MODULATOR DRIVER

Amplifier Specifications

Table 2 listed below provides the basic specifications of our line of amplifiers and the interface configuration to the modulators. All of our amplifiers include a DC Bias Supply with greater than +/- 250 volts for setting the modulators operating point. The lump capacitance amplifiers have (2) BNC cables driving the modulator push-pull. The 50 ohms S.E. configuration has (2) SMA connectors for driving a 50 ohm single ended modulator and a third connector (BNC) for DC Bias. The 100 ohm and 50 ohm balanced line configuration has (2) twinax connectors for driving a balanced line modulator and a third miniature twinax connector for the DC Bias.

Table 2 Amplifier Details

Model	Bandwidth	Rise/Fall Times	Max. Output V	Typical Drive Configuration	Output
25A	DC TO 25MHz	14ns	145	100 Ohms B.L.	Analog
25D	DC TO 30MHz	8ns	175	100 Ohm's B.L.	Digital
50	DC TO 50MHz	7ns	90	50 Ohms B.L.	Analog
100	DC TO 100MHz	3.5ns	90	50 Ohms B.L.	Analog
200	10KHz TO 200MHz	-	170	50 Ohms S.E.	-
275	DC TO 8MHz	50ns	275	Lumped Capacitance	Analog
302RM	DC TO 250KHz	1micro sec	750	Lumped Capacitance	Analog
302A	DC TO 1MHz	350ns	350	Lumped Capacitance	Analog
307	DC TO 50KHz	8ns	800	Lumped Capacitance	Digital
505	20 TO 100MHz	-	44	50 Ohms S.E.	-
550	50 TO 500MHz	-	140	50 Ohms S.E.	-

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 3 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 3 Modulation Systems

Amplifier	Modulator	Bandwidth	Transmission at Longest wavelength
302RM	350-80LA	DC to 250KHz	85% @ 1040nm
302RM	350-50	DC to 250KHz	85% @ 830nm
302RM	350-80	DC to 250KHz	85% @ 1200nm
302A	350-105	DC to 1MHz	85% @ 830nm
307	350-50	DC to 50KHz	85% @ 900nm
505	360-80	20MHz to 100MHz	Phase Modulation
550	360-80	50 to 250MHz	85% @ 830nm
25A	350-160	DC to 25MHz	85% @ 600nm
25A	350-80	DC to 25MHz	85% @ 830nm
25D	350-160	DC to 30MHz	85% @ 700nm
25D	360-80	DC to 30MHz	85% @ 1064nm
50	380-2P	DC to 50MHz	85% @ 500nm
50	360-120	DC to 50MHz	85% @ 830nm
100	380-2P	DC to 100MHz	85% @ 500nm
100	360-120	DC to 100MHz	85% @ 830nm
200	350-80	10KHz to 200MHz	85% @ 350nm
200	350-160	10KHz to 100MHz	85% @ 600nm
200	360-80	10KHz to 200MHz	85% @ 830nm
275	350-105	DC to 8MHz	85% @ 650nm
275	350-160	DC to 8MHz	85% @ 1064nm

CHAPTER 3 PHOTONICS

ELECTRO-OPTIC BEAM DEFLECTORS

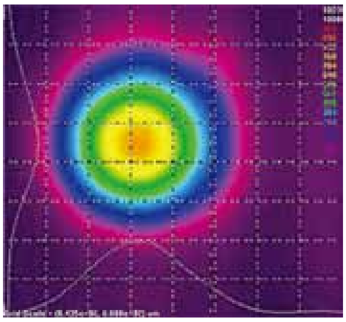
Conoptics series of electro-optic beam deflectors utilize a quadrapole electric field in an electro-optic material to produce a linear refractive index gradient proportional to the applied signal voltage. Choice of the proper material and crystallographic orientation eliminates piezoelectric ringing normally associated with other deflectors. There are no moving parts and they do not fatigue with prolonged use.

E-O Deflector

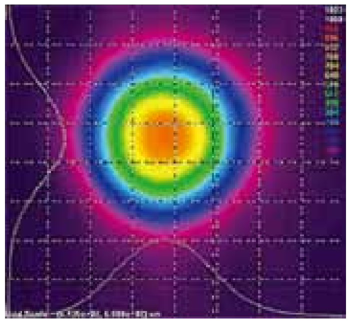
SPECIFICATION	M310A	M311A	M312	M312-2
Deflection Efficiency micro-radians/volt	1.5	3.0	0.6	1.2
Usable Aperture, mm	2.5	2.5	2.7	2.7
Capacitance, pf *	100	185	50	100
Spectral Range **	400→750	400→750	400→1100	400→1100
Length, "L" (mm)	4.65 (118)	8.62 (219)	2.77 (71)	4.9 (125)

* Available as 2 Port version - 50 and 100 ohms
** UV and DUV options available

Beam Profile Laser Alone



Beam Profile with Deflector



Deflector Specifications	
Dimensions	50mm Diameter x 20 mm long
Transmission	>90% 351//458
Aperture	<2..5 mm
Sensitivity	<2.63 microradians/volt (3 crystals)
	<0.875 microradians per volt (1 crystal)

M2100 Driver	
Connected to 3 Crystal Port	0 to +/- 0.5 mrad
Access Time	<35 nsec
Bandwidth	<10kHz to 12 MHz
Input	<0 dbm (626mv P-P) signal must have net DC = zero waveform (50% duty cycle)
Dimensions	122 x 38.1 x 49.9 cm
Maximum Pulse Width (2% droop)	200 nsec
Static DC Bias Range	0 to 550v
Electrical Input Power	1.6 KW

Model 302 Driver	
Connected to Single Crystal Port	0 to +/- 0.3 mrad;DC to 200 KHz
Access Time	<1 microsecond
Input Requirement	<2 Volts P-P
Input Impedance	<50 Ohms
Output Voltage	750 Volts P-P
-3 db Bandwidth	200 KHz
Driver Cabinet	6.5" W x 4.125" L x 4..15" H
Power Suply Cabinet	19" Rack x 5.25" H

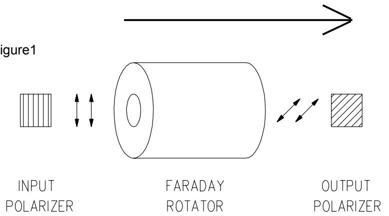
FARADY ROTATOR / ISOLATOR BASICS

Faraday Rotator

The negative effects of optical feedback on laser oscillators and laser diodes have long been know. Problems include frequency instability, relaxation oscillations, amplified stimulated emission and in extreme cases optical damage. As laser have improved, the need to protect laser oscillators and laser diodes from optical feedback has increased. A faraday isolators' ability to allow light to pass unimpeded in one direction while strongly attenuating light traveling in the opposite direction eliminates the negative effects of optical feedback.

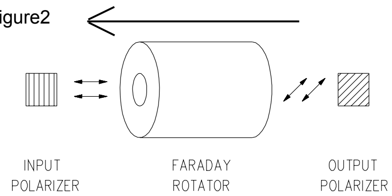
At the heart of a Faraday isolator is a Faraday rotator. Faraday rotators utilize high strength, rare earth permanent magnets in conjunction with a high damage threshold optical element to provide a uniform 45° polarization to light passing through the device.

Figure1



A Faraday isolator consists of three main components an input polarizer, a Faraday rotator and an output polarizer. As shown in Figure 1, light traveling in the forward direction passes through the input polarizer and becomes polarized in the vertical plane. Upon passing through the Faraday rotator, the plane of polarization will have been rotated 45° on axis. The output polarizer, which has been aligned 45° relative the input polarizer will then let the light pass through unimpeded. As Figure 2 shows, light traveling in the reverse direction will pass through the output polarizer and become polarized at 45°. The light will then pass through the Faraday rotator and experience an additional 45° of nonreciprocal rotation. The light is now polarized in the horizontal plane and will be rejected by the input polarizer, which only allows light polarized in the vertical plane to pass unimpeded.

Figure2



A Faraday isolators' ability to provide nonreciprocal rotation while maintaining a linear polarization is what differentiates it from a λ/4 plate-polarizer type isolator and allows it to provide higher isolation.

Broadband Isolator

Some applications, such as isolating individual amplifiers in a Ti:sapphire amplifier chain while maintaining the ability to tune rapidly over the amplifier bandwidth or isolating a femtosecond oscillator from a Ti:Sapphire regenerative amplifier, require isolators that are wavelength independent. Unfortunately, standard isolators are only capable of providing high isolation and transmission over a narrow range of wavelengths, usually about 30-40nm.

For this reason we provide Broadband isolators. Broadband isolators are unique in that they are passive devices which provide high isolators and good transmission over a 250nm range simultanceously.

A broadband isolator achieves its wide bandwidth by compensating for the dispersion in the Faraday rotator optic. While the direction of polarization rotation in a Faraday rotator is dependent upon the direction of the rotators' magnetic field, the direction of rotation in a crystal quartz rotator is dependent upon the direction of light propagating through it. By using a 45° crystal quartz optical rotator with its dispersion similar to the optic in the Faraday rotator, and aligning the Faraday rotator and crystal quartz rotator such that they rotate the polarization of back reflected light in opposite directions, the Faraday isolator becomes less wavelength dependent, if 45° rotator and crystal quartz rotator having the same dispersion and 90° (at the center wavelength only) in the forward direction.

Isolators for Laser Diode

Laser diodes present special challenges for Faraday isolators. Their beams tend to be highly elliptical. Some laser diodes (particularly single mode laser diodes) require very high isolators with 3x8mm apertures. These isolators utilize a proprietary magnetic design which allows them to be very small in size and low in cost.

The other challenge in designing an isolator for laser diodes, the need to attain high isolation, has also resulted in certain tradeoffs. Because ONSET's laser diode isolators are very small in size and inexpensive, applications requiring >60dB isolation can be solved by using two ONSET isolators in series. Another feature of ONSET's laser diode isolators is their ability to be tuned over a small wavelength range. This allows the performance of the isolator to be optimized for small changes in wavelength brought on by temperature drift of the laser diode.

Key Optical Components of a Faraday Isolator:

A. Faraday rotator optic: The most important optical element in a Faraday isolator is the Faraday rotator optic. The characteristics that one looks for in a Faraday rotator optic include a high verdet constant, low absorption coefficient, low non-linear refractive index and high damage threshold. Also, to prevent self-focusing and other thermal related effects, the optic should be as short as possible. The two most commonly used materials for the 650-1100nm range are terbium gallium garnet(TGG)and terbium doped borosilicate glass.

ONSET uses both materials.

B. Polarizers: Also of critical importance in determining the performance of Faraday isolator are the polarizers. Desirable polarizer characteristics include high damage threshold, high extinction ratios and low transmission losses. ONSET's 1030-11080nm isolators use thin film polarizers. Broadband isolators utilize calcite polarizers with Brewster angle entrance and exit faces. Laser diode isolator utilize PolarcorTM polarizers.

Optical Component Specifications:

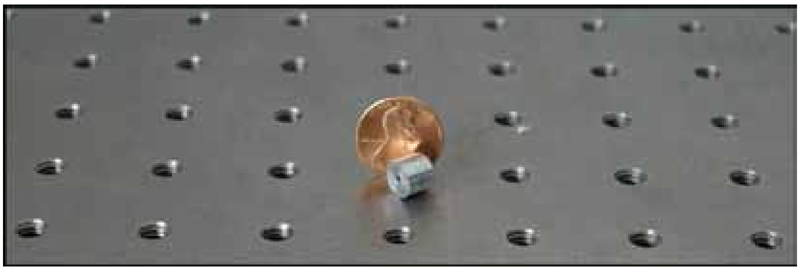
Faraday Rotator Optic Specifications:

	Tb:Glass	TGG
Bulk damage threshold @10nsec	2J/cm^2	5J/cm^2
Absorption coefficient @1064nm	<0.005cm-1	<0.0035cm-1
Nonlinear Refractive Index	2.7x10-13esu	8x10-13esu
Index of Refraction @1064nm	1.720	1.95
Verdet Constant @1064nm (min/Oe-cm)	0.098	0.125

Polarizer Specifications:

	1030-1080nm Isolators	Broadband Laser	Isolators Diode Isolators
Material	BK-7	Calcite	Polarcor™
Damage Threshold @10nsec	5J/cm^2	3J/cm^2	25W/cm^2(cw)
Refractive Index	1.517 @1064nm	1.48216 @800nm	1.529 @583nm
Transmittance	≥96%	≥98%	≥9%@800nm
Extinction Ratio	≥1000:1	≥10,000:1	≥10,000:1

1050-1080nm LOW POWER FREE SPACE FARADAY ISOIATORS



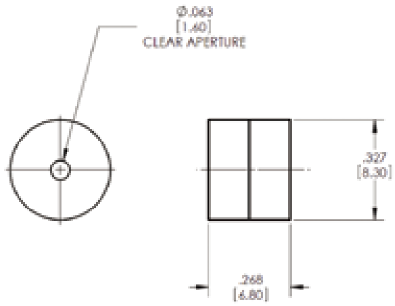
- Compact size
- 2I1064L2 gives >60dB isolation
- Great price/performance ratio

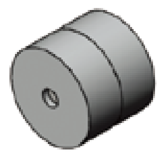
APPLICATIONS:

- Decouple seed lasers from slave lasers
  Eliminate frequency instability in laser diodes due to optical feedback

Part no. (Model)[a]	Clear Aper. (mm)	Transmission @25°C	Isolation @25°C	Pulsed Damage Threshold @ 10ns
110-10090-0001 (2BIG1064)	1.5	≥75%	≥30dB	500mW CW
110-10091-0001 (2BIG1064PBS)	1.5	≥75%	≥30dB	1MW/cm^2
110-10097-0001 (2I1064L2)	1.5	≥65%	≥60dB	500mW CW

Notes:
a. Product specifications and pricing subject to change without notice.





BROADBAND (Ti:Sapphire) FARADAY ROTATORS & ISOLATORS

- Prevent parasitic oscillations in high gain amplifier chains
- Prevents preferential lasing at outer low gain wavelengths

APPLICATIONS:

- Completely passive device, no tuning required
- Provides high isolation and good transmission simultaneously

ISOLATORS

Part No. (Model)[a]	Clear Aper.	Center λ (nm)	Spectral Range (nm)	Optical Path (mm)	Polarizer Type	Damage Threshold
110-10188-0001 (BB8-5I-RND)	5.0mm	800	720-950	42	Glan Laser	300MW/cm^2
110-10059-0001 (BB8-8I)	8.0mm	800	720-950	15	PBS Cube	100MW/cm^2
110-10155-0001 (BB8-10I)	10.0mm	800	720-950	28	PBS Cube	100MW/cm^2
110-10130-0001 (BB9-5I)	5.0mm	900	800-1050	43	Glan Laser	300MW/cm^2

ROTATORS

Part No. (Model)[a]	Clear Aper.	Center λ (nm)	Spectral Range (nm)	Optical Path (mm)	Pulsed Damage Threshold @10ns	Damage Threshold
110-10029-0001 (BB8-5R)	5.0mm	800	720-950	42	NA	5J/cm^2
110-10058-0001 (BB8-8R)	8.0mm	800	720-950	15	NA	5J/cm^2
110-10055-0001 (BB8-10R)	10.0mm	800	720-950	28	NA	5J/cm^2
110-10129-0001 (BB9-5R)	5mm	900	800-1050	43	NA	5J/cm^2

Notes:
a. Product specifications and pricing subject to change without notice.

500-1030nm WAVELENGTH TUNABLE FARADAY ISOLATORS

- Wavelength tunability allows optimal isolation over a range of wavelengths
- Easy to align isolator for various polarizationss
- Optical λ/2 plate available
- All isolators have double escape ports on input and output of the isolators

APPLICATIONS:

- Eliminate frequency instability in laser diodes due to optical feedback
- Eliminate parasitic oscillations in amplified laser systems
- Eliminate relaxation oscillations in mode-locked lasers

ISOLATORS

Part No. (Model) [a]	Center λ (nm)	Spectral Range (nm)	Isolation @25°C	Transmission @25°C	Polarizer Type	Damage Threshold
110-10081-0001 (4I980-LP)	980	960-1030	30-38dB	>90%	Dichroic Glass	25W/cm^2 CW
110-10077-0001 (4I850-LP)	850	840-960	30-38dB	>88%	Dichroic Glass	25W/cm^2 CW
110-10073-0001 (4I780-LP)	780	720-840	30-38dB	>82%	Dichroic Glass	25W/cm^2 CW
110-10069-0001 (4I650-LP)	650	630-700	30-35dB	>75%	Dichroic Glass	25W/cm^2 CW
110-10082-0001 (4I980-MP)	980	900-1030	27-35dB	>88%	PBS Cube	1J/cm^2 @ 10ns
110-10078-0001 (4I850-MP)	850	800-900	27-35dB	>88%	PBS Cube	1J/cm^2 @ 10ns
110-10074-0001 (4I780-MP)	780	720-830	27-35dB	>88%	PBS Cube	1J/cm^2 @ 10ns
110-10070-0001 (4I650-MP)	650	600-680	27-32dB	>88%	PBS Cube	1J/cm^2 @ 10ns
110-10068-0001 (4I532-MP)	532	500-600	27-32dB	>885	PBS Cube	1J/cm^2 @ 10ns

ROTATORS

Part No. (Model) [a]	Center λ ±10nm	Extinction @25°C (dB) [b]	Transmission @25Transmission @25°C	Polarizer Type	Pulsed Damage Threshold @10ns
110-10084-0001 (4R980)	980	≥30	>90%	NA	3J/cm^2
110-10080-0001 (4R850)	850	≥30	>88%	NA	3J/cm^2
110-10076-0001 (4R780)	780	≥30	>82%	NA	3J/cm^2
110-10072-0001 (4R650)	650	≥30	>75%	NA	3J/cm^2
110-10095-0001 (4R532)	532	≥30	>88%	NA	3J/cm^2

Notes:
a. Product specifications and pricing subject to change without notice.
b. When placed between crossed polarizers with extinction ratios of ≥1000:1.

1030-1080nm HIGHT POWER FREE SPACE FARADAY ROTATORS & ISOLATORS

- Device performance can be optimized for any wave length between 1030 and 1080nm
- All isolators have double escape ports on both the input and output of the device
- All isolators can be easily aligned for varying polarization states
- Optional λ/2 plate available for all devices

APPLICATIONS:

- Decouple laser oscillators from ASE created by amplifiers
- Eliminate relaxation oscillations in mode-locked lasers due to optical feedback
- Eliminate frequency instability in seed sources due to optical feedback

ISOLATORS

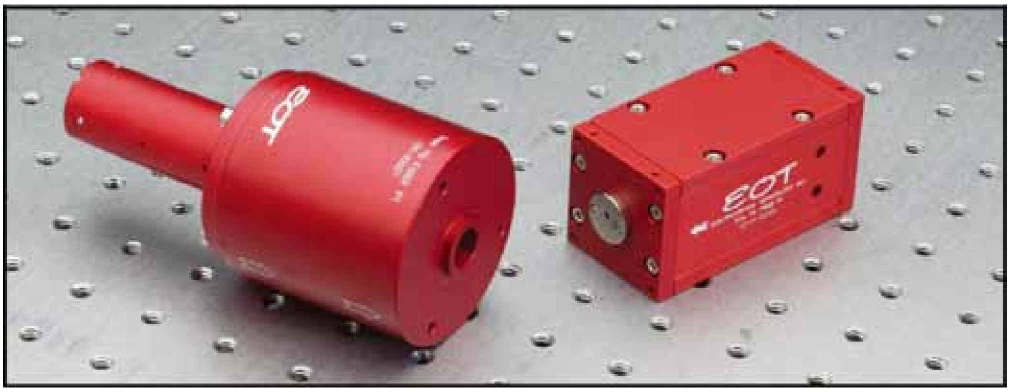
Clear Aper. (mm)	Part No. (Model) [a]	Trans. @25°C (%)	Isolation at 25°C (dB)	Rotation at Specified λ (°)	Optical Path (mm)/Rotating Medium	Pulsed Damage Threshold @ 10ns
2.0	110-10008-0001 (2I1055)	>92	>30	45±3	39 / TGG	5J/cm^2
4.0	110-10010-0001 (4I1055)	>92	>30	45±3	39 / TGG	5J/cm^2
8.0	110-10016-0001 (8I1055)	>92	>30	45±3	39 / TGG	5J/cm^2
12.0	110-10021-0001 (12I1055)	>92	>30	45±3	39 / TGG	5J/cm^2
15.0	110-10043-0001 (15I1055)	>92	>30	45±3	39 / TGG	5J/cm^2
20.0	110-10025-0001 (20I1055)	>92	>30	45±3	39 / TGG	5J/cm^2
25.0	110-10046-0001 (25I1055)	≥90	>30	45±3	57/Tb:glass	2J/cm^2
35.0	110-10140-0001 (35I1055)	≥90	>30	45±3	57/Tb:glass	2J/cm^2
45.0	110-10052-0001 (45I1055)	≥90	>30	45±3	57/Tb:glass	2J/cm^2

ROTATORS

Clear Aper. (mm)	Part No. (Model) [a]	Trans. @25°C (%)	Isolation at 25°C (dB) [b]	Rotation at Specified λ (°)	Optical Path (mm)/Rotating Medium	Pulsed Damage Threshold @ 10ns
2.0	110-10007-0001 (2R1055)	>98	>30	45±3	39 / TGG	5J/cm^2
4.0	110-10009-0001 (4R1055)	>98	>30	45±3	39 / TGG	5J/cm^2
8.0	110-10019-0001 (8R1055)	>98	>30	45±3	39 / TGG	5J/cm^2
12.0	110-10020-0001 (12R1055)	>98	>30	45±3	39 / TGG	5J/cm^2
15.0	110-10042-0001 (15R1055)	>98	>30	45±3	39 / TGG	5J/cm^2
20.0	110-10024-0001 (20R1055)	>98	>30	45±3	39 / TGG	5J/cm^2
25.0	110-10049-0001 (25R1055)	≥96	>30	45±3	57/Tb:glass	2J/cm^2
35.0	110-10050-0001 (35R1055)	≥96	>30	45±3	57/Tb:glass	2J/cm^2
45.0	10-10051-0001(45R1055)	≥96	>30	45±3	57/Tb:glass	2J/cm^2

Notes:
a. Product specifications and pricing subject to change without notice.
b. When placed between crossed polarizers with extinction ratios of ≥1000:1.

Yb:FIBER FREE SPACE PI ISOLATORS



- Protect pulsed Yb:Fiber lasers from back reflections during marking applications.
- Protect CW Yb:Fiber lasers from back reflections during etching, cutting, or welding applications.
- Models for power levels up to 300W, note example of spectral response (100W model shown).
- Models for 1/e 2 beam diameters from 350µm to 5mm.
- Mounting option for fiber collimator attachment.

Part No. (Model)a	110-10175-0001 (PI-0.7-Yb)	110-10235-0001 (PI-2.0-Yb)	110-10178-0001 (PI-6.2-Yb)	110-10125-0001 (PI-9.0-Yb-100)	110-10125-0003 (PI-9.0-Yb-300)
Clear Aperture	0.7mm	2.0mm	6.2mm	9.0mm	9.0mm
Max $1/e^2$ beam dia.	0.35mm	1.0mm	3.1mm	5.0mm	5.0mm
Isolator Type	Displacer	Displacer	Wedge[b]	Wedge[b]	Wedge[b]
Temp.-operating	5-50°C	5-50°C	5-50°C	5-50°C	5-50°C
Temp.-storage	-20 to 60°C	-20 to 60°C	-20 to 60°C	-20 to 60°C	-20 to 60°C
Isolation@23°C, 1070nm	>30dB	>30dB	>30dB	>27dB[a]	>25dB[a]
Min. Isolation across T-oper., 1070nm	>20dB	>20dB	>20dB[a]	>18dB[a]	>18dB[a]
Transmission	>94%	>94%	>94%	>94%	>94%
Return Loss	<-50dB	<-50dB	<-50dB	<-50dB	<-50dB
Operating Humidity	95%	95%	95%	95%	95%
Max. Power Handling	25W	40W	75W	100W	300W
Range of Focal Length of Thermal Lens at P-max and $1/e^2$ beam dia.	0.2-0.4m	1.1-1.9m	5.7-9.6m	11.2-18.7m	5.5-6.2m
Range of Absorbed Power	.075-0.13W	.12-0.2W	.225-0.38W	0.3-0.5W	0.9-1.0W
Min. distance from Laser Head	N/A	N/A	355mm[b]	516mm[b]	516mm[b]

Notes:
a. Product specifications and pricing subject to change without notice.
b. The isolated power in the wedge based isolator is directed out of the input aperture at an angle to the input beam; please refer to the Users Guides for more details. For applications at high average power and operating temperatures refer to the Users Guides and bulletins for more detailed information.

PHOTODETECTORS WITH ANALOG & TTL OUTPUTS

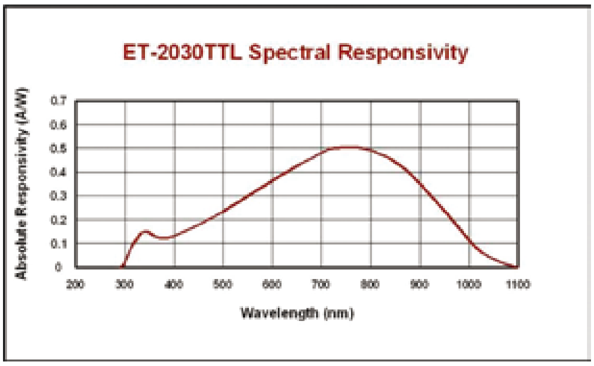
- Can generate analog or TTL output
- Contains pulse stretch feature
- Contains an adjustable trigger threshold

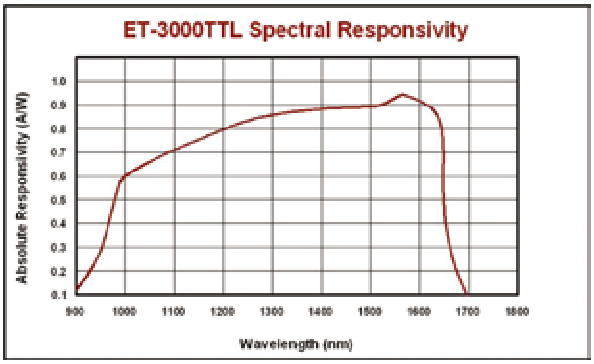
APPLICATIONS:

- Triggering applications with TTL output
- Monitoring the output of Q-switched lasers
- Monitoring the output of externally modulated CW lasers

Model	ET-2030TTL	ET-3000TTL
Detector Type	PIN	PIN
Detector Material	Silicon	InGaAs
Active Area (dia.)	0.4mm	100μm
Acceptance Angle	10°	20°
Power Supply	12VDC	12VDC
Mounting (Tapped Holes)	8-32 and M4	8-32 and M4
Analog Output		
Risetime/Falltime	<300ps	<175ps
Sensitivity	0.4A/W@830nm	
0.8A/W@1.3μm		
Frequency Response	DC-1.2GHz	DC-2GHz
Maximum Continuous Current	10mA	10mA
Max linear CW density	<10mA/mm2	<5mA/mm2 (damage)
Max linear pulse density	<10mA/mm2	<20mW/mm2 (damage)
Connector	BNC	BNC
TTL Output		
Risetime	<8ns	<8ns
Falltime	<9ns	<9ns
Adjustable Trigger Threshold	40-500mV	40-500mV
Threshold Monitor	External	External
Minimum Detectable Pulsewidth	8ns	8ns
Frequency Response	DC-60MHz	DC-60MHz
Logic High	>3.0V	>3.0V
Logic Low	<0.5V	<0.5V
Pulse Stretch (when enabled)	100ns typical	100ns typical
Termination	500Ω	500Ω
Connector	BNC	BNC

Notes:
a. Product specifications and pricing subject to change without notice.





BIASED SILICON PHOTODETCTOR

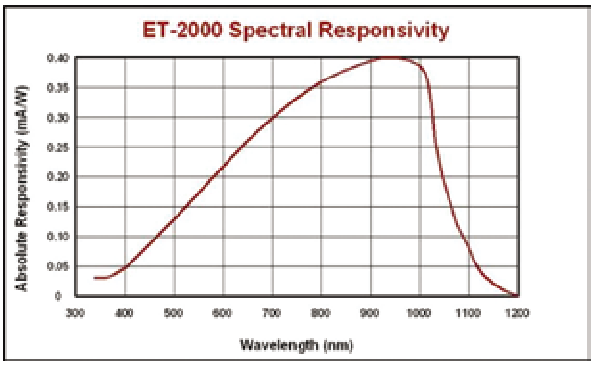
- All photodetectors come with their own internal or ex ternal power
- Combination 110/220VAC external power supply for externally biased models
- Available with optional FC or SMA input receptacle

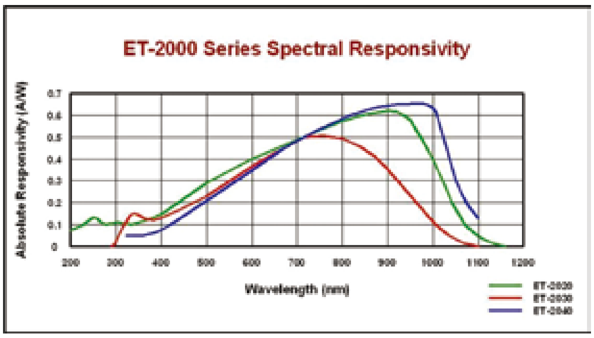
APPLICATIONS:

- Monitoring the output of Q-switched lasers
- Monitoring the output of mode-locked lasers
- Monitoring the output of externally modulated CW lasers
- Time domain and frequency response measurements

Model	(ET-2000)	(ET-2020)	(ET-2030)	(ET-2040)
Detector Type	PIN	PIN	PIN	PIN
Risetime	<200ps	<1.5ns	<300ps	<30ps
Falltime	<350ps	<1.5ns	<300ps	<30ps
Responsivity @830nm	0.4mA/W	0.5A/W	0.4A/W	0.5A/W
Bias Voltage	3V	24V	9V	24V
Cut Off Frequency into 50Ω	>1.5GHz	>200MHz	>1.2GHz	>25MHz
Active Area	0.006mm2	2.55mm dia.	0.4mm dia.	4.57mm dia.
Dark Current	<1nA	<10nA	<0.1nA	>20nA
Junction Capacitance	<4pF	<10pF	<1.5pF	<45pF
Reverse Breakdown Voltage	40V	150V	20V	50V
Acceptance Angle (1/2 angle)	20°	50°	30°	60°
Noise Equivalent Power	<0.1pW/√Hz	<1.0pW/√Hz	<0.0015pW/√Hz	<0.16pW/√Hz
Maximum Linear Ratings	20ns pulse @20mJ for 3mm dia. beam (damage)	CW density <5mA/mm^2 Pulse Density <20mA/mm^2	<10mA	CW current <2mA Optical Input <3mW
Mounting (Tapped Holes)	8-32 or M4	8-32 or M4	8-32 or M4	8-32 or M4
Output Connector	BNC	BNC	BNC	BNC

Notes:
a. Product specifications and pricing subject to change without notice.





BIASED InGaAs PHOTODETECTOR

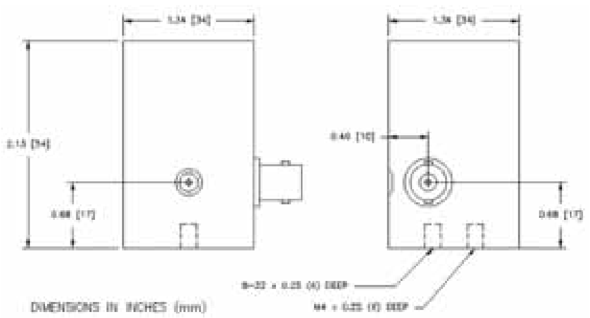
- All photodetectors come with their own internal or external power
- Available with optional FC or SMA input receptacle

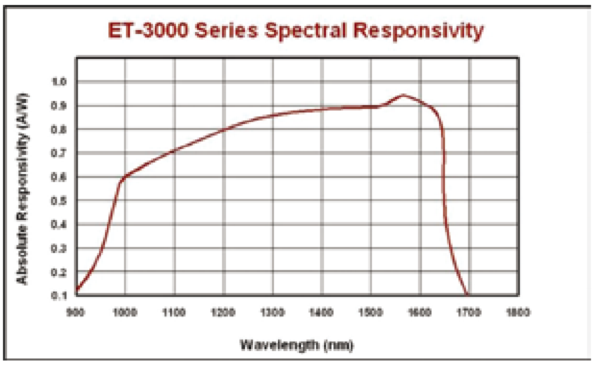
APPLICATIONS:

- Monitoring the output of Q-switched lasers
- Monitoring the output of mode-locked lasers
- Monitoring the output of externally modulated CW lasers
- Time domain and frequency response measurements

Model	ET-3000	ET-3010	ET-3020	ET-3040
Detector Type	PIN	PIN	PIN	PIN
Risetime	<175ps	<225ps	<6ps	<1.25ns
Falltime	<175ps	<225ps	<250ns	<3.70ns
Responsivity @1300nm	0.8A/W	0.8A/W	0.8A/W	0.9A/W
Bias Voltage	6V	6V	Non-biased b	6V
Cut Off Frequency into 50Ω	>2GHz	>1.5GHz	>2.5MHz	>50MHz
Active Area	100µm	100µm	3.0mm dia.	1.0mm dia.
Dark Current	<1nA	<1nA	<2000nA	<20nA
Junction Capacitance	<0.75pF	<1.25pF	<1300pF	<32pF
Reverse Breakdown Voltage	25V	25V	2V	20V
Acceptance Angle (1/2 angle)	20°	50°	50°	50°
Noise Equivalent Power	<0.1pW/√Hz	<0.1pW/√Hz	<1pW/√Hz	<0.1pW/√Hz
Maximum Linear Ratings	CW current (damage) 5mA CW power (damage) 20mW	CW current <5mA CW power <5mW	CW current (damage) 5mA CW power (damage0 20mW	CW current (damage) 5mA CW power (damage0 20mW
Mounting (Tapped Holes)	8-32 or M4	8-32 or M4	8-32 or M4	8-32 or M4
Output Connector	BNC	BNC	BNC	BNC
Fiber Optic Connector	N/A	FC	N/A	N/A

Notes:
a. Product specifications and pricing subject to change without notice.
b. Operates in the photovoltaic mode.





2GHz AMPLIFIED PHOTODETECTOR

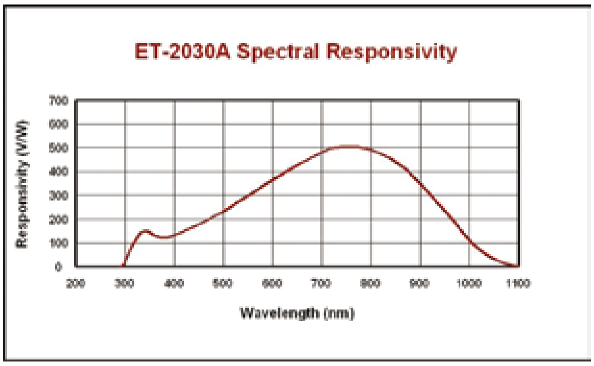
- Built-in transimpedance amplifier
- Optional FC input receptacle available

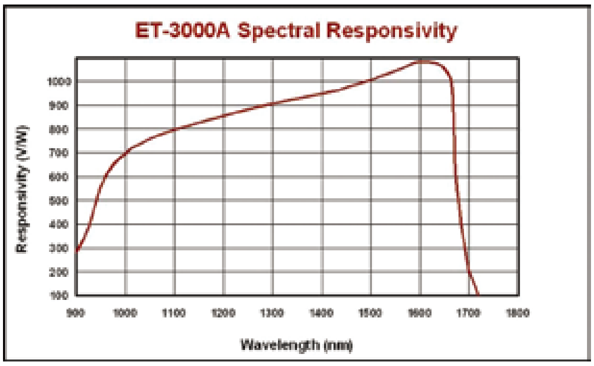
APPLICATIONS:

- Monitoring high repetition rate, externally modulated CW lasers
- Viewing <1mW

Model	ET-2030A	ET-3000A
Detector Material	Silicon	InGaAs
Risetime	<500ps	<400ps
Falltime	<500ps	<400ps
Responsivity	450V/W @830nm	900V/W @ 1300nm
Power Supply	24V	24V
Frequency Response	30kHz – 1.2GHz	30kHz – 1.5GHz
Active Area (dia.)	400µm	100µm
Acceptance Angle (1/2 angle)	10°	20°
Noise Equivalent Power (pW/√Hz)	<60	<30
Maximum Undistorted Output Voltage	500mV p-p	400mV p-p
Output Connector	BNC	BNC
Mounting (Tapped Hole)	8-32 and M4	8-32 and M4

Notes:
a. Product specifications and pricing subject to change without notice.
b. Not suitable for CW applications.





10GHz PHOTODETECTOR

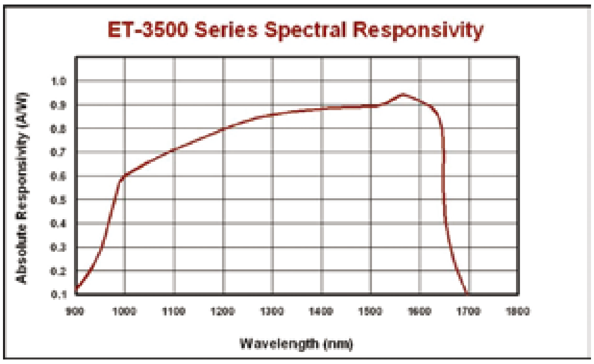
- Optional wall plug-in power supply available
- Typical frequency response for InGaAs models is >12.5GHz
- Comes with internal 6V battery bias

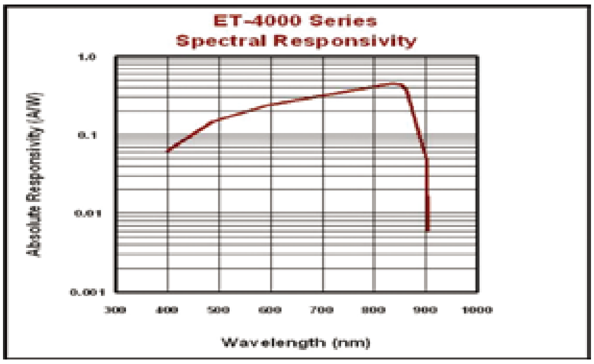
APPLICATIONS:

- Monitoring the output of externally modulated CW laser
- Monitoring the output of mode-locked lasers
- Time domain and frequency response measurements

Model	ET-3500	ET-3500F	ET-4000	ET-4000F
Detector Type	PIN	PIN	PIN	PIN
Detector Material	InGaAs	InGaAs	GaAs	GaAs
Spectral Range	1000-1650nm	1000-1650nm	400-900nm	400-900nm
Risetime	<35ps	<35ps	<35ps	<35ps
Falltime	<35ps	<35ps	<35ps	<35ps
Responsivity	0.88A/W@1550nm	0.88A/W@1550nm	0.45A/W@850nm	0.45A/W@850nm
Bias Voltage	6V	6V	6V	6V
Cut Off Frequency	>12.5GHz	>12.5GHz	>10GHz	>10GHz
Active Area Dia.	32μm	32μm	40μm	40μm
Dark Current	<3nA	<3nA	<200pA	>200pA
Junction Capacitance	0.12pF	0.12pF	0.3pF	0.3pF
Noise Equivalent Power	<0.04pW/√Hz	<0.04pW/√Hz	<0.02pW/√Hz	<0.02pW/√Hz
Max. Linear CW Power	10mW	10mW	10mW	10mW
Output Connector	SMA	SMA	SMA	SMA
Fiber Optic Connection	N/A	FC/UPC	N/A	FC/UPC
Mounting (Tapped Holes)	8-32 or M4	8-32 or M4	8-32 or M4	8-32 or M4

Notes: a. Product specifications and pricing subject to change without notice.





2μm AMPLIFIED HIGH SPEED DETECTOR

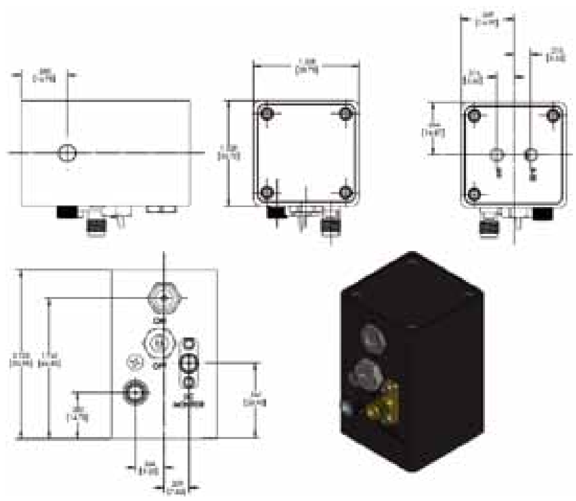
- Responsivity out to 2100nm
- Rise Time and Fall Time <250ps
- Available with free space or FC/UPC input

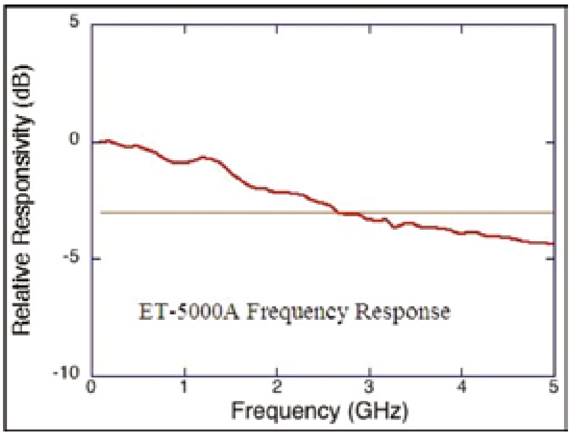
APPLICATIONS:

- Allows monitoring of Tm and Ho lasers
- Pulse width measurement of sub ns lasers
- Suitable for free space or fiber laser

Model	ET-5000A	ET-5000AF
Spectral Range	830 – 2100nm	830 – 2100nm
Detector Material	InGaAs	InGaAs
Detector Type	PIN	PIN
Risetime	<250ps	<250ps
Falltime	<250ps	<250ps
Conversion Gain	1600 V/W at 2000nm	1600 V/W at 2000nm
Bandwidth	20kHz – 1.5GHz	20kHz – 1.5GHz
Photodiode Active Area Dia.	55μm	55μm
NEP @ 2.0um:	<20pW/sqrt(Hz)	<20pW/sqrt(Hz)
Power Supply	5V	5V
Mounting (Tapped Hole)	8-32 or M4	8-32 or M4
Fiber Optic Connection	N/A	FC/UPC (SMF-28e)

Notes:
a. Product specifications and pricing subject to change without notice.





2µm HIGH SPEED DETECTOR

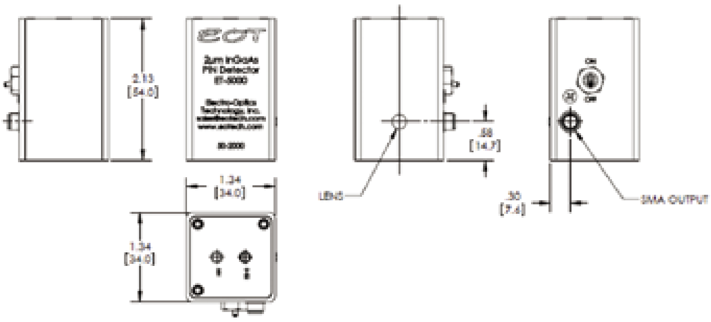
- Responsivity out to 2100nm
- Rise Time and Fall Time <35ps
- Available with free space or FC/UPC input

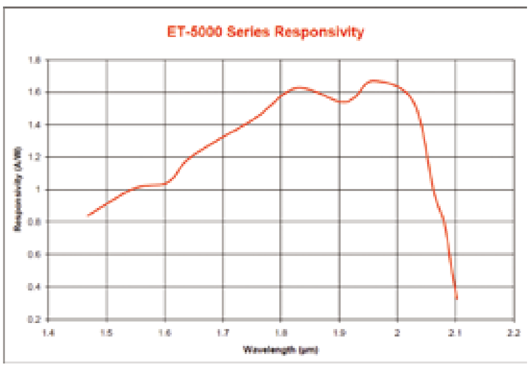
BENEFITS:

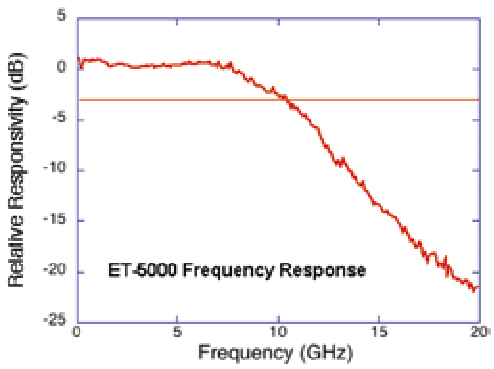
- Allows monitoring of Tm and Ho lasers
- Pulse width measurement of sub ns lasers
- Suitable for free space or fiber laser

Model	ET-5000	ET-50000F
Spectral Range	830 – 2100nm	830 – 2100nm
Detector Material	InGaAs	InGaAs
Detector Type	PIN	PIN
Risetime	<35ps	<35ps
Falltime	<35ps	<35ps
Responsivity	1.6 A/W at 2000nm	1.6 A/W at 2000nm
Cutoff Frequency	>10GHz	>10GHz
Photodiode Active Area Dia.	40µm	40µm
Dark Current	<10µA	<10µA
NEP @ 2.0um:	<20pW/sqrt(Hz)	<20pW/sqrt(Hz)
Power Supply	3V , battery	3V , battery
Mounting (Tapped Hole)	8-32 or M4	8-32 or M4
Fiber Optic Connection	N/A	FC/UPC (SMF-28)

Notes: a.Product specifications and pricing subject to change without notice.







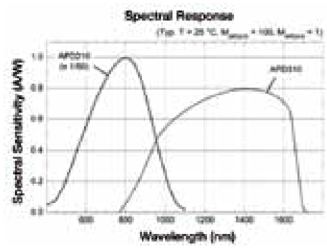
HIGH SENSITIVITY AVALANCHE DETECTORS

- High-Speed Response up to1 GHz
- Continuously Adjustable Gain
- 400-1000 nm and 850-1650 nm Wavelength Ranges Available
- SM05 Threaded for Lens Tube and Cage Assembly Integration

APPLICATIONS:
- Detection of Fast Laser Pulses
- For Beat Signals of Low-Level Inputs
- LIDAR (Light Detection and Ranging)
- Testing of Optical Components

Menlo Systems' Avalanche Photodetector (APD) series provides an extremely lightsensitive alternative to traditional PIN photodiodes. The APDs are sensitive and fast enough for the characterization of pulsed lasers on the the order of nanoseconds. The silicon avalanche photodiode of the APD210 provides exceptional performance for low-light applications in the 400 - 1000 nm range, while the APD310 covers the InGaAs range of 850 - 1650 nm. The APD maintains high-gain stability over the operating temperature range by utilizing a temperature-compensation circuit, which adjusts the ~150 VDC bias to ensure operation near the breakdown voltage.

A 40 dB gain amplifier is integrated into the package and is AC-coupled to band the output BNC. The output is matched to 50 Ω impedance. The detector has an electronic width of 1 MHz to 1 GHz and offers a user-accessible potentiometer providing a continuous gain adjustment. The APD series has SM05 threads for easy integration into Thorlabs' entire family of lens tubes and cage assemblies. The bottom of the detector has a metric (M4) mounting hole and an M4 to #8-32 adapter for post mounting. The compact packaging allows the APD to be substituted directly into an existing setup while maintaining a small footprint on the benchtop.



These photodetectors are not suitable for pulses longer than 30 ns or continuous light levels.

	APD210	APD310
Optical Input	Free Spacea	Free Spacea
Supply Voltage	12-15 V	12-15 V
Current Consumption	200 m A	200 m A
Max. Incident Power	10 mW	10 mW
Operating Temperature	10-40 °C	10-40 °C
Spectral Range	400-1000 nm	850-1650 nm
Detector Diameter	0.5 mm	0.03 mm
Frequency Range	1-1600 MHz	1-1800 MHz
3 dB Bandwidth	5-1000 MHz	5-1000 MHz
Rise Time	500 ps	500 ps
Maximum Gainb	2.5 x 105V/W @ 1 GHz, 800 nm	2.5 x 104 V/W @ 1 GHz, 1500 nm
Dark State Noise Levelc	-80 dBm	-80 dBm
NEP (calculated)	0.4 pW/√Hz	2 pW/√Hz
Output Connectors	BNC	BNC
Output Impedance	50Ω	50Ω
Device Dimensions	60 mm x 56 mm x 47.5 mm	60 mm x 56 mm x 47.5 mm
Output Coupling	AC	AC

DET SERIES PHOTO DETECTORS

DET Series Features

- High Speed Response
- Responsive from 150 to 2600nm
- Easy to Use
- Internal A23 +12V Bias Battery Included
- Low Profile Housing Minimizes Light Path Interference
- Includes Threaded Mount for 1" (25mm) Optics
- Compatible with SM1 & SM05 Series Products
- Battery Level Check Included

The DET-series detectors are compact, versatile, highspeed optical detectors. Each model comes complete with a fast PIN photodiode and an internal bias battery packaged in a rugged aluminum housing. With a wide bandwidth DC-coupled output, these detectors are ideal for monitoring fast-pulsed lasers as well as DC sources. The direct photodiode anode current is provided on a rear panel BNC. This output is easily converted to a positive voltage using a terminating resistor. We recommend a 50ohm load resistance for fastest response times.

Each DET housing includes a detachable 1" Optic Mount (SM1T1) for installing Neutral Density Filters, spectral filters and lenses. The optical head is fully compatible with Thorlabs SM1-series and cage plate accessories. Thorlabs has decreased the package diameter to better fit our cage plate assemblies. Also available are fiber optic adapters for use with connectorized fiber.

METRIC ITEM#	TYPE	NEP1 (W/ √ Hz)	RISE TIME	ACTIVE AREA	SPECTRAL RANGE
DET25K/M	GaP	1.6 x 10^{-14}	1 nsb	4.8mm^2 (2.2 x 2.2 mm)	150-550nm
DET36A/M	Si	1.6 x 10^{-14}	14ns (Max)	13mm^2 (3.6 x 3.6 mm)	350-1100nm
DET10A/M	Si	1.9 x 10^{-14}	1ns (Max)	0.8mm^2 (Ø1 mm)	200-1100nm
DET100A/M	Si	5.5 x 10^{-14}	43ns (Max)	75.4mm^2 (Ø.9.8 mm)	350-1100nm
DET50B/M	Ge	4 x 10^{-12}	440ns (Max)	19.6mm^2 (Ø5.0mm)	800-1800nm
DET10C/M	InGaAs	1.6 x 10^{-14}	10ns (Max)	0.8mm^2 (Ø1.0mm)	700-1800nm
DET10D/M	InGaAs	2 x 10^{-12}	25ns (Max)	0.8mm^2 (Ø1.0mm)	1200-2600nm

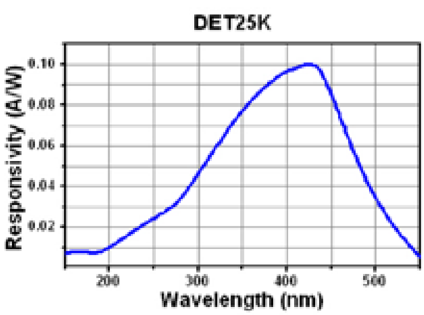
Fiber Adaptor

The SM1-Series fiber adapters thread directly onto DETSeries detectors for convenient attachment of fiber optics.

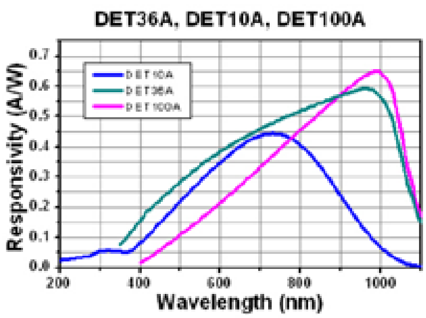
They can also be used with the SM1-series stackable lens tubes.

Item#	Description
SM1FC	FC Adaptor
SM1SMA	SMA Adaptor
SM1ST	ST Adaptor

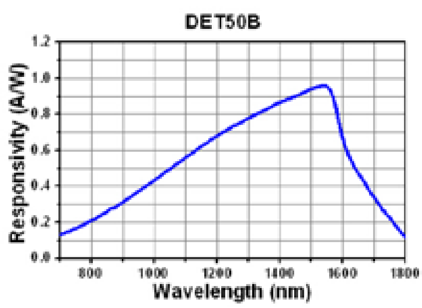
GaP Detector - UV Wavelengths



Si Detector - VIS Wavelengths



Ge Detector - NIR Wavelengths



SWITCHABLE-GAIN PHOTODETECTOR

PDA36A
Base assembly sold separately.
Power Supply Included.

The new PDA series detector housing utilizes a thin profile to allow access to light paths with the minimum amount of interference. All connections and controls are located perpendicular to the light path providing increased accessibility.

Each PDA includes a low noise transimpedance or voltage amplifier and provides a 50& drive capability. The wideband models have a fixed gain and 150MHz bandwidth, while the switchable gain versions provide 70dB of adjustment.

New for the PDA line is the addition of IR detectors with the ability to detect light out to 4.8μm. These photoconductive sensors include an AC coupled amplifier with a fixed voltage gain of 100V/V (50V/V with 50& load).

The new PDA series housing includes a removable threaded coupler that is compatible with any number of our SM1 and SM05 threaded accessories. This allows convenient mounting of external optics, light filters, and apertures, as well as providing an easy mounting mechanism when using our cage assembly accessories. Each housing provides two 8-32 tapped mounting holes (M4 for -EC versions) centered on the detector surface. A 120VAC AC/DC power supply is included.

ITEM#	SENSOR	BANDWIDTH	WAVELENGTH RANGE	ACTIVE AREA	GAIN
PDA25K	GaP	7.5 MHz	150-550 nm	6.25 mm^2 (2.5 × 2.5 nn)	1.5 × 10^3 to 4.75 × 10^6 V/A[C]
PDA10A	Si	150 MHz	200-1100 nm	0.8 mm^2(Ø1 nn)	1 × 10^4 V/A
PDA8A	Si	50 MHz	320-1000 nm	0.5 mm^2 (Ø0.8 nn)	1 × 10^6 V/A
PDA36A	Si	17 MHz	350-1100 nm	6.25 mm^2 (2.5 × 2.5 nn)	1.5 × 103 to 4.75 × 106 V/A[C]
PDA100A	Si	1.5 MHz	400-1100 nm	13 mm^2 (3.6 × 3.6 nn)	1.5 × 103 to 4.75 × 106 V/A[C]
PDA10CF	InGaAs	150 MHz	700-1800 nm	754 mm^2(Ø9.8 nn)	1 × 10^4 V/A
PDA10CS	InGaAs	17 MHz	700-1800 nm	0.2 mm^2 (0.5 nn)	1.5 × 103 to 4.75 × 106 V/A[C]
PDA50B	Ge	400 KHz	800-1800 nm	19.6 mm^2 (Ø5 nn)	1.5 × 103 to 4.75 × 106 V/A[C]
PDA10D	InGaAs	15 KHz	1200-2600 nm	0.8 mm^2 (Ø1 nn)	1 × 10^4 V/A
PDA30G	PbS	0.2 KHz to 1 kHz[d]	1000-2900 nm	9 mm^2 (3.0 × 3.0 nn)	100X
PDA20H	PbSe	0.2 KHz to 10 kHz[d]	1500-4800 nm	4 mm^2 (2.0 × 2.0 nn)	100X

SM1FC
Fiber Adapters

The SM1-Series fiber adapter thread directly onto PDA Series detectors for convenient attachment of fiber optics. They can also be used with the SM1-series stackable lens tubes.

ITEM#	DESCRIPTION
SM1FC	FC Adapter
T4119	In-Line Terminator

PDA Series Features

- GaP, Si, Ge, InGaAs, PbS, and PbSe Versions Available
- Our line of PDAs Cover A Wide Wavelength Range from 150nm to 4800nm
- Up to DC-150MHz Bandwidth
- High-Speed PIN Photodiode
- Low-Noise, Wide Band Amplifier
- 0 to 10V Output
- Includes Threaded Mount for 1" (25mm) Optics
- Compatible with SM1 Series and SM05 Series Products

PHOTODIODES

- 15 Models to Choose From
- InGaAs, Silicon, Ge or GaP Photodiodes
- Ideal for Measuring Pulsed and CW Sources
- Mounted in SM05 or SM1 Threaded Tubes

SM05PD

SM1PD1B

SM05-Threaded Mounted Photodiodes, Cathode Grounded

Item #	Detector	Rise/Fall Time (ns)	Active Area (Dimensions)	NEP (W/√Hz)	Dark Current	Spectral Range (nm)	Material	Junction Capacitancea
SM05PD7A	FGAP71	1 / 140	4.8 mm^2 (Ø2.5 mm)	1.0×10^{-14}	10 nA	150-550	GaP	-
SM05PD2A	FDS010	1	0.8 mm^2 (Ø1.0 mm)	5.0×10^{-14}	2.5 nA	200-1100	Si	10 pF @ 0 V
SM05PD1A	FDS100	20	13 mm^2 (3.6 x 3.6 mm)	1.2×10^{-14}	20 nA	350-1100	Si	20 pF @ 1V
SM05PD4A	FGA10	12	0.8 mm^2 (Ø1.0 mm)	1.0×10^{-14}	25 nA	800-1800	InGaAs	80 pF @ 0 V
SM05PD5A	FGA21	66/ 66	3.1 mm^2 (Ø2.0 mm)	3.0×10^{-14}	200 nA	800-1800	InGaAs	500 pF @ 0 V
SM05PD6A	FDG03	1400	7.1 mm^2 (Ø3.0 mm)	1.0×10^{-12}	4.0 μA	800-1800	Ge	4 nF @ 1V

SM05-Threaded Mounted Photodiodes, Anode Grounded

Item #	Detector	Rise/Fall Time (ns)	Active Area (Dimensions)	NEP (W/√Hz)	Dark Current	Spectral Range (nm)	Material	Junction Capacitancea
SM05PD1B	FDS100	20	13 mm^2 (3.6 x 3.6 mm)	1.2×10^{-14}	20 nA	350-1100	Si	20 pF @ 1 V
SM05PD2B	FDS010	1	0.8 mm^2 (Ø1.0 mm)	5.0×10^{-14}	2.5 nA	200-1100	Si	10 pF @ 0 V

SM1-Threaded Mounted Photodiodes, Cathode Grounded

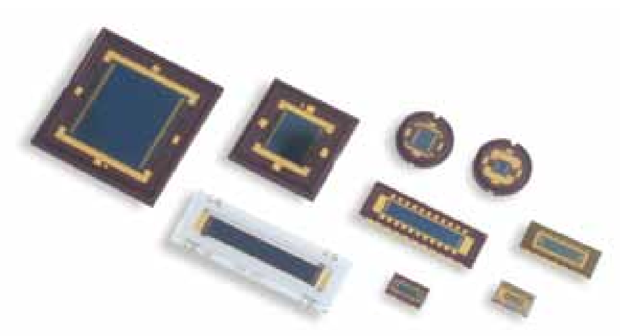
Item #	Detector	Rise/Fall Time (ns)	Active Area (Dimensions)	NEP (W/√Hz)	Dark Current	Spectral Range (nm)	Material	Junction Capacitancea
SM1PD2A	-	45	63.6 mm^2	9.1×10^{-14}	1.0 μA	200-1100	UV Si	1750 pF @ 0V
SM1PD1A	FDS1010	45	63.6 mm^2 (Ø9.0 mm)	5.5×10^{-14}	600 nA	400-1100	Si	375 pF @ 5V
SM1PD5A	-	3500	Ø9.0 mm (63.6 mm^2)	$4 \times 10^{-14-2}$	50 μA	800-1800	Ge	-

SM1-Threaded Mounted Photodiode, Anode Grounded

Item #	Detector	Rise/Fall Time (ns)	Active Area (Dimensions)	NEP (W/√Hz)	Dark Current	Spectral Range (nm)	Material	Junction Capacitancea
SM1PD1B	FDS1010	45	63.6 mm^2 (Ø9.0 mm)	5.5×10^{-14}	600 nA	400-1100	Si	375 pF @ 5 V

POSITION SENSING DETECTORS

For Non-Contact Measurement Of Position,Motion, Distance And Vibration



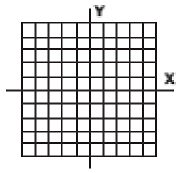
Features

- Superior Linearity—Better Than 99.95% Over 80% of ActiveArea
- Proven Analog Resolution Better Than 1 Part Per Million
- Low Thermal Drift, Less Than 40 ppm/°C
- Fast Response Time
- Simultaneous Position and Intensity Measurement
- Wide Spectral Range
- Independent of Light Spot Size

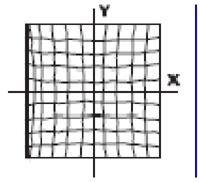
Model	Active Area mm	Responsivity @ 940 nm A/W	Dark Current nA		Noise Current pA/Hz1/2		Capacitance pF@15V		Rise Time μs 10-90% 15V	
			Typ.	Max	Typ.	Max	Typ.	Max	Typ.	Max
One Dimensional PSD Series										
1L2.5SP	2.5 x 0.6	0.63	2	10	0.4	1.0	1.6	2.0	.03	.05
1L5SP	5.0 x 1.0	0.63	4	20	0.4	1.0	5	6	.05	.08
1L10	10.0 x 2.0	0.63	8	50	0.4	1.0	15	20	.20	.40
1L20	20.0 x 3.0	0.63	50	250	0.5	1.0	45	55	.50	1.0
1L30	30.0 x 4.0	0.63	150	1000	0.5	1.0	90	110	1.0	1.8
1L45	45 x 3.0	0.63	110	1500	0.4	0.9	105	125	2.7	4.2
1L60	60 x 3.0	0.63	150	2000	0.4	1.0	135	160	4.5	8.5
One Dimensional PSD SeriesWith Stray Light Elimination										
1L5NT	5.0 x 0.25	0.63	4	20	0.3	0.6	5	6	.25	.40
1L10NT	10.0 x 0.5	0.63	8	50	0.3	0.6	15	20	0.7	1.4
Two Dimensional PSD Series—Duolateral										
2L2SP	2.0 x 2.0	0.63	50	200	1.3	2.5	7	8	.03	0.6
2L4SP	4.0 x 4.0	0.63	50	200	1.3	2.5	20	25	.08	.16
2L10SP	10.0 x 10.0	0.63	100	500	1.3	2.5	90	110	.40	.80
2L20SP	20.0 x 20.0	0.63	200	2000	1.5	3.5	360	430	1.6	3.0
2L45	45 x 45.0	0.63	400	4000	1.5	3.5	1600	2000	7	14

PSD General Description

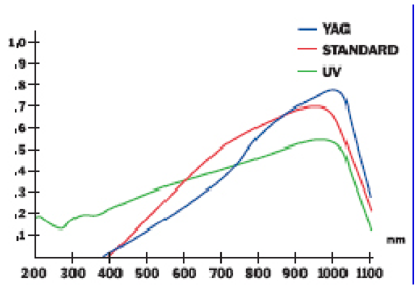
We offers a broad range of Position Sensing Detectors (PSD) that enable you to simultaneously monitor position and light intensity.
Ideal for non-contact measurement of position, motion, distance and vibration, all devices are silicon-based detectors that provide an analog output directly proportional to the position of a light spot on the detector's active area.
The continuous analog-output of silicon-based detectors provides numerous advantages over discrete element devices. These advantages include superior position linearity, unsurpassed analog resolution, faster response time and simpler operating circuits.
For more information on Position Sensing Detectors, and how they can benefit your particular application, please call us.



On-Trak Duolateral
PSD Linearity (typical)



Competitor PSD
PSD Linearity (typical)



Reverse Bias V			Detector Resistance (k Ω)			Thermal Drift ppm/°C		Position Non-Linearity	
Min	Typ.	Max	Min	Typ.	Max	Typ.	Max	Typ.	Max
5	15	20	40	50	80	20	100	0.1	0.2
5	15	20	40	50	80	20	100	0.1	0.2
5	15	20	40	50	80	20	100	0.1	0.2
5	15	20	40	50	80	20	100	0.1	0.2
5	15	20	40	50	80	20	100	0.1	0.2
5	15	20	90	115	150	20	100	0.1	0.2
5	15	20	12	150	200	20	100	0.1	0.2
5	15	20	160	200	300	20	100	0.1	0.2
5	15	20	160	200	300	20	100	0.1	0.2
5	15	20	7	10	16	40	200	0.3	1.0
5	15	20	7	10	16	40	200	0.3	0.8
5	15	20	7	10	16	40	200	0.3	0.8
5	15	20	7	10	16	40	200	0.3	0.8
5	15	20	7	10	16	40	200	0.3	1.0

CHAPTER 3 PHOTONICS

POSITION SENSING MODULES

For Non-Contact Measurement Of: Position,Motion, Distance And Vibration

Features

- Fully Packaged Position Sensing Detectors
- Silicon Linear: 400-1100 nm
  Silicon Duolateral: 400-1100 nm
  Silicon Quadrant: 400-1100 nm
  GermaniumTetra-Lateral: 800-1800 nm
- Removable Filter Holder Adapter
- Standard Mounting Holes
- Plug and Play Compatibility with all the
- Position Sensing Amplifiers

PSM Series Position Sensing Modules. Plug-And-Play Precision

Position Sensing Modules are fully packaged position sensing detectors that, when used with an On-Trak position sensing amplifier, provide an analog output directly proportional to the position of a light spot on the detector active area.
Yet, what truly sets them apart is heir proprietary, plug-and-play design. Never has position sensing been so convenient...or accurate.

Finally,APlug-And-Play Solution.

No more hassling with breadboards, soldering, cutting and wiring. Instead, all Positron Sensing Modules (PSMs) incorporate a subminiature 9-pin connector that plugs directly into any Position Sensing Amplifier.
Just plug it in and go. It's that simple

Single, Duolateral, Quadrant.

Select from several distinct configurations; each module contains a linear, duolateral, tetralateral, or quadrant position sensing detector. All modules are conveniently packaged to allow simultaneous monitoring of position and light intensity. Position Sensing Modules come in two package sizes: Standard and Compact. The standard measures 2.8" x 2.45" x 1.125". The ompact measures 1.25" x 1.25" x 0.975".

Filters And Filter Holder Adapters.

Harsh ambient lighting conditions? No problem. Each module readily accepts a complete range of optional filters toreduce the effect of noise caused by ambient light. Moreover, a filter holder is included with each module at no extra cost.

Standard Mounting Holes.

All PSMs feature standard mounting holes for easy mounting with your existing lab equipment. Whether your post and stands are 1/4 -20 or 8/32, you'll be up and running in a matter of minutes.

Robust Aluminum Housings.

The Position Sensing Modules are encased in rugged aluminum housings to protect your investment.

PSM Specifications

Model	Active Area (mm)	Detector Type	Wavelength Range	Package Type	Typ. Resolution	Typ. Linearity
PSM 1-2.5	2.5 x 0.6	Linear Silicon	400-1100 nm	Compact	62.5 nm	0.1%
PSM 1-5	5.0 x 1.0	Linear Silicon	400-1100 nm	Compact	125 nm	0.1%
PSM 1-10	10.0 x 2.0	Linear Silicon	400-1100 nm	Standard	250 nm	0.1%
PSM 1-20	20.0 x 3.0	Linear Silicon	400-1100 nm	Standard	500 nm	0.1%
PSM 1-30	30.0 x 4.0	Linear Silicon	400-1100 nm	Standard	750 nm	0.1%
PSM 2-2	2.0 x 2.0	Duolateral Silicon	400-1100 nm	Compact	50 nm	0.3%
PSM 2-4	4.0 x 4.0	Duolateral Silicon	400-1100 nm	Compact	100 nm	0.3%
PSM 2-4Q	4.0 x 4.0	Quadrant Silicon	400-1100 nm	Compact	100 nm	N/A*
PSM 2-5G	5.0 x 5.0	Pincushion Tetralateral Germanium	800-1800 nm	Compact	5 ģm	—
PSM 2-10	10.0 x 10.0	Duolateral Silicon	400-1100 nm	Standard	250 nm	0.3%
PSM 2-10Q	9.0 x 9.0	Quadrant Silicon	400-1100 nm	Standard	100 nm	N/A*
PSM 2-10G	10.0 x 10.0	Pincushion Tetralateral Germanium	800-1800 nm	Standard	5 ģm	—
PSM 2-20	20.0 x 20.0	Duolateral Silicon	400-1100 nm	Standard	500 nm	0.3%
PSM 2-45	45.0 x 45.0	Duolateral Silicon	400-1100 nm	Standard	1.25 ģm	0.3%

PSM Accessories

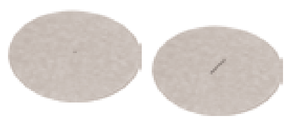
Model	Description
F12.5-632.2	12.5 mm optical filter. 632.8 nm, +2.0/-0 nm. FWHM 10 + 2 nm. 50% transmittance
F25-632.8	25 mm optical filter. 632.8 nm, +2.0/-0 nm. FWHM 10 + 2 nm. 50% transmittance
F12.5-635	12.5 mm optical filter. 635 nm, +5.0/-0 nm. FWHM 10 + 2 nm. 50% transmittance
F25-635	25 mm optical filter. 635 nm, +5.0/-0 nm. FWHM 10 + 2 nm. 50% transmittance
F12.5-670	12.5 mm optical filter. 670 nm, +3.0/-0 nm. FWHM 10 + 2 nm. 50% transmittance
F25-670	25 mm optical filter. 670 nm, +3.0/-0 nm. FWHM 10 + 2 nm. 50% transmittance
F12.5-HA	12.5 mm Blank Filter Holder Adapter
F25-HA	25 mm Blank Filter Holder Adapter
CA-DB9MM-5	5 foot molded cable. DB9 connector
CA-SC10FR-3	3 foot ribbon cable. 10 pin socket connector. Unterminated
PS-3	Post and Stand

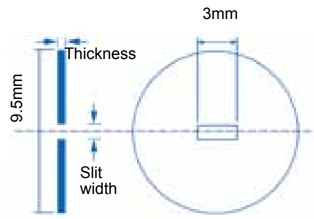
LASER APERTUERS

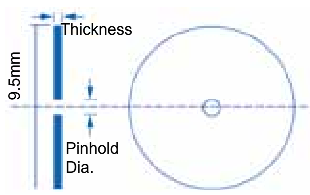
Precision Pinholes

Model No.	Diameter	Tolerance	Thickness
IP001	1µm	±1/2µm	0.0005”
IP002	2µm	±1/2µm	0.0005”
IP005	5µm	±1µm	0.0005”
IP008	8µm	±1µm	0.0005”
IP010	10µm	±1µm	0.0005”
IP012	12.5µm	±5µm	0.0005”
IP015	15µm	±5µm	0.0005”
IP020	20µm	±5µm	0.0005”
IP025	25µm	±5µm	0.0005”
IP035	35µm	±5µm	0.001”
IP050	50µm	±5µm	0.001”
IP100	100µm	±5µm	0.001”
IP200	200µm	±5µm	0.001”
IP300	300µm	±5µm	0.001”
IP400	400µm	±5µm	0.001”
IP500	500µm	±5µm	0.001”
IP600	600µm	±5µm	0.001”
IP800	800µm	±5µm	0.001”
IP900	900µm	±5µm	0.001”
IP1000	1000µm	±5µm	0.001”

Stainless Steel, 3/8" (9.5mm) Dia., high quality aperture centered to ±0.002" (50 micron). Typical applications include leak detection, aerosol studies, laser aperturing, holography, fiber optics guides, spatial filtering, and research.







High Power Apertures

Gold plated copper disc, 3/8" (9.5mm) Dia., aperture is centered to ±0.005". Specifically used for laser aperturing of Nd:Yag and CO2 lasers. One side of aperture is gold on polished copper for high reflectivity. The aperture thickness can withstand and quickly dissipate increased irradiation from high energy lasers. Densities as high as 100MW/cm2 have been used without damage to the aperture-making it the best to hold off laser power for aperturing and spatial filtering.

Model No.	Diameter	Tolerance	Thickness
IPH005	5µm	±10%	0.0005”
IPH010	10µm	±10%	0.0005”
IPH025	25µm	±10%	0.0005”
IPH035	35µm	±10%	0.0005”
IPH050	50µm	±10%	0.0005”
IPH100	100µm	±5%	0.0005”
IPH200	200µm	±5%	0.0005”
IPH500	500µm	±5%	0.0005”
IPH1000	1000µm	±5%	0.0005”

Precision Air Slits

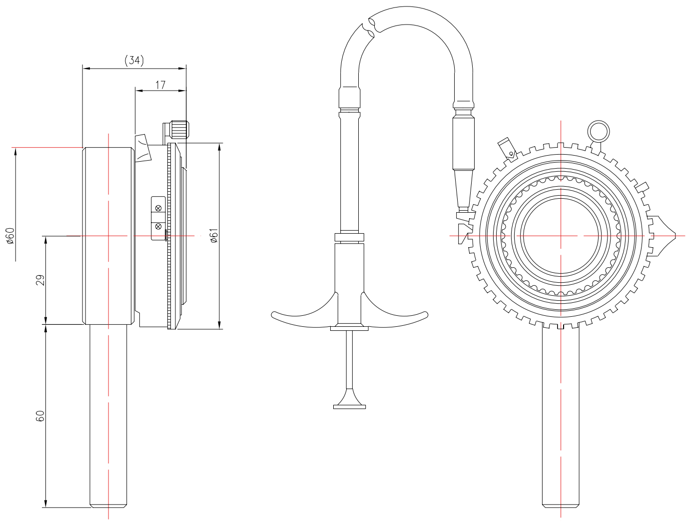
Used in optical systems and educational efforts. By scanning across the focal point, MTF and point spread function can be calculated. More commonly used in light aperturing, spectrophotometer image analysis, and various optical experiments. 3/8" (9.5mm) stainless steel disc.

Model No.	Slit Width	Slit Length	Substrate Thickness
IPS005	5µm±1µm	3mm	0.0005”
IPS010	10µm±1µm	3mm	0.0005”
IPS025	25µm±3µm	3mm	0.0005”
IPS050	50µm±5µm	3mm	0.0005”
IPS075	75µm±5µm	3mm	0.0005”
IPS100	100µm±5µm	3mm	0.0005”
IPS200	200µm±5µm	3mm	0.0005”
IPS500	500µm±5µm	3mm	0.0005”
IPS1000	1000µm±5µm	3mm	0.0005”

MECHANICAL SHUTTER

- The holder is available to use for opened and shut of optical path for laser beam
- The holder is available to use remote-operated by release(L=150mm)
- Shutter speed is available set up T, B, 1, 1/2 - 1/500
- T command will be open shutter when release was hold, and the shutter will be shut when release was re-hold
- B command will be open during holding the release.
- The holder is available to use with our post systems.

Model No.	Aperture Diameter MaxΦ(mm) MinΦ(mm)	Shutter speed (second)	Number of Blades(pcs)	MATERIAL	Finish	Weight(kg)
SHH	24 1.5	T,B,1,1/2,1/4,1/8,1/15,1/30, 1/60,1/125,1/250,1/500	5	AL	BAL	0.28



CHAPTER 3 PHOTONICS

SHUTTER SYSTEMS

CS Series (Unique Patented Design)
–Applications: Video Imaging, Telescopy, Microscopy, and Holography
–Long Lifetime
–Small Size to Aperture Ratio

Model	Aperture	Time to Open
CS25	25 mm	9.0 msec
CS35	35 mm	13.0 msec
CS45	45 mm	14.0 msec
CS65	65 mm	29.0 msec
CS90	90 mm	70.0msec

DSS Series
- There are no protruding components allowing flush mounting on either side of the device.
- Circular envelope and concentric aperture allow for easy and fast integration into customer specific applications.
- Simplicity of design allows for unprecedented ease of scaling from apertures as small as 10mm.

Model	Aperture	Time to Open
DSS10	10 mm	5.0 msec
DSS20	20 mm	12.5 msec
DSS25	25 mm	12.6 msec

LS Series (Laser Switching)
–Applications: Video Imaging, Telescopy, Microscopy, and Holography
– Operation Frequency up to 400 Hz

Model	Aperture	Time to Open
LS2	2 mm	300 μsec
LS3	3 mm	500 μsec
LS6	6 mm	700 μsec

NS Series (N-CAS® Patent Pending Design)
–Features patent pending Non-Contact Actuation System (N-CAS) to provide accurate and reliable shutter operation
–Versatile design allows for shutters to be easily configured bi-stable, normally open or normally closed
–Five bladed design minimizes outside diameter to fit where space is at a premium
–Machined aluminum body allows for direct mounting to flat surfaces

Model	Aperture	Time to Open
NS15B	15 mm	3.0 msec
NS25B	25 mm	5.0 msec
NS25S	25 mm	5.0 msec
NS35B	35 mm	12.0 msec
NS45B	45 mm	12.0 msec
NSR25S	25 mm	5.0 msec

TS Series
- Single bladed design along with bi-stable configuration, only requiring power to change state
- Alternate blade material can be made available by special order for x-ray or other unique customer applications
- There are no protruding components allowing flush mounting on either side of the device.
- Circular envelope and concentric aperture allow for easy and fast integration into customer specific applications.

Model	Aperture	Time to Open
TS6B	6 mm	1.7 msec

VS Series
–Applications: Video Imaging, Telescopy,Microscopy, and Holography
– Ideal For Custom Applications
– Fast Open Times

Model	Aperture	Time to Open
VS14	14 mm	1.5 msec
VS25	25 mm	3.0 msec
VS35	35 mm	13.0 msec

XRS Series (X-RAY Shutter)
– Applications: X-Ray Switching
– Capable of Blocking up to 30 keV Continuously

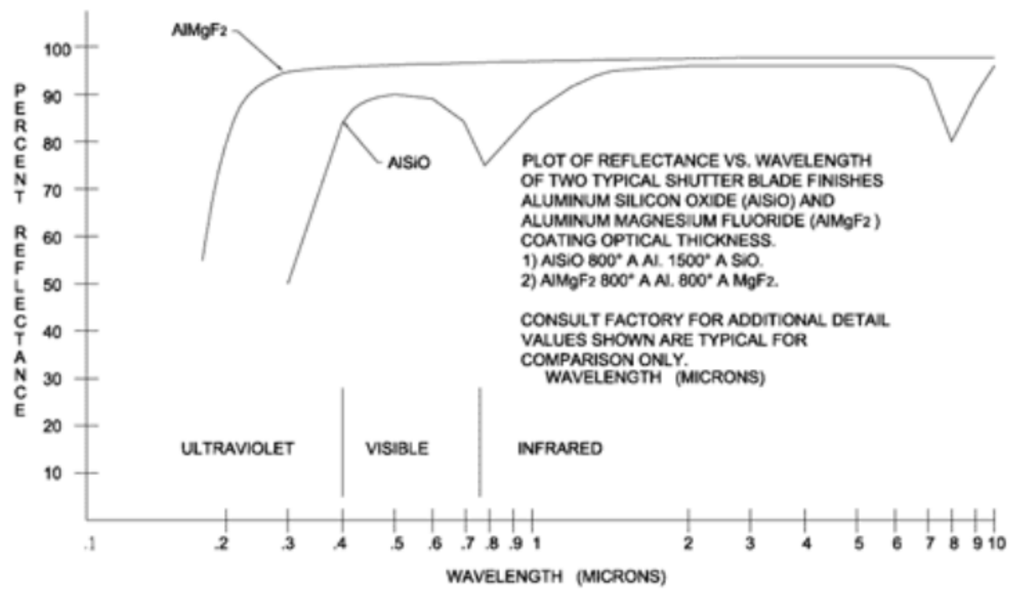
Model	Aperture	Time to Open
XRS14	14 mm	20.0 msec
XRS25	25 mm	10.0 msec
XRS6	6 mm	20.0 msec

COATING AND MOUNTING OPTIONS FOR SHUTTER SYSTEMS

SHUTTER MODEL	ULTRAVIOLET .3-.4μm (microns)		VISIBLE .4-.75μm (microns)		INFRARED .75-.106μm (microns)	
	AlSiO	AlMgF2	AlSiO	AlMgF2	AlSiO	AlMgF2
BDS25	N/A	5 W/mm2	10 W/mm2	5 W/mm2	5 W/mm2	5 W/mm2
CS25	N/A	5 W/mm2	10 W/mm2	5 W/mm2	5 W/mm2	5 W/mm2
CS35	N/A	5 W/mm2	10 W/mm2	5 W/mm2	5 W/mm2	5 W/mm2
CS45	N/A	5 W/mm2	10 W/mm2	5 W/mm2	5 W/mm2	5 W/mm2
CS65	N/A	5 W/mm2	10 W/mm2	5 W/mm2	5 W/mm2	5 W/mm2
CS90	N/A	N/A	N/A	N/A	N/A	N/A
LS2	N/A	2.5 W/mm2	5 W/mm2	2.5 W/mm2	2.5 W/mm2	2.5 W/mm2
LS3	N/A	2.5 W/mm2	5 W/mm2	2.5 W/mm2	2.5 W/mm2	2.5 W/mm2
LS6	N/A	2.5 W/mm2	5 W/mm2	2.5 W/mm2	2.5 W/mm2	2.5 W/mm2
QCS45	N/A	5 W/mm2	10 W/mm2	5 W/mm2	5 W/mm2	5 W/mm2
UHS1	N/A	2.5 W/mm2	5 W/mm2	2.5 W/mm2	2.5 W/mm2	2.5 W/mm2
VS14	N/A	5 W/mm2	10 W/mm2	5 W/mm2	10 W/mm2	5 W/mm2
VS25	N/A	5 W/mm2	10 W/mm2	5 W/mm2	5 W/mm2	5 W/mm2
VS35	N/A	5 W/mm2	10 W/mm2	5 W/mm2	5 W/mm2	5 W/mm2
XRS14	N/A	N/A	N/A	N/A	N/A	N/A
XRS25	N/A	N/A	N/A	N/A	N/A	N/A
XRS6	N/A	N/A	N/A	N/A	N/A	N/A

Mounts by Type

* 100 Mounting Ring,	* 101 Mounting Ring	* 102 Mounting Ring
* 103 Mounting Ring	* 105 Male C Mount Adapter	* 106 Female C Mount Adapter
* 110 T Mount Adapter	* 125 Camelia Adapter	* 126 F Type Male Adapter
* 127 Dalstar Adapter	* 128 Cooke Adapter	* 17 CS25 F Type Female Video Adapter
* 17 CS35 F Type Female Video Adapter	17 CS45 F Type Female Video Adapter	* 17 VS14/25 F Type Female Video Adapter
* 17 VS35 F Type Female Video Adapter	* 21 Zeiss Axiovert Type Microscope Mount Set	* 22 Nikon Type Microscope Mount Set
* 23 Olympus Type Microscope Mount Set	* 24 Olympus Type Microscope Mount Set	* 26 Leica Type Mount Set
* 27 Nikon Type Microscope Mount Set	* 28 Olympus Type Mount Set	* 29 Nikon Type Mount Set
* 30 Leica Type Mount Set	* 31 Nikon/Confocal Type Mount Set	* 32 Nikon Type Microscope Mount Set
* 90 Mounting Ring		



If you have quesions for coating and mounting on shutters systems, please contact ONSET sales members.

DRIVERS FOR SHUTTER SYSTEMS

D880C

ED12DSS

N-CAS VDM1000 Single Channel CE/ UL/CSA Approved Shutter Driver

N-CAS VDM1000B Open Frame Drive Controller

VCM-D1 Single Channel CE/UL/ CSA Approved Shutter Driver

VMM-D3 Three Channel Shutter Driver

VMM-D4 Four Channel Shutter Driver

VMM-T1 Single Channel Shutter Driver/ Timer

INFRARED SENSITIVE CARD

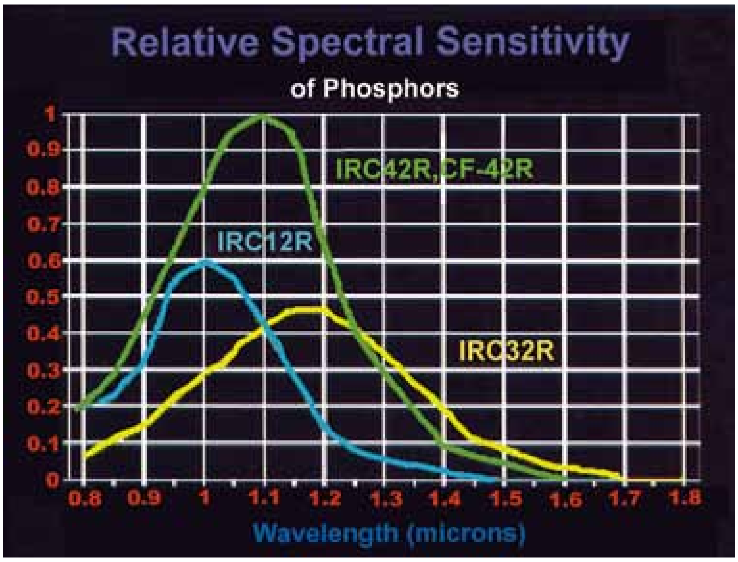
FEATURE

- Low Cost
- Reusable
- Safe non-direct view of laser
- Safe to use up $100W/cm^2$ power density
- Spectrally specific models

Infrared sensitive phosphor cards enable users of infrared optical devices an easy way to locate laser beams and estimate beam size, trouble-shoot areas and test infrared emitting devices. The easy-to-use cards consist of an IR-sensitive phosphor material(2"x2") laminated in clear plastic. After being exposed to room light(400-500nm) for about one minute (for activation of the phosphor), these cards will emit a visible glow when illuminated by infrared light. The intensity of the glow is in proportional with the intensity of the infrared illumination.

For use with high-powered laser beams, the model CF-42R and CF-16R cards are recommended for use with Nd:YAG (1.06μm) and CO_2 (10.6μm) laser beams, respectively. The CF-42R and CF-16R are designed with a 2" round phosphor material mounted on a ceramic substrate in order to dissipate the resulting heat. These cards can be used with beams having up to $100W/cm^2$ power density.

Model	Spectral Range (μm)	Required Dark	Intensity Required	Resolution (Lp/mm)	Ideal Sources
IRC12R	0.7-1.4	$12μW/cm^2$	$500μW/cm^2$	3	0.7-08μm sources
IRC42R	07.-1.6	$3μW/cm^2$	$200μW/cm^2$	3	0.8-1.3μm sources
IRC32R	0.8-1.7	$6μW/cm^2$	$800μW/cm^2$	3	1.55μm sources
CF-16R	10.6	$1W/cm^2$	$50μW/cm^2$	3	Hi-power CO2 laser
CF-42R	0.7-1.6	$30μW/cm^2$	$500μW/cm^2$	3	Hi-power YAG laser

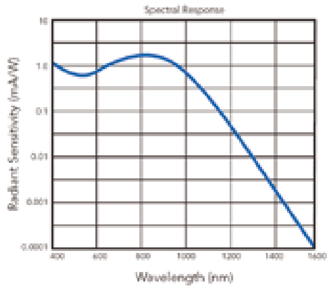


CHAPTER 3 PHOTONICS

INFRARED VIEWER

APPLICATIONS:

- Observation of GaAs laser diodes and IR LEDs
- Beam alignment (e.g. Nd:YAG, Ti: Sapphire)
- Thermal imaging of obects 600ºC (1112°F) and hotter
- View in-the-dark processes
- Forensic analysis of inks, pigments
- Sub-surfa wafer inspection (Si, GaAs)



CONVERTS 0.41-1.5µm RADIATION TO VISIBLE

ElectroViewer 7215 is a high-performance, hand-held Infrared Viewer designed to meet the requirements of viewing in the near-IR wavelength range. Unlike any other infrared imaging device, the ElectroViewer delivers an image that is remarkably bright. And with focusing as close as 3 inches, the ElectroViewer is the perfect tool for in-the-lab and in-the-field.

- Excellent image quality
- Bright, high-contrast image
- Focuses as close as 3”
- Adustable iris included
- Accepts C-mount lenses
- Interfaces to CCTV cameras
- Rugged and shock-proof design

OPERATION

The ElectroViewer is powered by pressing and maintaining the push-button switch. The objective lens, adusted for obects at distances from 3” to infi nity, brings the scene into sharp focus, producing a bright, green fl uorescent image seen through the eyepiece.

High-resolution images are generated in accordance with the incident intensity of the radiation and the S-1 spectral responsivity of the photocathode material (see Spectral Response characteristic)

The ElectroViewer image output can either be viewed directly using the adustable eyepieceincluded or can be attached to a CCTV camera with the 7215-202 CCTV Relay Lens accessory (optional, thus effectively extending the CCTV camera’s response range to beyond 1.3µm!

SPECIFICATION

Input Photocathode	s-1
Output Fluorescent Screen	P-20 Phosphor
Output Resolution	60 lp/mm
Peak Emission Wavelenght	550nm
Responsivity@1.06µm	0.45-0.85 mA/W
Object Distance	3” to ∞
Field of View	40°
Battery Life	100 hours (typical)
Battery Type	9V Alkaline
Size (L W H)	3¼” x 3¼” x 2¼ “ (8x8x6 cm exc . ha ndle and lens es
Weight w/o Lens	1¼ lb. (5 70 gp)

Option: 7215-202 camera accesory

ITEM	PART NO.	DESCRIPTION
ElectroViewer 7215	914646	Selected to detect 20mW/cm 2@1.3µm. Includes a 25mm objective lens, eyepiece, and 9V alkaline battery
ElectroViewer 7215P	914646	Selected to detect 50mW@/cm 2@1.5µm. Includes a 25mm objective lens, eyepiece, and 9V alkaline battery
Switch Option		Toggle ON/OFF switch replaces push button in above models
AC Option		Viewer has additional AC adapter jack in parallel with 9V battery terminals.
CCTV Relay Lens	914644	Interfaces with 1/2” CCTV cameras
Extension Tube Set	908007	Reduces minimum object distance to 1–2”
Close-up Lens Set	908005	Attaches to filter thread of 25mm lens and reduces minimum object distance to about 2”
Wide Angle Objective Lens	908001	16mm F1.6 (no iris)
2X Telephoto Objective Lens	908004	50mm F1.8
5X Objective Lens	908000	135mm F2.8
1/2X to 3X Zoom Objective Lens	908006	12.5-75mm F1.2
Carrying/Storage Case	902017	Foam-lined case for storage and transport
Visible Light Cut Filter	902031	Mounts on 25mm Lens fi lter thread
Filter Holder	909000	Captures any 1” filter onto 25mm objective lens
1”Long Pass Filters		Select cut-on wavelength (nm): 700, 750, 800, 850, 900, 950, 1000, more
1”Short Pass Filters		Select cut-off wavelength (nm): 700, 750, 800, 850, 900, 950, 1000, more
1”Band Pass Filters		Select center wavelength (nm): 700, 710, …, 1050, 1060, more
1”Band Pass Filters		Select optical density: 0.1, 0.2, …, 0.9, 1.0, 1.5, 2.0, 3.0, more

OPTICAL CHOPPER

- Crystal-Stabilized, Phase-Locked Feedback Loop Suppresses Low Frequency Drift and Pulse Jitter
- Manual, USB, and External Trigger Controller
- 7 blades Covering Frequencies of 1 HZ to 6kHz

MC1F10 Blade Included


MC1F2 MC1F15 MC1F30

MC1F60 MC1F100 MC2F57

Performance Specifications	
Chopping Frequency	
MC1F2 (2 slot)	1 Hz – 99 Hz
MC1F10 (10 slot, Default Blade)	20 Hz – 1 kHz
MC1F15 (15 slot)	30 Hz – 1.5 kHz
MC1F30 (30 slot)	60 Hz – 3 kHz
MC1F60 (60 slot)	120 Hz – 6 kHz
MC1F100 (100 slot)	250 Hz – 10 kHz
MC2F57 (2f slot)	Outer: 14 – 700 Hz Inner: 10 – 500 Hz
Chopping Range	
Harmonic	2 to 15x
Sub-Harmonic	1/2 to 1/15x
Communications	
Communications Port	USB
Protocol	USB (RS232 Emulated)
Optical Head Specifications	
Chopping Blade Diameter	Ø4.0” (Ø101.6 mm)
Chopping Blade Thickness	0.010” (0.254 mm)
Mounting Base	1/4”-20 (or M8) Clearance Slots Spaced 3.0” (Compatible with Thorlabs Breadboards)
Mounting Hole	1/4”-20 with 1/4” Max Screw Depth

Blade Specifications	
Chopping Blade Slots	
MC1F2	2
MC1F10 (Default Blade)	10
MC1F15	15
MC1F30	30
MC1F60	60
MC1F100	100
MC2F57	7 Outer, 5 Inner
Slot Angle	
MC1F2	180°
MC1F10 (Default Blade)	36°
MC1F15	24°
MC1F30	12°
MC1F60	6°
MC1F100	3.6°
MC2F57	51.4° Outer, 72° Inner
Physical Features	
Dimensions (W x H x D)	5.8” x 2.8” x 12.5” (147 mm x 71 mm x 317.5 mm)
Input and Output Connectors	BNC
Menu Control	Twist / Push-Button Knob
Input Power Connection	IEC Connector w/ US Style Power Cord
Weight	5 lbs (9.1 lbs Shipped Weight)
Operating Temperature	10 – 40 °C
Display Type	240 x 124 Pixel LCD Graphics Display
Frequency Resolution	1 Hz (10, 15, 30, 60, 100, and 2f blades) 0.01Hz (2 slot blade)

HOLOGRAM RECORDING FILM

ONSET provides several types of films for hologram recording purpose. The VRP-M are standard materials. The PFG-01 is for using a CW laser and the VRP-M is for using a pulsed laser, other series for specific applications please see the following. Material life is more than two years. See the figures for spectral Sensitivity, density and diffraction efficiency characteristics.

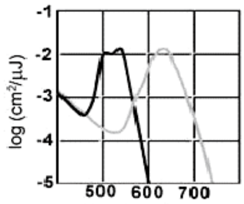


Figure1: Spectral Sensitivity curves for VRP-M (left) and PFG-01 (right).

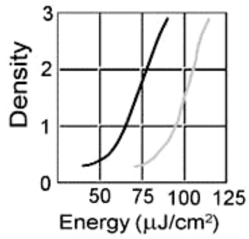


Figure 2: Characteristic Curves for VRP-M (left) and PFG-01 (right).

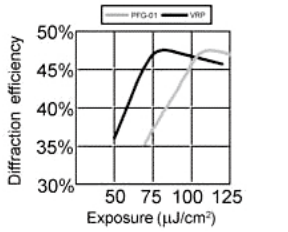


Figure 4: Diffraction Efficiency Curves for VRP-M and PFG-01.

CW, reflection, PFG-03M

This material is designed for reflection hologram recording using CW radiation in the red spectral range (633nm - HeNe laser and 647nm - Krypton laser).

The PFG-03M material has a higher diffraction efficiency and a very high signal to noise ratio. Hologram recorded on this material have a very clear and powerful object reconstruction and excellent layer transparency.

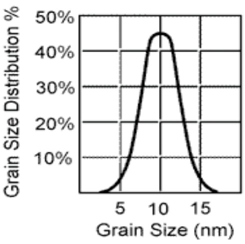


Figure 1: Grain size distribution for PFG03M.

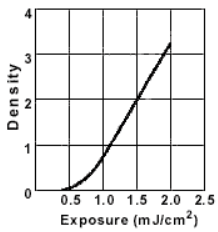


Figure 2: Characteristic curve for PFG03M.

CW, reflection Denisyak-type, PFG-04

Designed for the recording of reflection Denisyuk-type holograms using CW laser radiation (488nm, 514nm -Argon laser). Its grainless structure,makes this material have very high resolving power and a diffraction efficiency of >75%

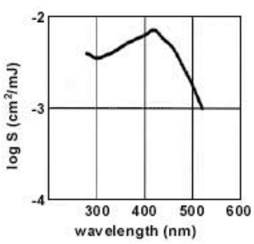


Figure 1: Spectral sensitivity curves for PFG-04.

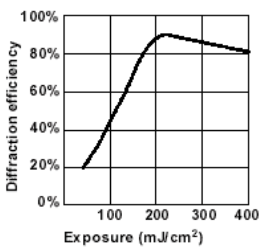


Figure 11: Diffraction efficiency curve for PFG-04.

CW Pull-colour reflection, PFG-03C

This production is for full-colour reflection holograms using CW laser radiation in the blue (457nm - Argon laser), green (514nm - Argon laser) and red (633nm -HeNe laser).

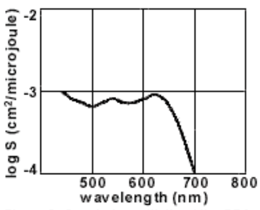
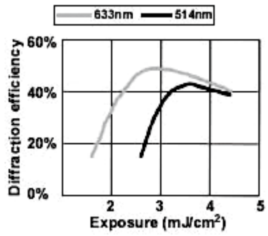


Figure 2: Spectral sensitivity of the PFG-03C material.



Diffraction efficiency of PFG-03C.

Model NO.		PFG-01	VRP-M	PFG-03M	PFG-03C	PFG-04
Holographic Sensitivity µJ/cm²	@457nm CW				2000	8 x 10^4
	@488nm CW					10^5
	@514.5nm CW		75		3000	2.5 X 10^5
	@526.5nm, 30ns					
	@633nm CW	100		1500-2000	3000	
Plate Size mm x mm	Q-ty per box					
	30	63 x 63	63 x 63	63 x 63	63 x 63	63 x 63
	25	102 x 127	102 x 127	102 x 127	102 x 127	102 x 127
	6	203 x 254		180 x 240		180 x 240
	6	300 x 400	300 x 400	300 x 400	300 x 400	300 x 400
	4		400 x 600			
Film Size mm x mm (Sheet) mm x m (Roll)	Q-ty of sheet or Rolls per box					
	5 (Sheet)	200 x 300	200 x 300	200 x 300		
	1 (Roll)	36 x 20	36 x 20	36 x 20		
	1 (Roll)	102 x 20	102 x 20	102 x 20		
	1 (Roll)	203 x 20	203 x 20	203 x 20		
	1 (Roll)	304 x 10	304 x 10	304 x 10		
	1 (Roll)	350 x 10	350 x 10			
	1 (Roll)	610 x 10	610 x 10			
	1 (Roll)	1200 x 10	1200 x 10			

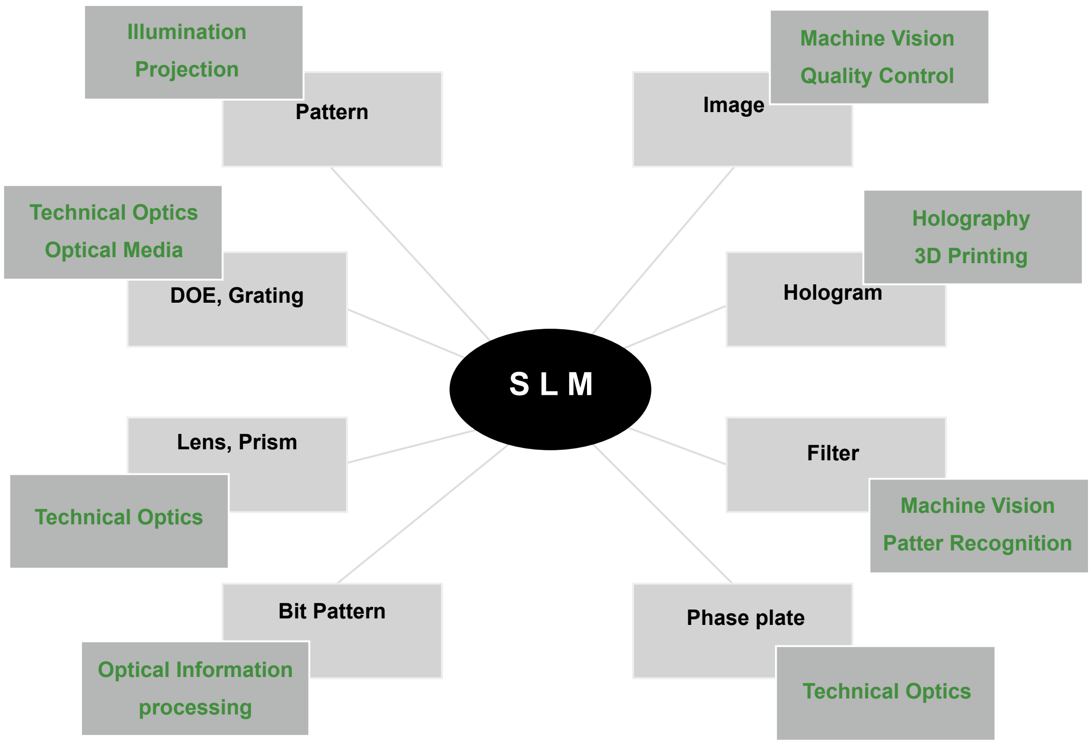
SPATIAL LIGHT MODULATOR(SLM)

The Need for Switchable Optical Devices

Switchable optical devices give new opportunities:

- the optical function can be modified without need to change optical components.
- the optical function can be programmed.
- high switching speeds provide for real-time applications.
- laser light can be spatially modulated either in amplitude or phase.

ApplicationS



A-O Modulators
AOTF
E-O Modulators
Rotators & Isolators
Photodetectors & PSD
Laser Apertures
Shutters
Laser Detections
Optical Chopper
Holography Films
Spatial Light Modulators
Laser Safety

CHAPTER 3 PHOTONICS

TRANSLUCENT SVGA SLM

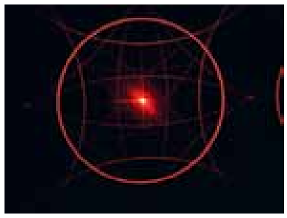
Spatial Light Modulators

The Spatial Light Modulator (SLM) systems are based on liquid crystal microdisplays. These devices can modulate light spatially in amplitude and phase, so they act as a dynamic optical element. The optical function or information to be displayed can be taken directly from the optic design or an image source and can be transferred by a computer interface.

Implementation is very easy due to the smart system architecture and by an easy addressing using VGA or DVI signals directly from a computer graphics card.

LC 2002

The LC 2002 is an easy-to-use spatial light modulator system based on an translucent LC microdisplay designed for prototyping in industrial development and research. It can be used to modulate light spatially, where the modulation function can be electrically addressed by a computer using a MS Windows software. Also strong laser pulses can be shaped by applied phase functions. The LC 2002 supports several display formats with a max. resolution of 832 x 624 pixels.
The highest potential of SLMs is the use as a dynamic phase modulating device, which acts as an addressable diffractive element. Besides display applications particular laser applications, such as beam splitting and beam shaping, diffractive optics, digital holography and biological laser applications are the main applications and challenges for SLMs.



APPLICATIONS

- Display Applications
- Image Projection
- Beam Splitting
- Laser Pulse Modulation
- Laser Beam Shaping
- Phase Shifting
- Digital Holography
- Coherent Wavefront Modulation
- Optical Tweezers
- Pattern Recognition

Main Features:

Liquid Crystal Microdisplay (Transmission)
SVGA Resolution (800 x 600 Pixels)
60 Hz Image Frame Rate
Full Developers Kit (easy to run using a standard PC)
Microsoft Windows Driver Software
Application Software

Display Features:

Pixels: 800 x 600
Pixel Pitch: 32 µm
Fill Factor: 85%
Panel Size: 21 x 26 mm
Addressing: 8 Bit (256 Pixel Values)
Signal Format: VGA, SVGA

Special Optical Features:

Amplitude or Phase Modulation
2 π Phase Shift @ 532 nm
Intensity Ratio of 1000:1 @ 633 nm Coherent Light Source

Software Features:

Driver: Brightness / Contrast / Geometry / Gamma Control
Application: Basic DOE computations; Generation of optical functions(Circular Aperture, Fresnel Zone Lens, Axicon, Single and Double Slit ...);Gratings (incl. Blazed and Sinusoidal)

Light Source

CH2

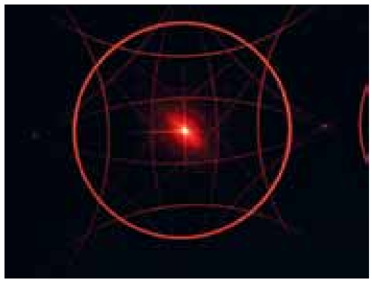
ALL-ROUND XGA SLM

Spatial Light Modulators

The Spatial Light Modulator (SLM) systems are based on liquid crystal microdisplays. These devices can modulate light spatially in amplitude and phase, so they act as a dynamic optical element. The optical function or information to be displayed can be taken directly from the optic design or an image source and can be transferred by a computer interface. Implementation is very easy due to the smart system architecture and by an easy addressing using VGA or DVI signals directly from a computer graphics card.

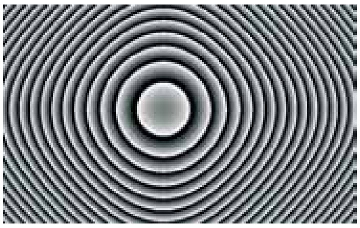
LC-R 2500

The LC-R 2500 is an easy-to-use spatial light modulator system based on a reflective LCoS microdisplay designed for prototyping in industrial development and research. It can be used to modulate light spatially in amplitude and phase, where the modulation function can be electrically addressed by a computer using a MS Windows software. The LC-R 2500 supports DVI-signals with a resolution of 1024 x 768 pixels. High efficiency due to the reflective LCoS display and phase mostly modulation guarantee excellent optical performance.



The highest potential of SLMs is the use as a dynamic phase modulating device, which acts as an addressable diffractive element.

Besides display applications particular laser applications, such as diffractive optics, Biophotonics and medical laser applications to material processing, where strong laser pulses can be shaped by applied phase modulation are the main applications and challenges for this SLMs.



APPLICATIONS

- Display Applications
- Laser Pulse Modulation
- Digital Holography
- Beam Splitting
- Phase Shifting
- Coherent Wavefront Modulation
- Laser Beam Shaping
- Optical Tweezers

Main Features:

LCoS Microdisplay (Reflective)
XGA Resolution (1024 x 768 Pixels)
72 Hz Image Frame Rate
Full Developers Kit (easy to run using a standard PC)
Microsoft Windows Driver Software
Application Software

Display Features:

Pixels: 1024 x 768
Pixel Pitch: 19 µm
Fill Factor: 93%
Panel Size: 19,6 x 14,6 mm
Addressing: 8 Bit
Signal Format: DVI - XGA Resolution

Special Optical Features:

Amplitude or Phase Modulation
2 π Phase Shift between 400 and 700 nm
Intensity Ratio of 1000:1 @ 532 nm Coherent Light Source

Software Features:

Driver: Brightness / Contrast / Geometry / Gamma Control
Application: Basic DOE computations; Generation of optical functions (Circular Aperture, Fresnel Zone Lens, Axicon, Single and Double Slit ...); Gratings (incl. Blazed and Sinusoidal)

CHAPTER 3 PHOTONICS

HIGH SPEED WXGA SLM

Spatial Light Modulators

The Spatial Light Modulator (SLM) systems are based on liquid crystal microdisplays. These devices can modulate light spatially in amplitude and phase, so they act as a dynamic optical element. The optical function or information to be displayed can be taken directly from the optic design or an image source and can be transferred by a computer interface. Implementation is very easy due to the smart system architecture and by addressing VGA or DVI signals directly from a computer graphics card.

LC-R 720

The LC-R 720 is an easy-to-use Spatial Light Modulator system based on a reflective LCOS microdisplay designed for prototyping in industrial development and research. It can be used to modulate light spatially in amplitude and phase, where the electro optical modulation function can be modified by a computer using a MS Windows software. The LC-R 720 supports DVI-signals with a resolution of 1280 x 768 pixels. High light efficiency due to the reflective LCOS display and phase only modulation guarantee excellent optical performance. Due to the high image frame rate of 180 HZ and the short response time of 3 ms the higest potential of the LC-R 720 is the use at high speed applications. Besides imaging and projection applications particular laser applications, such as diffractive optics, Bio-photonics and medical laser applications to material processing, where strong laser pulses can be shaped by applied phase modulation are the main applications and challenges for this SLMs.

APPLICATIONS

- Display Applications
- Fringe Projection
- Digital Holography
- Imaging & Projection
- Laser Beam Shaping
- Laser Pulse Modulation
- Beam Splitting
- Optical Tweezers

Main Features:

LCoS Microdisplay (Reflective)
WXGA Resolution (1280 x 768 Pixels)
Up to 180 Hz Image Frame Rate
Full Developers Kit (easy to run using a standard PC)
Microsoft Windows Driver Software
Application Software

Display Features:

Pixels: 1280 x 768
Pixel Pitch: 20 µm
Fill Factor: 92%
Response Time: < 3 ms
Addressing: 8 Bit
Signal Format: DVI - WXGA Resolution
Trigger Sync

Special Optical Features:

Amplitude or Phase Modulation
Above 1 π Phase Shift in the Visible
Intensity Ratio of 1000:1 @ Typical
Phase Only Modulation Mode
High Light Efficiency (Diffraction Efficiency up to 60 %)

Software Features:

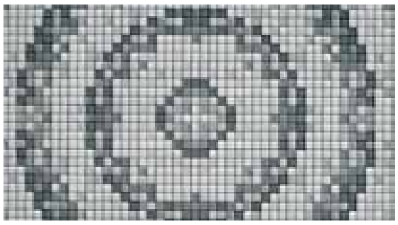
Driver: Brightness / Contrast / Geometry / Gamma Control
Application: Basic DOE computations; Generation of optical functions (Circular Aperture, Fresnel Zone Lens, Axicon, Single and Double Slit ...); Gratings (incl. Blazed and Sinusoidal)

HIGH RESOLUTION & HIGH CONTRST WUXGA SLM

LC-R 1080

The LC-R 1080 is an easy-to-use Spatial Light Modulator system based on a reflective LCoS™ microdisplay designed for prototyping in industrial development and research. It can be used to modulate light spatially in amplitude and phase, where the electro optical modulation function can be modified by a computer using a MS Windows software. The LC-R 1080 supports DVI-signals with a WUXGA/ HDTV resolution of 1920 x 1200 pixel. High light efficiency due to the reflective LCoS display and the Brillian high contrast mode guarantee excellent optical performance.

Due to the high resolution (1920 x 1200 - HDTV-resolution) and the small pixel pitch of 8.1 µm the LC-R 1080 is an allround spatial light modulator. Besides display applications particular laser applications, such as diffractive optics, Bio-photonics and medical laser applications to material processing, where strong laser pulses can be shaped by applied phase modulation are the main applications and challenges for this SLMs.



APPLICATIONS

- Display Applications
- Laser Beam Shaping
- Digital Holography
- Imaging & Projection
- Coherent Wavefront Modulation
- Laser Pulse Modulation
- Beam Splitting
- Optical Tweezers

Main Features:

LCoS Microdisplay (Reflective)
WUXGA Resolution (1920 x 1200 Pixel)
60 Hz Image Frame Rate
Full Developers Kit (easy to run using a standard PC)
Microsoft Windows Driver Software
Application Software

Display Features:

Pixels: 1920 x 1200
Pixel Pitch: 8.1 µm
Fill Factor: 90%
Diagonal Image Array Size: 18.34 mm (WUXGA)
Addressing: 8 Bit
Signal Format: DVI - WUXGA Resolution

Special Optical Features:

Amplitude or Phase Modulation
Above 1.2 π Phase Shift in the Visible
Intensity Ratio of 2000:1 (@ 633 nm Coherent Light Source)
High Contrast

Software Features:

Driver: Brightness / Contrast / Geometry / Gamma Control
Application: Basic DOE computations; Generation of optical functions (Circular Aperture, Fresnel Zone Lens, Axicon, Single and Double Slit ...); Gratings (incl. Blazed and Sinusoidal)

CHAPTER 3 PHOTONICS

PHASE ONLY SPATIAL LIGHT MODULATORS

APPLICATIONS

- Phase Shift Applications
- Optical Networking Applications
- Optical Tweezers
- Lithography
- Wave Front Correction
- Holographic Applications
- Holographic Security Sytems
- Optical Metrology - Interferometry
- Pulse Shaping
- Interferometry

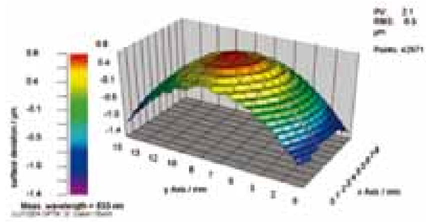
Phase Modulating LCOS Microdisplays

HOLOEYE developed high resolution, pure phase modulating microdisplays with very small pixels and high light efficiency. Applications range from holographic applications (holographic projection), litography, optical metrology, interferomenty, optical networking applications, holographic security systems, wavefront correction to optical tweezing, trapping and micro manipulation applications.

PLUTO - Phase Only Spatial Light Modulator Series

The PLUTO phase modulator models are based on reflective LCOS microdisplays with 1920 x 1080 pixel resolution. The PLUTO devices are packaged in a very small housing to ensure an easy integration into optical setups and applications. The PLUTO phase modulator series now includes 4 versions, optimized for the visible, a version optimized for a broad wavelength band centered at 850 nm, optimized for the near infrared around 1064 nm and a version optimized for typical telecommunication wavelengths around 1550 nm.

Phase Modulating LCOS Microdisplays



HOLOEYE developed high resolution, pure phase modulating microdisplays with very small pixels and high light efficiency. Applications range from holographic applications (holographic projection), litography, optical metrology, interferomenty, optical networking applications, holographic security systems, wavefront correction to optical tweezing, trapping and micro manipulation applications. PLUTO - High Efficiency and Easy Addressing The displays show a reflectivity of approx. 60% and diffraction efficiencies of more than 80%. Thereby a total light efficiency of more than 50% per addressable diffractive device is possible. The driving of the PLUTO devices is as easy as with all HOLOEYE Spatial Light Modulators. A HDTV graphics card is sending HDTV resolution images to the device (via DVI) with a frame rate of 60 Hz. The Pluto modulators are easily addressed as an external monitor.

PLUTO - Optimized for Different Wavelengths Bands

HOLOEYE provides 4 versions of the PLUTO modulator:

- PLUTO-VIS: This version is optimized for the visible because of a broadband AR (anti reflection) coating for this spectral range.

- PLUTO-NIR: This version is optimized for the near infrared around 1064 nm because of an AR coating for 1064 nm and a thicker LC layer.

- PLUTO-NIR-2: This version is usable for a broad wavelength band around 850 nm and in the lower visible.

- PLUTO-TELCO: This version is optimized for common telecommunication wavelenghts ranges around 1550 nm.

Display Type	Resolution	Pixel Pitch	Fill Factor	Adressing	Frame Rate	Signal Format
Reflective LCoS	1920 x 1080 Pixel	8.0 µm	87 %	8 Bit	60 Hz	DVI - HDTV Res.

AUTOMATIC DARKEING EYEWEAR

Protect your eyes from IPL.

Automatic darkening filters for personal eye protection from IPL (Intense Pulse Light.)

- Hight Tec filter shuts automatically after sensing the IPL for the purpose of protecting your eyes.
- You will have clear vision and you will be able to see your patients' skin condition during the IPL treatment.
- Sersitive sensor achieves shutter speed of about 0.0002 sec.(Shutter speed of the human eye is about 0.25 sec.)
- Built-in solar battery backs up the battery.

Protection not only for visible light but also UV & IR.

Adjustable fitting angle and temple length

Soft rubber prevents scattered light from entering the goggle through all possible angles.

SPECITICATION	
Weight	95 g
Shutter speed	0.0002 sec.
shade number	Close:#11
visible light transmittance	Close:0.005% Open:16%
Standard	EN379 CE

Shutter open:
Clear view through open filter.

Shutter closed:
Perfect protection from IPL light exposure.

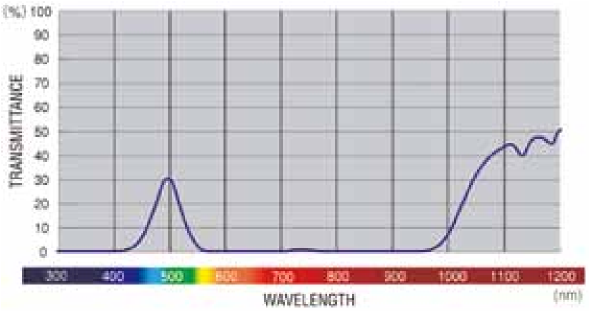
CE approved For FLASH LAMP

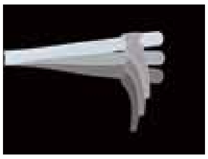
This product is developed to protect your eyes from strong light such as Flash Lamp Light.

IPL-717SC

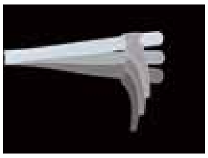
Specification

The upper, lower and side shield covers, prevent light from entering through any angle. The angle of the front frame and length of the temples can be adjusted.





The angle of the frame can be adjusted to conform to the contour of the wearer's face



The length of temple can be adjusted to conform to the wearer's face

The application of this over glass provides following product features:

1) All parts are made of plastic.
   Light weight
   Antistatic
2) Features of PETROID Lens filter:
   Super high impact-resistance
   Anti-scratch
3) Overglass provides a wide view.
   Wearing over prescriptioin eyewear
4) Comfortable wearing:
   Soft forehead pad
   Soft non-slip temples

CE approved: YL 1 S CE
usable for IPL:OD>5 between 590 and 700nm; OD>3 between 760 and 950nm; OD>2 between 555 and 975nm

LASER SAFETY EYEWEAR

Protect your eyes from Lasers

CE **CE Products**

Snug fitting elastomer frame developed from ergonomics.

Lens and frame are unified by a molding process.

YL-130 (Laser absorption type)

FILTER CODE	COLOR/LUMINOUS TRANSMITTANCE	APPLICABLE LASER	WAVELENGTH (nm)	OPTICAL DENSITY (OD)	REMARKS
YL-130 Nd-YAG (SHG)	RED/16%	Nd-YAG (SHG)	532	10	D180-315 L7/R180-315 L53 DIR>315-532 L5 YL S CE
YL-130 ALEXANDRITE	PINK/30%	ALEXANDRITE	755	6	D180-315 L7/R180-315 L3 DIR>315-360 L5 DI780-860 L4 DI>860-870 L3 YL S CE
		LASER DIODE	750～800	4～10	
			800～850	10～4	
		TI-SAPPHIRE	750～850	4	
YL-130 Nd-YAG	GREEN/50%	Nd-YAG	1064	6	DIR870-925 L4 DIR>925-1065 L5 DIR>1065-1090 L3 DI9000-11000 L3 YL S CE
		Nd-YLF	1053		

YL-130C (Application for Multi band lasers)

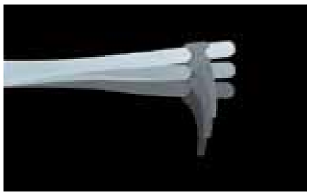
FILTER CODE	COLOR/LUMINOUS TRANSMITTANCE	APPLICABLE LASER	WAVELENGTH (nm)	OPTICAL DENSITY (OD)	REMARKS
YL-130C Nd-YAG2	AMBER/40%	Nd-YAG (FHG)	266	10	D180-315 L7/R180-315 L3 DIR>315-360 L5 D>360-532 L5/IR>360-532 L6 DI800-830 L3 DI>830-925 L4 DIR>925-1065 L5 DIR>1065-1090 L3 YL S CE
		Nd-YAG (THG)	355	10	
		Nd-YAG (SHG)	532	4	
		Nd-YAG	1064	6	

YL-130M (Type Attenuation to 1/100 for "alignment work")

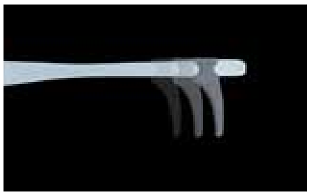
FILTER CODE	COLOR/LUMINOUS TRANSMITTANCE	APPLICABLE LASER	WAVELENGTH (nm)	OPTICAL DENSITY (OD)	REMARKS
YL-130M Nd-YAG (SHG)	RED/30%	Nd-YAG (SHG)	532	2	D180-315 L7/R180-315 L3 DIR>315-360 L5 500-532 R2 YL S CE
YL-130M VLD	BLUE/55%	VISIBLE LASER DIODE	660～680	2	D180-315 L7/R180-315 L3 DIR>315-360 L5 625-640 R1 >640-655 R2 >655-665 R1 >665-680 R2 YL S CE

Protect your eyes from Lasers

YL-717



The frame angle can be changed according to the face of the user.



The length of temples can be changed according to the head shape of the user.

YL-717 (Laser absorption type)

FILTER CODE	COLOR/LUMINOUS TRANSMITTANCE	APPLICABLE LASER	WAVELENGTH (nm)	OPTICAL DENSITY (OD)	REMARKS
YL-717 EX	CLEAR/85%	EXCIMER	193 248 308	10	D180-315 L7/R180-315 L3 DIR>315-360 L5 DI9000-11000 L3 YL S CE
YL-717 Nd-YAG (SHG)	RED/16%	Nd-YAG (SHG)	532	10	D180-315 L7/R180-315 L3 DIR>315-360 L5 D>360-532 L5 IR>360-532 L6 YL S CE
YL-717 HeNe	BLUE/25%	He-Ne	632.8	5	D180-315 L7/R180-315 L3 DIR>315-360 L5 DIR620-694 L4 YL S CE
YL-717 ALEXANDRITE	PINK/30%	ALEXANDRITE	755	6	D180-315 L7/R180-315 L3 DIR>315-360 L5 DI780-860 L4 YL S CE
		LASER DIODE	750~800	4~10	
			800~850	10~4	
		TI-SAPPHIRE	750~850	4	
YL-717 Nd-YAG	GREEN/50%	Nd-YAG	1064	6	DIR870-925 L4 DIR>925-1065 L5 DIR>1065-1090 L3 DI9000-11000 L3 YL S CE

YL-717C (Application for Multi band lasers)

YL-717C LD	GREEN/ 7%	VISIBLE LASER DIODE	660~680	2~3	D180-315 L7/R180-315 L3 DIR>315-360 L5 DIR665-690 L3 DIR>690-730 L4 DIR>730-1065L5 DIR>1065-1090 L3 YL S CE
		LASER DIODE	740	4	
			820	4	
		TI-SAPPHIRE	680~1100	3~5	
		Nd-YAG	1064	5	
YL-717C Nd-YAG2	AMBER/40%	Nd-YAG (FHG)	266	10	D180-315 L7/R180-315 L3 DIR>315-360 L5 D>360-532 L5/IR>360-532 L6 DI800-830 L3 DI>830-925 L4 DIR>925-1065 L5 DIR>1065-1090 L3 YL S CE
		Nd-YAG (THG)	355	10	
		Nd-YAG (SHG)	532	4	
		Nd-YAG	1064	6	

YL-717M (Type Attenuation to 1/100 for "alignment work")

YL-717M Nd-YAG (SHG)	RED/30%	Nd-YAG (SHG)	532	2	D180-315 L7/R180-315 L3 DIR>315-360 L5 500-532 R2 YL S CE
YL-717M VLD	BLUE/55%	VISIBLE LASER DIODE	660~680	2	D180-315 L7/R180-315 L3 DIR>315-360 L5 625-640 R1 >640-655 R2 >655-665 R1 >665-680 R2 YL S CE

Protect your eyes from Lasers

YL-290（Laser absorption type）

FILTER CODE	COLOR/LUMINOUS TRANSMITTANCE	APPLICABLE LASER	WAVELENGTH（nm）	OPTICAL DENSITY（OD）	REMARKS
YL-290 EX He-Cd	YELLOW/80%	EXCIMER	193	10	D180-315 L7/R180-315 L3 DIR>315-460 L5 YL S CE
			248		
			308		
		He-Cd	325		
			441.7		
		Nd-YAG（THG）	355		
		Nd-YAG（FHG）	266		
YL-290 Nd-YAG（SHG）	RED/16%	Nd-YAG（SHG）	532	10	D180-315 L7/R180-315 L3 DIR>315-360 L5 D>360-532 L5 IR>360-532 L6 YL S CE
YL-290 ALEXANDRITE	PINK/30%	ALEXANDRITE	755	6	D180-315 L7/R180-315 L3 DIR>315-360 L5 DI740-860 L4 YL S CE
		LASER DIODE	750～800	4～10	
			800～850	10～4	
		TI-SAPPHIRE	750～850	4	
YL-290 Nd-YAG	GREEN/50%	Nd-YAG	1064	6	DIR870-925 L4 DIR>925-1065 L5 DIR>1065-1090 L3 DI9000-11000 L3 YL S CE

YL-290C（Application for Multi band lasers）

YL-290C Nd-YAG2	AMBER/40%	Nd-YAG（FHG）	266	10	D180-315 L7/R180-315 L3 DIR>315-360 L5 D>360-532 L5/IR>360-532 L6 DI800-830 L3 DI>830-925 L4 DIR>925-1065 L5 DIR>1065-1090 L3 YL S CE
		Nd-YAG（THG）	355	10	
		Nd-YAG（SHG）	532	4	
		Nd-YAG	1064	6	

YL-290M（Type Attenuation to 1/100 for “alignment work”）

YL-290M Nd-YAG（SHG）	RED/30%	Nd-YAG（SHG）	532	2	D180-315 L7/R180-315 L3 DIR>315-360 L5 500-532 R2 YL S CE
YL-290M VLD	BLUE/55%	VISIBLE LASER DIODE	660～680	2	D180-315 L7/R180-315 L3 DIR>315-360 L5 625-640 R1 >640-655 R2 >655-670 R1 >670-680 R2 YL S CE

Protect your eyes from Lasers

- High visible transmittance
- High color transmission
- High chemical agent resistance
- Three different OD filters of NdYAG are available according to the laser power

- Frame / Plastic
- Lens / Tempered glass
- Specification / Can be worn over prescription eyewear

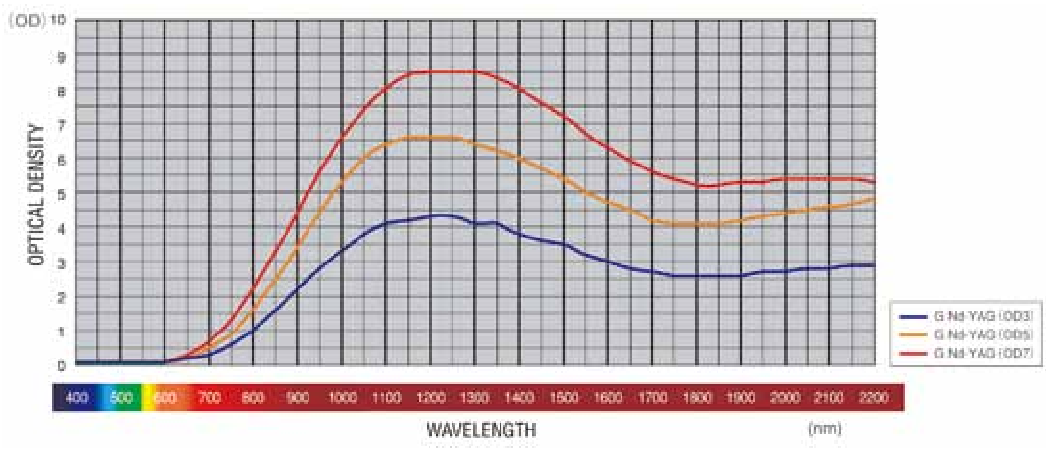
Tempered Glass

It is important to see your environment while working with lasers. In order to increase the visibility and color transmission, this type is made to have a high visible light transmittance. Please choose the filter according to the laser power.

G Tempered Glass (Laser absorption type)

Please note that the following optical density graphs are based on measurement values, they are not based on standard values.

FILTER CODE	YL250G	COLOR/LUMINOUS TRANSMITTANCE	APPLICABLE LASER	WAVELENGTH (nm)	OPTICAL DENSITY (OD)	REMARKS
Nd-YAG (OD3)	○	GREEN/80%	Nd-YAG	1064	3<	These tempered glasses are applicable for Nd-YAG 1064nm. Available for OD3, OD5 and OD7 types.
			Ho-YAG	2100	2<	
			Er-YAG	2940	2<	
			TELECOM	980	3<	Applicable for the Telecommunication Laser Diode 1310nm and 1550nm.
				1310	2<	
				1550	2<	
			LASER DIODE	780	0.8<	
Nd-YAG (OD5)	○	GREEN/74%	Nd-YAG	1064	5<	These tempered glasses are applicable for Nd-YAG 1064nm. Available for OD3, OD5 and OD7 types.
			Ho-YAG	2100	3.5<	
			Er-YAG	2940	3.5<	
Nd-YAG (OD7)	○	GREEN/69%	Nd-YAG	1064	7<	
			Ho-YAG	2100	5<	
			Er-YAG	2940	5<	



Precautions when using the Tempered Glass Laser protective eyewear

1.Do not use this laser protective eyewear for any other laser other than the applicable laser.
2.Do not take off this laser protective eyewear while working with a laser.
3.Do not use this laser protective eyewear for welding protection.
4.Do not look directly into the laser beam even when wearing this laser protective eyewear.
5.Do not use this product if it was exposed to a laser with a high power density or if it is damaged.

Protect your eyes from Lasers

- Laser Safeguard provides protection from a direct laser beam for three seconds. (Conditional I
- High optical density
- High threshold against applicable laser (Both frame and filter)
- Laminated glass provides high impact resistance

- Frame / Laminated plastic frame
- Lens / Laminated glass filter
- Specification / Can be worn over prescription eyewear

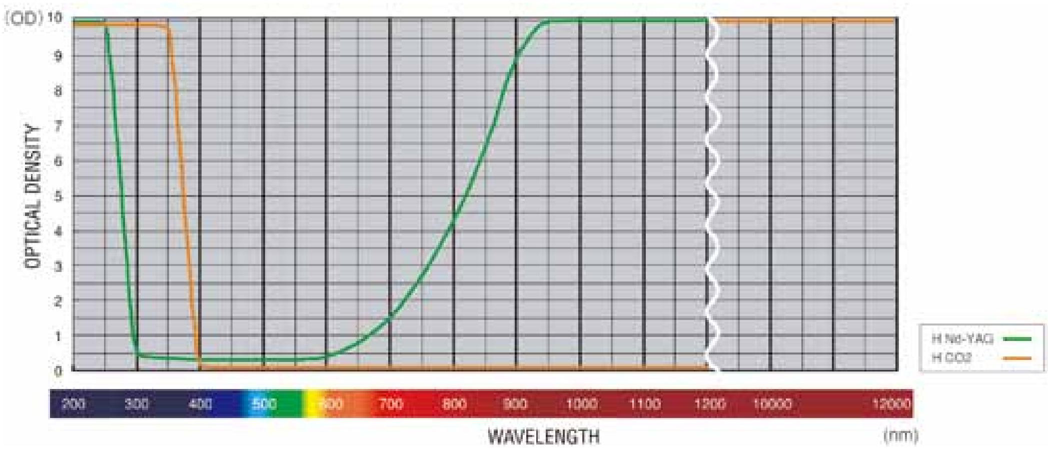
High-powered laser goggle

This product is developed to protect the user and gives him ample time to take evasive action in the case that, during routine work, the protection ic hit from not only a scattered laser beam but also from a direct laser beam.

H HIGH - POWERED LASER (Laser absorption type)

Please note that the following optical density graphs are based on measurement values, they are not based on standard values.

FILTER CODE	YL120H	COLOR/LUMINOUS TRANSMITTANCE	APPLICABLE LASER		WAVELENGTH (nm)	OPTICAL DENSITY (OD)	REMARKS
Nd-YAG	○ CE	GREEN/67%	Nd-YAG		1064	7<	No penetration by a laser of power density 10^8W/m^2 at 1064nm within three seconds This filter provides over OD7 between 1000 and 1600nm.
					1319.5		
			Nd-GLASS		1060		
			Nd-YLF		1047		
					1053		
CO_2	○ CE	CLAR / 86%	CO_2		10600	10<	No penetration by a laser of power density 10^8W/m^2 at 1600nm within three seconds This filter provides over OD10 between 190 and 320nm.
			EXCIMER	ArF	193		
				KrF	248		
				XeCl	308		



Precautions when using the High - Powered Laser Safeguard

1.Do not use this laser protective eyewear for any other laser other than the applicable laser.
2.Do not take off this laser protective eyewear while working with a laser.
3.Do not use laser protective eyewear for welding protection.
4.The frame and filter of the Laser Safeguard are designed not to be penetrated by a direct laser beam within three seconds, in order to give the user enough time to take evasive action

LASER MACHINING SAFETY EYEWEAR YL-500

Protect your eyes from Lasers

- 40cm × 40cm (thickness 3mm)
- Only for CO2, thickness is 4mm
- Only for Nd-Yag, maximum size is 120cm × 100cm (thickness 3.5mm)
- Material: Polymetyl Meta Acrylate
- Sales Unit: Any size within the above mentioned sizes

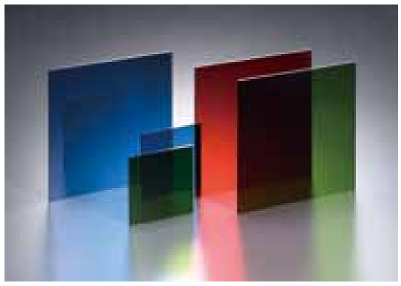
Outline of Product

- Due to the acrylic material, accurate measurement processing is available. (We perform any customized measurement processing including perforation processing.)

This product is used as a measure to protect operators from laser risks, as it is essential to avoid exposure from laser radiation due to laser emitting equipment. Laser processing machines are most likely to cause a risk due to umforeseen laser reflections. The Laser Shield Window can be used for a variety of applications such as a viewing window, a partition of a control area or an aperture installation on doors.

Installation method of the Laser Shield Window:

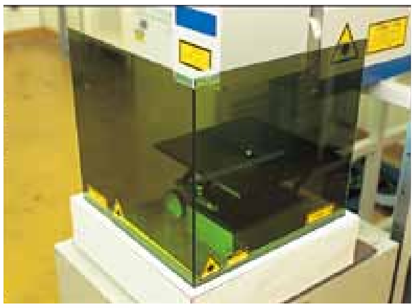
Because any perforation and measurement processing is applicable, you can install this product easily to any ready-made equipment.

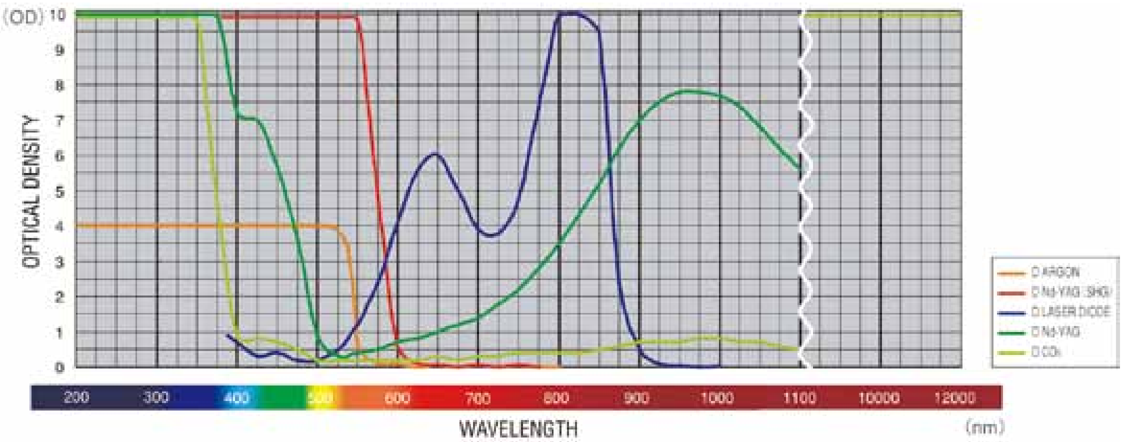


D Laser absorption type

Please note that the following optical density graphs are based on measurement values; they are not based on standard values.

CODE NAME	COLOR / LUMINOUS TRANSMITTANCE	APPLICABLE LASER	WAVELENGTH (nm)	MIN.OPTICAL DENSITY (OD)	MAXIMUM SIZE (mm)	THICKNESS (mm)
ARGON	ORANGE/60%	EXCIMER ARGON He-Cd	200~514.5	4<	400×400	3.0
Nd-YAG (SHG)	RED/15%	ARGON Nd-YAG (SHG)	480~540	6<	400×400	3.0
LASER DIODE	BLUE/7%	LASER DIODE He-Ne	632.8, 760~850	5<	400×400	3.0
Nd-YAG	GREEN/25%	Nd-YAG	1064	5<	1200×1000	3.5
CO_2	GREEN/60%	CO_2	10600	10<	400×400	4.0





YL-600

- Size: Effective width 33cm (thickness 0.7mm)
- Material: plasticized polyvinyl chloried
- Sales unit: Length 50cm, Maximum length 10m per roll
  Size: Effective width 33cm, Thickness 0.7mm
  Unit: 50cm. maximum length available 10 meters

Outline of the Product:

- As this product is made of plasticized polyvinyl chloride, you can easily cut the curtain by scissors and fit it to the size of any ready-made facilities.
- Long length product is available and you can use it for a large area

It is essential to contain a laser within an enclosed area from a safety point of view. When you isolate the work area from the outside, the outside operators can not identify the condition of the operators within such an enclosed area and this is not advisable form a safety perspective. The Laser Curtain not only provides isolation of the laser control area but it also offers peace of mind and safety to all workers which will constitute a safe working environment.

Installation method of the Laser Shield Curtain:

The Laser Shield Curtain is made of plasticized polyvinyl chloride. Therefore, it is soft and flexible making its installation much easier as it can be made into any shape according to its required applications. However, in order to maximize its effectiveness, your attention is drawn to the following information.

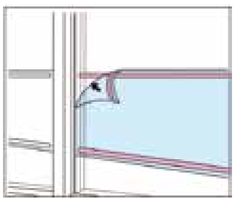
D Laser absorption type shield curtain YL-600

CODE NAME	COLOR / LUMINOUS TRANSMITTANCE	APPLICABLE LASER	WAVELENGTH (nm)	MIN.OPTICAL DENSITY (OD)
ARGON	RED/20%	EXCIMER	190~380	3<
		ARGON	488	
			514.5	
		He-Cd	441.6	
		Nd-YAG (SHG)	532	
He-Ne	BLUE/12%	He-Ne	632.8	2<
		(Dye)	570~630	
		GOLD VAPOR	627.8	
		KRYPTON	647.1	
			676.4	
		Ruby	694.3	
LASER DIODE	GREEN/12%	LASER DIODE	740~910	3<
		ALEXANDRITE	740~820	
		Ti-SAPPHIRE	700~1000	1~3
Nd-YAG	GREEN/30%	Nd-YAG	1064	3<
		CO_2	10600	

Please note that the following optical density graphs are based on measurement values, they are not based on standard values.

C Application for Multi band laser YL-600C

CODE NAME	COLOR / LUMINOUS TRANSMITTANCE	APPLICABLE LASER	WAVELENGTH (nm)	MIN.OPTICAL DENSITY (OD)
Nd-YAG 2	AMBER/7%	Nd-YAG (FHG)	266	3<
		Nd-YAG (THG)	355	
		Nd-YAG (SHG)	532	
		Nd-YAG	1064	



Installation of the Laser Curtain to Transparent Panels The surface of the Laser Curtain is slightly adhesive. Firstly, place the Laser Curtain onto the panels, and then push out any air bubbles which may exist between he curtain and the panel. If any air bubbles still remain, the effectiveness of the curtain will not be reduced. After that, apply 3M multi-purpose adhesive (approx 1cm in width) to the upper and lower edges of both the curtain and the panel and then fasten.