



ACOUSTO-OPTICS



Acousto-Optic Devices
Radio frequency Technology

- Modulators - Pulses pickers
- Polychromatic modulators
- Fixed & variable frequency shifters
- Deflectors - AOTF
- Q-Switches - Cavity Dumpers
- Fiber pigtailed devices
- Power Amplifiers
- Fixed and variable frequency sources
- Custom developments



Focused on

High Technology

and Customer's Added Value



The AA GROUP...

AA-GROUP is a Human size, independant Group involved in High Technologies in the fields of Opto-electronics, Radio frequency and Microwave technologies.

Our aim is to become a worldwide leader in providing solutions from the beginning of the design, to the manufacturing of high quality components and systems. Our objective is to master all specialties of our jobs, thanks to an in-house vertical concentration, in order to offer flexibility, State-of-the-Art and cost effective products to our national and international customers and partners.

Stability and long term vision... is driven by:

- Customer Excitement: High-value solutions that meet the technological, performance, safety, and cost-competitive pressures that challenge our future
- Societal Responsibility: solutions answering the paramount considerations of versatility, environmental protection, security and social coordination
- Successful on-time, on-quality, on-price introduction of new products and processes
- Technology leadership to fuel business growth



State of the Art Acousto-optic and RF Technology



Telecommunications, Industrial & Research, Biomedical & Life Science, Defence & Aerospace, Sustainable development

In our industry, the pace of the competition is permanently intensifying, the time-to-market for breakthrough technologies is decreasing, while the integration of technologies becomes as important as the individual breakthrough technologies themselves.

Our mission is to be a focal point for Research & Technology and for innovation across our expertise fields. We also steer the AA Group-wide harmonisation of transversal technical processes, methods and tools, and skills development programmes. Since Innovation is not only about Research and Technology but also about increased quality and optimized information and production processes.

Fundamentally, our Research & Technology strategy is to drive the emergence and development of new European microwave and optoelectronic technologies to maturity, to help our customers and partners meet the evolving needs in our home markets and emerging markets. Our Research & Technology strategy creates the company's technology portfolio and aligns it with the business strategy. It has a clear focus on growing markets and the key technologies for a successful on-time, on-quality, on-price introduction of new products and services.

We keep the innovation pipeline constantly full to replace ageing technologies and processes. Our researchers are developing technologies which are directly related to the requirements of today's society, we always keep in mind the needs of our customers as well as the maintainability and the life-cycle costs of our products.

The skilled AA Group workforce is our real treasure. We recognize that the technical expertise of our employees is of vital importance for a successful future. Together with our Human Resources department, it is a key job for us to keep this expertise at the appropriate level and to strengthen our competencies by developing and managing our R&T employees.

We create We manufacture

X Ray
Orientation

Crystal
sawing
polishing

AR Coating
Transducer
bonding

Pre-Serie
Production



AA OPTO-ELECTRONIC: Experience our engineering...

AA was founded in **1979**, under the name «Automates et Automatismes». It became a limited company in 1988 under the new name of AA Sa, specialising in acousto-optic components and their associated RF drivers. Early products included a multi-beam, low RF power modulator for use in the near infra-red and a compact 2-axis deflector system, completed in the 90's by AA's famous polychromatic modulator. Since then the range of products has increased dramatically.

Nowadays, AA is a world leader in the manufacturing of quality Acousto-optic and radio frequency devices. Close collaboration with universities and research institutes, provided invaluable knowledge and experience in the design and manufacturing processes of Acousto-optic devices and radio-frequency sources. Continuous R&D keeps pace with advances in laser and electronic technology to ensure AA continues to offer state-of-the-arts products. AA offers its customers solutions from prototype design to large volume manufacturing thanks to its internal resources:

In-house design capabilities: AO design software, opto-mechanical design software, RF/microwave simulation software .

In-house manufacturing capabilities: X-ray orientation, crystals and glasses sawing and polishing, Anti-reflexion coatings, metallic deposition, molecular bonding under vacuum .

In-house test and quality control equipments:

Laser interferometers, network analyzers, spectrum analyzers, digital oscilloscopes, a large range of lasers for final tests and controls, and more.

Mastering all critical areas of the AO and RF technology, allows AA to accompany its customers from the concept design to large volume manufacturing, and to respond efficiently and flexibly to any request. AA thrives to maintain a high-tech up-to-date line of products and excellent service. Our company is **ISO 9001** certified: this is a guaranty for service and quality... All our products are RoHS compliant.

Our Headquarter is located in ORSAY, near Paris. This is also our optical manufacturing center. All RF drivers are manufactured in our St Avertin plant, located 200 kms south of Paris.



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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.

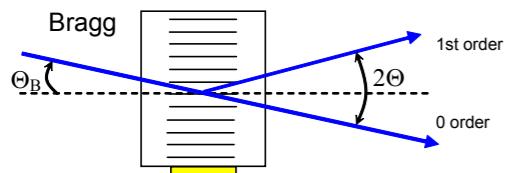
At this date, the acousto-optic interaction was only a pleasant laboratory experimentation. The only application was the measurement of constants and acoustic coefficients.

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 (Θ_B):

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.

Theory

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 an 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

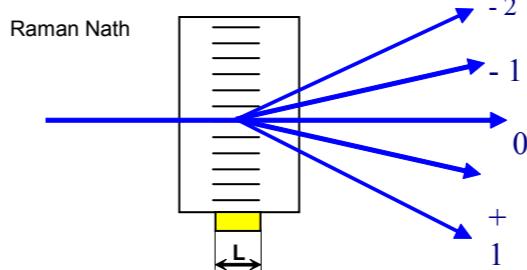
A parameter called the "quality factor, Q", determines the interaction regime. Q is given by:

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

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 Λ is the acoustic wavelength.

$Q \ll 1$: 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.

$Q \gg 1$: This is the Bragg regime. At one particular incidence angle Θ_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 :

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

$K_i = 2\pi n_i / \lambda_o$ – wave vector of the incident beam.

$K_d = 2\pi n_d / \lambda_d$ – wave vector of the diffracted beam.

$K = 2\pi F / v$ – wave vector of the acoustic wave.

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

Energy conservation leads to : $F_d = F_i + / - F$

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 $F \ll F_d$ or F_i , 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, Θ_B :

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

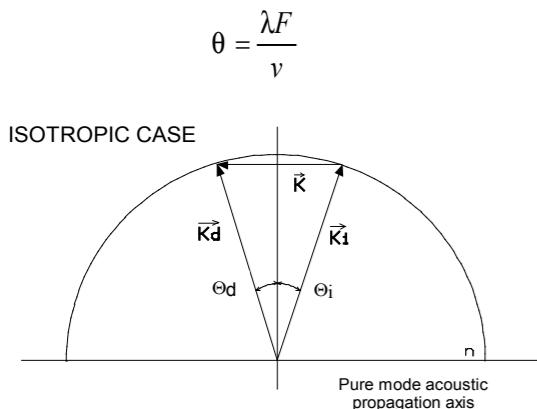
where $\lambda = \lambda_c / n$ is the wavelength inside the crystal, v is the acoustic velocity and F is the RF frequency.



Acousto-optic

Theory

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



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

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

Here I_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. λ_0 is the wavelength of the incident beam.

Diffraction efficiency (relative) is the ratio I_1/I_0 :

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

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:

$$\frac{I_0}{I_1} = \eta \sin c^2 \sqrt{\eta + \frac{\Delta\phi^2}{4}}$$

where $\Delta\phi = \Delta K \cdot L$ and is called the "phase asynchronism".

In the isotropic case :

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

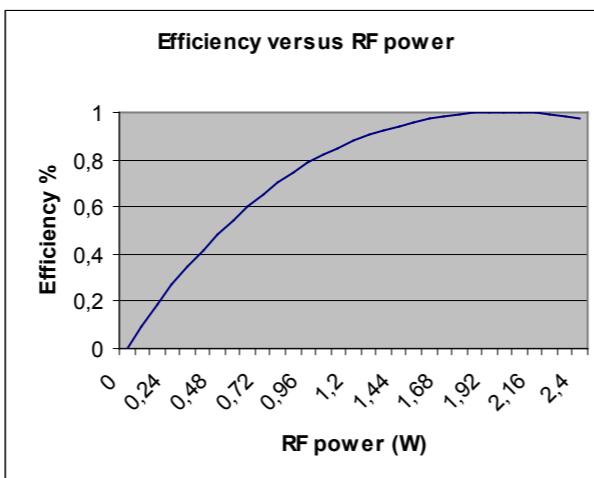
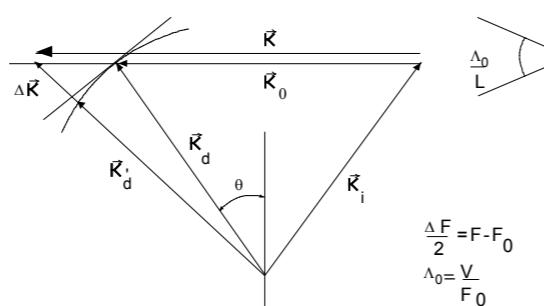
At the correct Bragg frequency, $\Delta\phi=0$ ($F=F_0$) and efficiency is maximum

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 ΔF - 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.

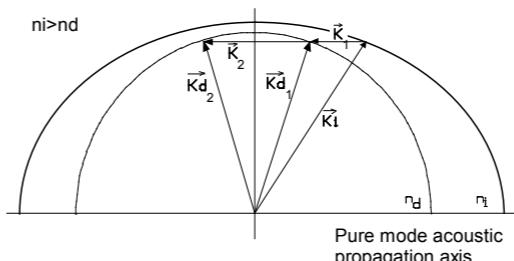


Anisotropic interaction

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 K_1 connects the index curves of the incident and diffracted waves. (K_2 simply represents a similar interaction at a very different RF frequency).

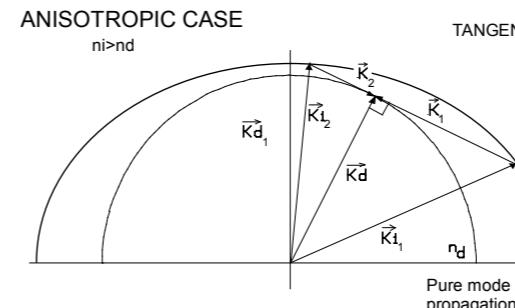
The same asymmetry which causes the difference in refractive indexes also causes the acoustic wave to travel in a "shear-mode" and, in the particular example of tellurium dioxide, this results in a drastic reduction in the acoustic velocity.

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.



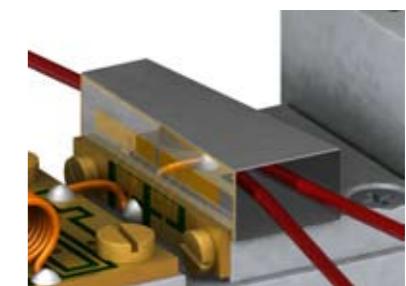
This means that the length of the acoustic wave-vector can vary quite grossly while only producing small changes in the length of the diffracted beam's wave-vector. So, in this situation, ΔK (and, hence, $\Delta\phi$) is quite insensitive to changes in RF frequency.

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.

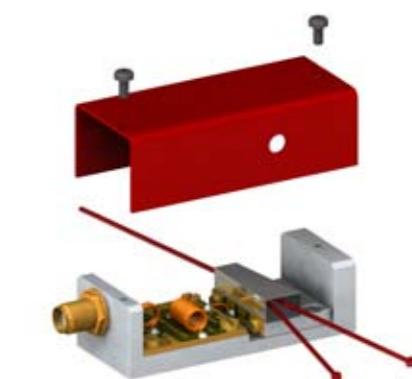
The shape of the electrode can be varied for impedance matching or to "shape" the acoustic wave.

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 reflections 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.





Acousto-optic

MODULATORS

Modulators

Such a device allows the modulation of the light intensity. The Bragg interaction regime with only one diffracted order is used for these devices.

Rise time:

The rise time (TR) of the modulator is proportional to the acoustic traveling time through the laser beam. The rise time of a fast modulator must be very short:

$$T_R = \beta \frac{\phi}{V}$$

β : constant depending on laser beam profile

Φ : beam diameter

v : acoustic velocity

Φ is the only parameter to minimize TR. Consequently, one focuses the incident light beam on the acoustic beam in order to reduce the beam diameter and reduce rise time... β is equal to 0.66 in the case of a TEM00 beam.

$$T_R = 0.66 \frac{\phi}{V}$$

(Valid for a TEM00 laser beam, $1/e^2$ dia)

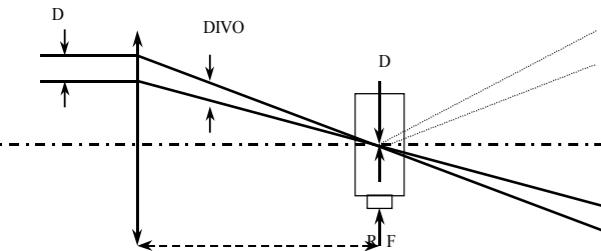
D: beam diameter before the lens

F: focal length of the lens

DIV0: incident laser beam divergence

D= $\alpha * F * \lambda / \Phi$: diameter of the light beam in the crystal.

α : constant depending on beam profile ($=4/\pi$ for TEM00 beams)



Limitations

To allow the interaction, (L) must remain sufficiently large compared with the acoustic wavelength.

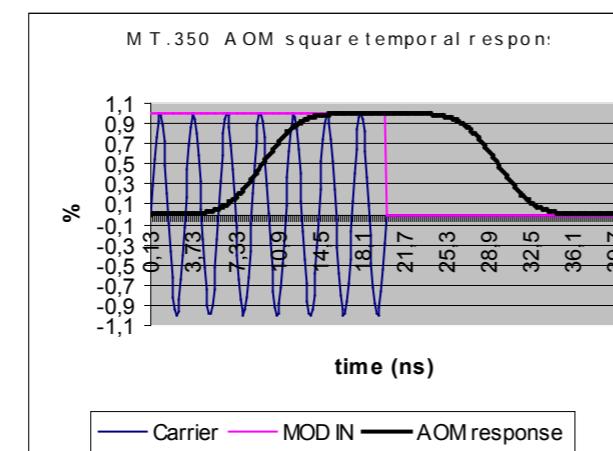
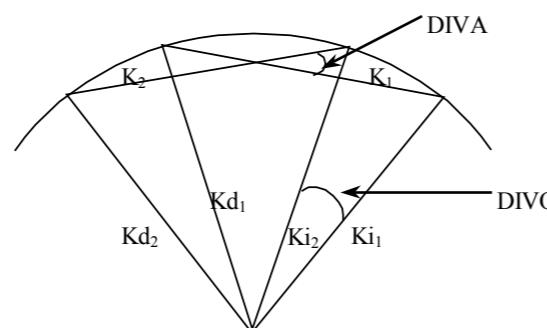
The light beam has a divergence which cannot be neglected. To preserve the efficiency of the interaction on all the bandwidth Δf , it is necessary to reach the Bragg conditions for all the "angles" of the light beam.

For this purpose, the acoustic divergence (DIVA) ($=\Lambda/L$) where Λ is the acoustic wavelength and L the dimension of the ultrasonic source) must compensate for light divergence DIVO.

If DIVO>>DIVA : the "asynchronism" is very large for the directions of incidence far away from the Bragg angle, and then the interaction will not occur correctly. The section of the diffracted light beam is then elliptic.

If DIVO<<DIVA : the bandwidth is reduced. An acoustic divergence slightly higher than the light divergence makes it possible to neglect the ellipticity all while maintaining the bandwidth.

Lastly, let us remind that the efficiency of the modulator is related to $\sqrt{P/P_0}$ and that P_0 is inversely proportional to L. For a maximum acceptable value of P_0 by the crystal (which takes account the maximum power that can withstand the crystal), one reaches a limit of the efficiency.



Contrast ratio (static and dynamic)

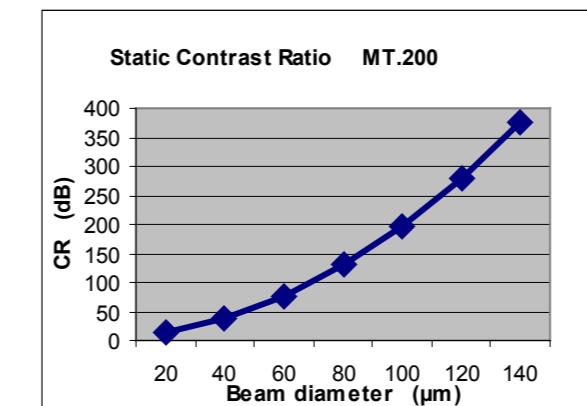
The incident laser beam properties have a significant impact upon modulator performances (temporal response and extinction ratio). The static contrast ratio measures the ability of the modulator to separate the different diffraction orders (especially 0 and 1st orders).

As a consequence, the lower carrier frequencies and highly focused beams will be a physical limitation of the static extinction ratio. The Gaussian profile (TEM00) gives the best performances and will be considered in the following part. The far field 1st order beam (propagating at angle $(+\theta_B)$) is typically separated from the 0 order ($-\theta_B$) with a beam block which is placed such that angles up to 0 are stopped (angles higher than $+2\theta_B$ can also be stopped to suppress higher orders scattering light).

TEM00 static contrast ratio can be written as :

$$CR = \int_0^{2\theta_B} I(\theta) d\theta / \int_{-\infty}^{+\infty} I(\theta) d\theta$$

The static CR is physically limited by imperfection of the crystal and scattered light.



$$MTF(f) = \exp\left(-\frac{f^2}{f_c^2}\right) \quad f_c = \frac{\sqrt{8V}}{\pi\phi}$$

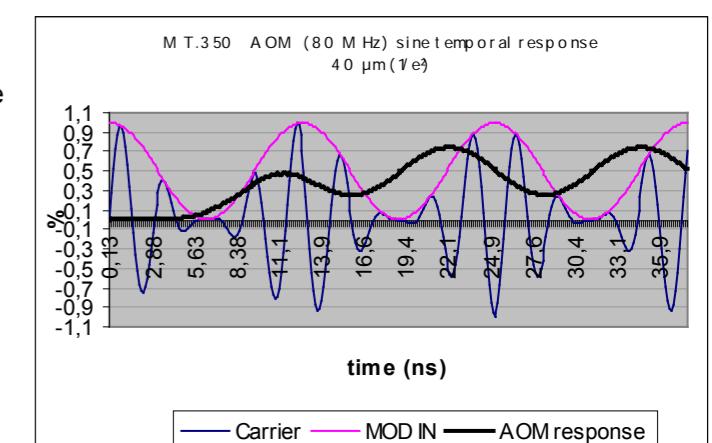
V: acoustic velocity, \square : beam diameter ($1/e^2$)
Fc : frequency to the $1/e^2$ response rolloff

An other common measure of frequency response rolloff is the analog modulation bandwidth at -3dB (50% reduction point) which is related to fc by

$$F_{-3\text{dB}} = \sqrt{\log_e 2} f_c$$

From which we can deduce the relationship between f-3dB and rise time :

$$F_{-3\text{dB}} \approx \frac{0.48}{T_r}$$



Best performances
rise time: 4-8 ns
efficiency : 70-85 %

Applications

- Laser Printing
- Transmission of a video signal
- Noise eater
- Locker-mode

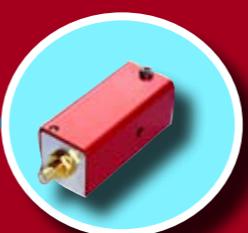
Specific application

Multi-beam modulators. Several discrete frequencies (F_1, F_2, \dots, F_n) belonging to the bandwidth of the modulator are sent in the modulator. The diffracted beams are ordered separately, in different directions.

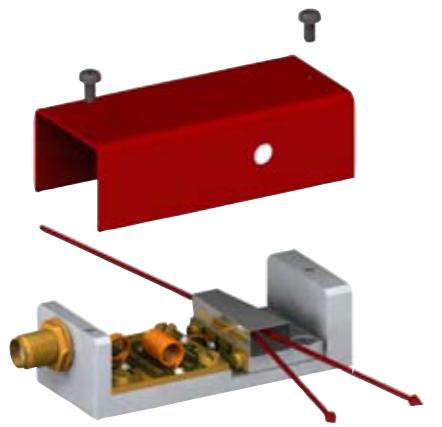
A scanning system (for example deflecting) in the perpendicular direction allows, amongst other things, to form characters (printer).



Focus on



MODULATORS & Fixed Frequency Shifters



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.

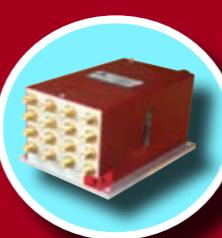
The first order beam of a modulator is frequency shifted by the amount of the RF carrier frequency : it acts like as fixed frequency shifter.



| 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-A1,5-244.266-B | Fused silica | 244-266 | 1,5 x 1 | 180 | Linear | 60 | 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 1 | 180 | Linear | 10 | 48 | 80 |
| MQ110-A1-UV | Fused silica | 325-425 | 1 x 2 | 110 | Linear | 15 | 32 | 85 |
| MQ110-A3-UV | Fused silica | 325-425 | 3 x 3 | 110 | Linear | 50 | 10 | 90 |
| MQ240-A0,2-UV | Fused silica | 325-425 | 0,2 x 1 | 240 | Linear | 6 | 80 | 70 |
| MTS130-A3-400.442 | TeO ₂ | 400-442 | 3 x 3 | 130 | Linear | 1000 | 0,4 | 85 |
| MQ180-A0,25-VIS | Fused silica | 440-650 | 0,25 x 1 | 180 | Linear | 10 | 48 | 70 |
| MCQ110-A2-VIS | Quartz | 488-633 | 2 x 2 | 110 | Linear | 50 | 8 | 85 |
| MT350-A0,12-VIS | TeO ₂ | 450-700 | 0,12 x 1 | 350 | Linear | 5 | 96 | 80 |
| MT250-A0,5-VIS | TeO ₂ | 450-700 | 0,5 x 2 | 250 | Linear | 6 | 80 | 80 |
| MT200-A0,5-VIS | TeO ₂ | 450-700 | 0,5 x 2 | 200 | Linear | 8 | 60 | 85 |
| MT110-A1-VIS | TeO ₂ | 450-700 | 1 x 2 | 110 | Linear | 15 | 32 | 85 |
| MT110-A1,5-VIS | TeO ₂ | 450-700 | 1,5 x 2 | 110 | Linear | 50 | 9 | 85 |
| MT80-A1-VIS | TeO ₂ | 450-700 | 1 x 2 | 80 | Linear | 23 | 21 | 85 |
| MT80-A1,5-VIS | TeO ₂ | 450-700 | 1,5 x 2 | 80 | Linear | 50 | 9 | 85 |
| MTS110-A3-VIS | TeO ₂ | 458-633 | 3 x 3 | 110 | Linear | 1000 | 0,4 | 85 |
| MTS40-A2-VIS | TeO ₂ | 532-700 | 2 x 2 | 40 | Linear | 1000 | 0,4 | 85 |
| MTS40-A3-IR | TeO ₂ | 750-850 | 3 x 3 | 40 | Linear | 1000 | 0,4 | 85 |
| MT110-A1,5-IR-Hk (Ti:sa) | TeO ₂ | 690-1064 | 1,5 x 2 | 110 | Linear | 50 | 9 | 80 |
| MT350-A0,12-800 | TeO ₂ | 700-950 (1100) | 0,2 x 1 | 350 | Linear | 5 | 96 | 80 |
| MT250-A0,5-800 | TeO ₂ | 700-950 (1100) | 0,2 x 2 | 250 | Linear | 6 | 80 | 80 |
| MT200-A0,5-800 | TeO ₂ | 700-950 (1100) | 0,5 x 2 | 200 | Linear | 8 | 60 | 85 |
| MT110-A1-IR | TeO ₂ | 700-950 (1100) | 1 x 2 | 110 | Linear | 15 | 32 | 85 |
| MT110-A1,5-IR | TeO ₂ | 700-950 (1100) | 1,5 x 2 | 110 | Linear | 50 | 9 | 85 |
| MT80-A1-IR | TeO ₂ | 700-950 (1100) | 1 x 2 | 80 | Linear | 23 | 21 | 85 |
| MT80-A1,5-IR | TeO ₂ | 700-950 (1100) | 1,5 x 2 | 80 | Linear | 50 | 9 | 85 |
| MT200-A0,5-1064 | TeO ₂ | 980-1100 | 0,5 x 1 | 200 | Linear | 8 | 60 | 80 |
| MT200-A0,2-1064 | TeO ₂ | 980-1100 | 0,2 x 1 | 200 | Linear | 8 | 60 | 80 |
| MT110-A1-1064 | TeO ₂ | 980-1100 | 1 x 2 | 110 | Linear | 15 | 32 | 85 |
| MT80-A1-1064 | TeO ₂ | 980-1100 | 1 x 2 | 80 | Linear | 23 | 21 | 85 |
| MT80-A1,5-1064 | TeO ₂ | 1000-1100 | 1,5 x 2 | 80 | Linear | 50 | 9 | 85 |
| MTS80-A3-1064Ac | TeO ₂ | 1064 | 3 x 3 | 80 | Linear | 500 | 1 | 85 |
| MQ40-A3-L1064-W | SiO ₂ | 1064 | 3 x 3 | 40 | Linear | 120 | 4 | 85 |
| MCQ40-A2,5-1064 | Quartz | 1064 | 2,5 x 2,5 | 40 | Linear | 180 | 2,5 | 85 |
| MGAS40-A1 | Doped Glass | 1300-1600 | 1 x 2 | 40 | Random | 50 | 10 | 85 |
| MGAS80-A1 | Doped Glass | 1300-1600 | 1 x 2 | 80 | Random | 50 | 10 | 85 |
| MGAS110-A1 | Doped 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 |



Focus on



PULSES PICKERS & Multi-channels AOMs

Associated RF drivers for MODULATORs & Fixed Frequency Shifters



| Model | Carrier Frequency | Max RF Power | Rise Fall/ Time | Video In | Extinction 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 |

*Other on request

These drivers based on quartz oscillators, produce a fixed RF frequency 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. Usually the driver is coupled internally to a power amplifier; if the output power required is very high then the amplifier will be provided separately, offering RF powers up to 500 W CW.



Multi channel AOMs

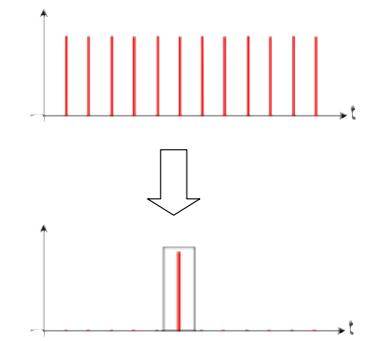
| Model | Material | Number of channels | Wavelength nm | Aperture mmxmm | Freq (Shift) MHz | Polarisation | ns Rise Time | Modul.BW MHz (AM) | Efficiency % |
|----------------------|--------------|--------------------|---------------|----------------|------------------|--------------|--------------|-------------------|--------------|
| 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 |
| MT65-B20A2-2x | TeO2 | 2 | 1064 | 2 x 2 | 65 | Linear | 160 | 3 | 85 |

Pulses Pickers

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

Short and Ultrashort pulses are in most cases generated by a mode-locked laser in the form of a pulse train with a pulse repetition rate of the order of 10MHz – few GHz.

For various reasons, it is often necessary to pick certain pulses from such a pulse train, i.e., to transmit only certain pulses and block all the others. This can be done with a pulse picker, which is essentially an electrically controlled optical gate.



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 | 14.3 @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 |



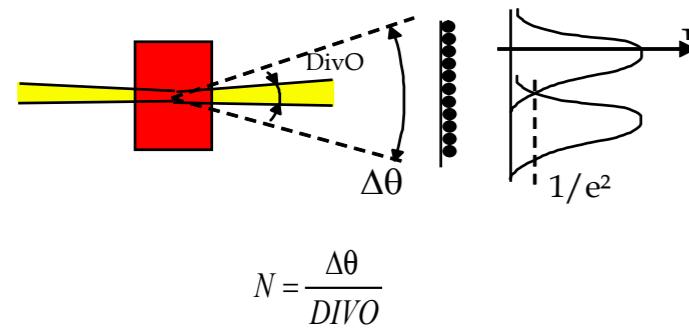
Acousto-optic

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. The center of two consecutive points will be separated by the laser beam diameter (at $1/e^2$) in the case of a TEM00 beam.



$\Delta\theta$: deflection angle range
DIVO: laser beam divergence

$$N = \frac{\pi}{4} \Delta F \frac{\phi}{V}$$

for a TEM00 laser beam
 ΔF : AO frequency range
 ϕ : beam diameter ($1/e^2$)
V: acoustic velocity

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

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 commute from one position to another one. A deflector is often characterized with the time x bandwidth product $T_a \times \Delta F$.

- dF/dt : frequency modulation slope
-V: acoustic velocity
- α : parameter depending on beam profile
(=1 for rectangular shape, about 1.34 for TEM00)

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.

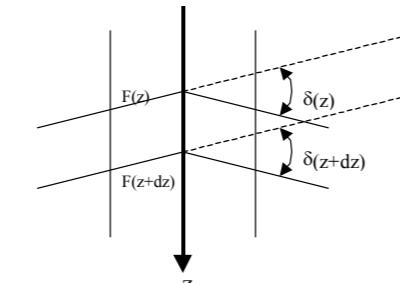
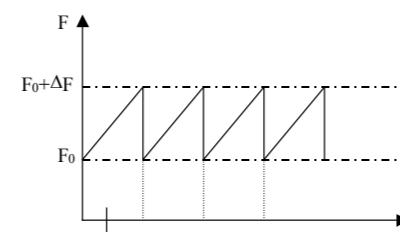
In the case of a linear frequency sweeping:

In Z=0 (at the crystal's entry), the frequency F is equal to:

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

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).

$$\begin{aligned} \delta &= \delta(Z, t) = \frac{\lambda F}{V} = \frac{\lambda}{V} (F_0 + \frac{\Delta F}{T}(t - \frac{Z}{V})) \\ d\delta &= \frac{\lambda}{V} (\frac{\partial F}{\partial t} dt + \frac{\partial F}{\partial Z} dz) \end{aligned}$$

In z and z+dz, the angle of deviation is not the same one. There is focusing, in only one plane, of the diffracted beam. It is significant to notice this effect of cylinder lens, intervening during sequential sweeping (television with raster scan, printing...).

Equivalent cylindrical focal length:

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

- dF/dt : frequency modulation slope

-V: acoustic velocity

- α : parameter depending on beam profile

(=1 for rectangular shape, about 1.34 for TEM00)

DEFLECTORS Frequency Shifters

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

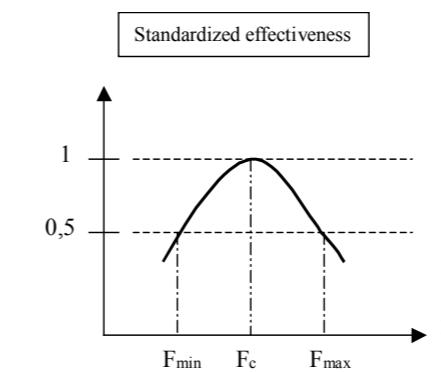
Examples:

| N | Ta (μs) | T (μs) | 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.

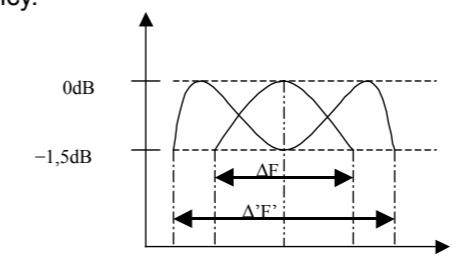
The efficiency curve versus frequency has the following shape for isotropic interaction:



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 synchronization frequencies to match the Bragg conditions, so that the deflection angle range can be broaden with good efficiency.



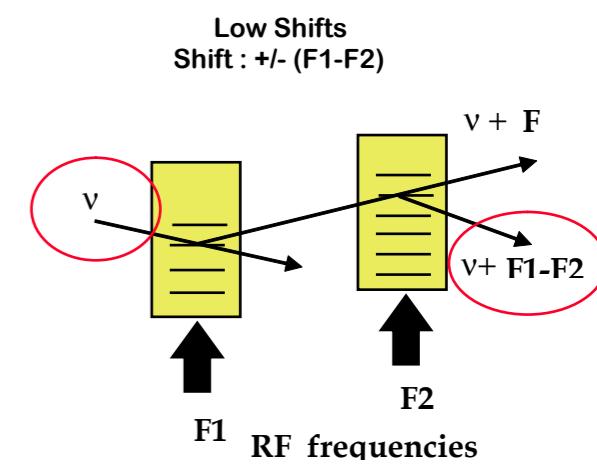
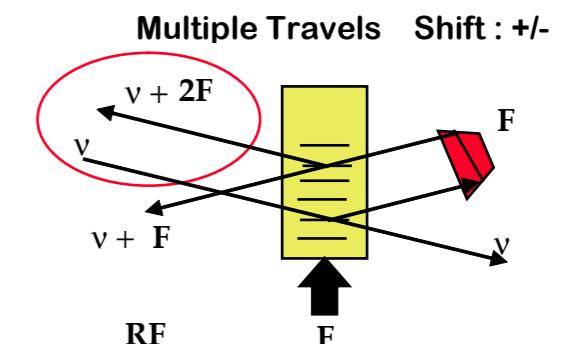
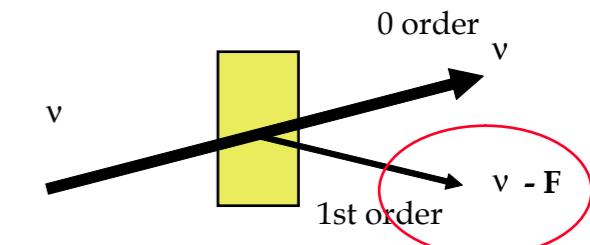
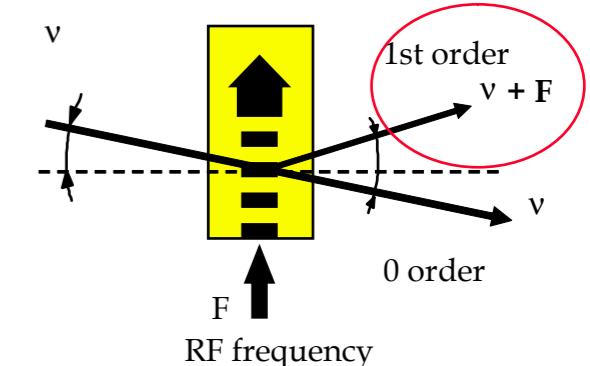
Standardized effectiveness

Frequency Shifters

These components use the modification of frequency of the diffracted light. ($F_d = F_i +/- F$) 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 deflector.

Fixed Shifts





Focus on



DEFLECTORS & Variable Frequency Shifters

High Resolution

| Model | Material | Wavelength nm | Aperture mmxmm | Freq (Shift) MHz | Polarisation | Resolution T.ΔF | Deflexion angle range | Efficiency % |
|---------------------------|-------------------------|---------------|----------------|------------------|--------------|-----------------|-----------------------|--------------|
| DTSX-250 | TeO ₂ | 350-1600* | 4,5 x 4,5 | f(λ) | Linear | 300@633nm | 48@633nm | > 70 |
| DTSX-400 | TeO ₂ | 350-1600* | 7,5 x 7,5 | f(λ) | Linear | 500@633nm | 48@633nm | > 70 |
| DTSXY-250 | 2 Axis TeO ₂ | 350-1600* | 4,5 x 4,5 | f(λ) | Linear | 300x300@633nm | 41 x 41@532nm | > 45 |
| DTSXY-400 | 2 Axis TeO ₂ | 350-1600* | 7,5 x 7,5 | f(λ) | Linear | 500x500@633nm | 41 x 41@532nm | > 45 |
| DT230-B120A0,5-UV | TeO ₂ | 400-450 | 0,5 x 17,5 | 230+/-60 | Linear | 500 | 11,4@400nm | > 50 |
| DT230-B120A0,5-VIS | TeO ₂ | 450-670 | 0,5 x 17,5 | 230+/-60 | Linear | 500 | 15@532nm | > 50 |

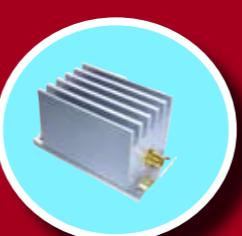
Low resolution

| Model | Material | Wavelength nm | Aperture mmxmm | Freq (Shift) MHz | Polarisation | Resolution T.ΔF | Deflexion angle range mrd | Efficiency % |
|---------------------------------|------------------|---------------|----------------|------------------|---------------|-----------------|---------------------------|--------------|
| MQ200-B30A1.5-244.266-Br | Fused Silica | 244-266 | 1.5 x 2 | 200+/-15 | Linear | 5 | 1,3@266nm | > 60 |
| MQ110-B30A1-UV | Fused Silica | 325-425 | 1 x 2 | 110+/-15 | Linear | 10 | 1.8@355nm | > 60 |
| MT200-B50A0,5-400.442 | TeO ₂ | 400-442 | 0,5 x 2 | 200+/-25 | Linear/random | 23 | 5,4 @458nm | > 80 |
| MT200-B100A0,5-VIS | TeO ₂ | 450-700 | 0,5 x 2 | 200+/-50 | Linear/random | 47 | 12,6@532nm | > 60@633nm |
| MT110-B50A1-VIS | TeO ₂ | 450-700 | 1 x 2 | 110+/-25 | Linear/random | 23 | 6,3@532nm | > 60@633nm |
| MT110-B50A1,5-VIS | TeO ₂ | 450-700 | 1,5 x 2 | 110+/-25 | Linear/random | 23 | 6,3@532nm | > 60@633nm |
| MT80-B30A1-VIS | TeO ₂ | 450-700 | 1 x 2 | 80+/-15 | Linear/random | 14 | 3,8@532nm | > 65 |
| MT80-B30A1,5-VIS | TeO ₂ | 450-700 | 1,5 x 2 | 80+/-15 | Linear/random | 14 | 3,8@532nm | > 65 |
| MT200-B100A0,5-800 | TeO ₂ | 750-950 | 0,5 x 2 | 200+/-50 | Linear/random | 47 | 18,6 @785nm | > 60 |
| MT200-B40A1-800 | TeO ₂ | 750-950 | 1 x 2 | 200+/-20 | Linear/random | 19 | 7,4 @800nm | > 70@785nm |
| MT350-B120A0,12-800 | TeO ₂ | 750-950 | 0,2 x 1 | 350+/-60 | Linear/random | 28 | 22,8@800nm | > 60 |
| MT250-B100A0,5-800 | TeO ₂ | 750-950 | 0,5 x 2 | 250+/-50 | Linear/random | 47 | 19@800nm | > 60 |
| MT200-B100A0,5-800 | TeO ₂ | 750-950 | 0,5 x 2 | 200+/-50 | Linear/random | 47 | 19@800nm | > 60@785nm |
| MT110-B50A1-IR | TeO ₂ | 700-1100 | 1 x 2 | 110+/-25 | Linear/random | 23 | 9,5@800nm | > 60@785nm |
| MT110-B50A1,5-IR | TeO ₂ | 700-1100 | 1,5 x 2 | 110+/-25 | Linear/random | 23 | 9,5@800nm | > 60@785nm |
| MT80-B30A1-IR | TeO ₂ | 700-1100 | 1 x 2 | 80+/-15 | Linear/random | 14 | 5,7@800nm | > 70@785nm |
| MT80-B30A1,5-IR | TeO ₂ | 700-1100 | 1,5 x 2 | 80+/-15 | Linear/random | 14 | 5,7@800nm | > 70@765nm |
| MT200-B100A0,5-1064 | TeO ₂ | 980-1100 | 0,4 x 2 | 200+/-50 | Linear/random | 47 | 25,3@1064nm | > 35 |
| MT200-B100A0,2-1064 | TeO ₂ | 980-1100 | 0,2 x 1 | 200+/-50 | Linear/random | 47 | 25,3@1064nm | > 60 |
| MT110-B50A1-1064 | TeO ₂ | 980-1100 | 1 x 2 | 110+/-25 | Linear/random | 23 | 12,6@1064nm | > 55 |
| MT110-B30A1,5-1064 | TeO ₂ | 960-1100 | 1,5 x 2 | 110+/-15 | Linear/random | 14 | 7,6@1064nm | > 60 |
| MT80-B30A1-1064 | TeO ₂ | 980-1100 | 1 x 2 | 80+/-15 | Linear/random | 14 | 7,6@1064nm | > 65 |
| MT80-B30A1,5-1064 | TeO ₂ | 980-1100 | 1,5 x 2 | 80+/-15 | Linear/random | 14 | 7,6@1064nm | > 65 |

* Designed for a single line in the range 350-1600 nm



Focus on



Power Amplifiers & Variable Frequency sources

Associated RF drivers for Deflectors & Agile Frequency Shifters

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.



DDS drivers

(Direct Digital Synthesizer)

To get a high resolution driver with fast switching time, AA has designed direct digital synthesizers 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.



DRFA10Y-XX

Frequency range

Adapted at factory to AO device
Max 50-110, 60-150, 90-210, 150-300, 200-350 MHz
(Other on request)

Frequency control

0-10 V / 10 Kohms

Modulation Input

0-5 V / 50 Ohms

Sweeping Time

$\leq 1 \mu\text{s}$

Power Supply

24VDC or 110-230 VAC

Output RF Power

Nominal 0 dBm (to be matched with AA power amplifier)

--> On request DRFA1.5Y 85-135 MHz, sweeping time 150 ns

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 |

DDSPA-XX

Frequency range

Max 10-350 MHz (400 MHz on request)

Frequency control

15, 23 or 31 bits (1 bit E/D)

Frequency Step

15 KHz, 60 Hz, 0.25 Hz

Modulation Input

0-5 V / 50 Ohms (8 bits on request)

Access Time

40, 64, 80 ns

Power Supply

24VDC or 110-230 VAC

Output RF Power

Nominal 0 dBm (to be matched with AA power amplifier)

--> On request USB Controller for PC, designed to drive 1 or 2 DDSPA through USB port (Windows XP/NT)

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.





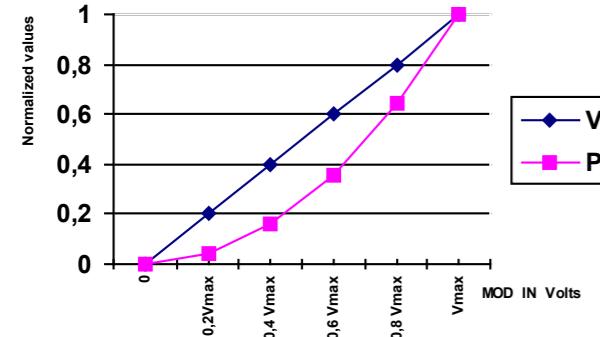
Acousto-optic

RF Drivers

Output RF power

The output RF power PRF through a 50Ω 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)

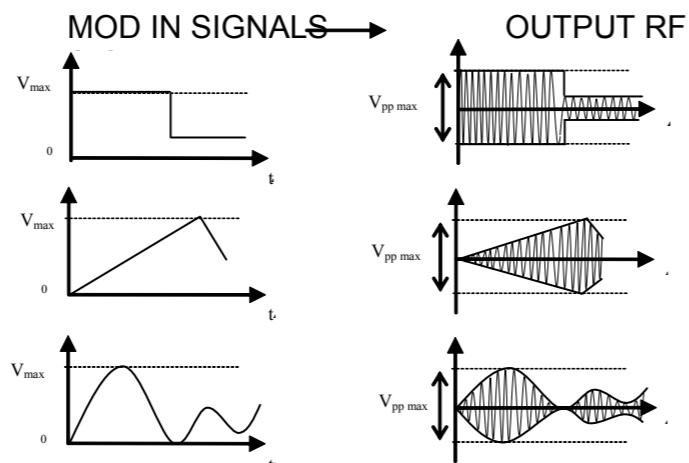
The analog modulation input of your driver controls linearly and continuously the output RF amplitude of the signal from 0 to maximum level.

- When applying 0 V on "MOD IN", no output signal

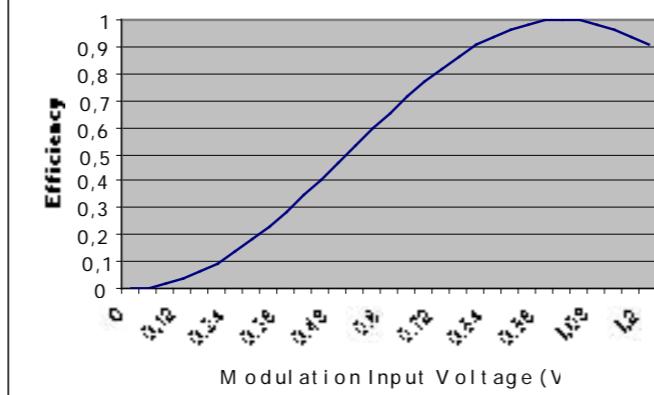
- When applying Vmax on "MOD IN", maximum output signal level

The output RF waveform is a double-sideband amplitude modulation carrier.

Vmax can be adjusted at factory from 1 V to 10 V.



AOM Response versus input voltage
(Video In)



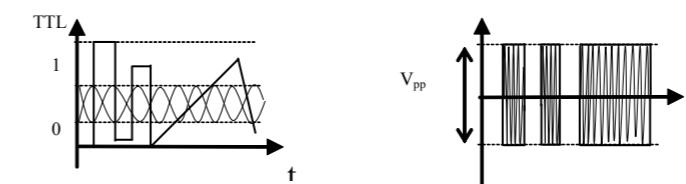
TTL MODULATION (ON/OFF)

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 a "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.



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.

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

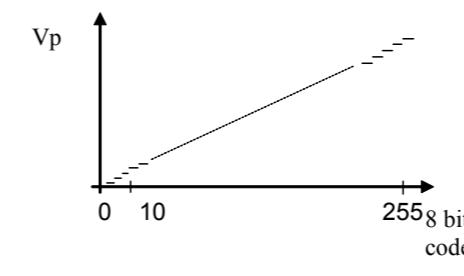
FREQUENCY CONTROLS

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 "OFFSET" and "GAIN".

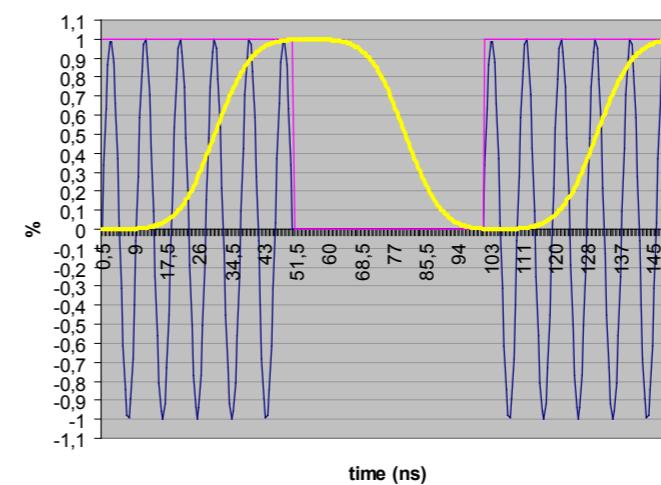
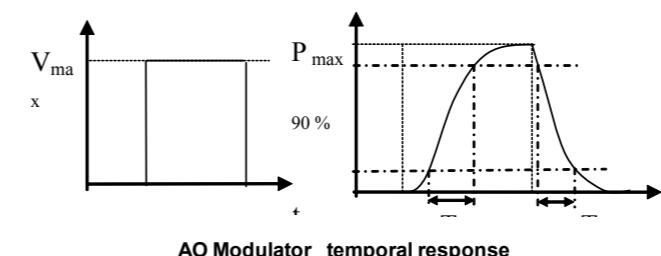
The typical linearity of the frequency versus input command for standard VCOs is typically +/- 5%.



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.

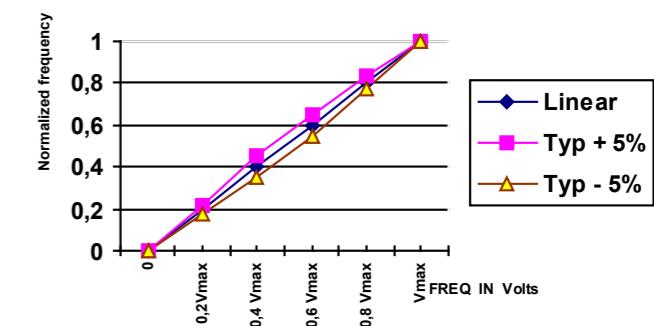
The class A drivers from AA, offer the best rise/fall time performances.



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 / 1KΩ).



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



Focus on



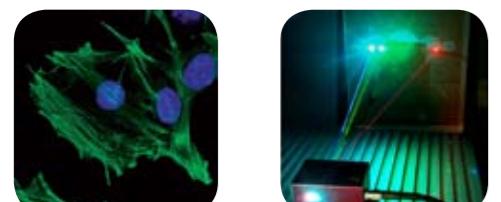
POLYCHROMATIC MODULATORS & Associated RF drivers

The AOTFnC is a special acousto-optic tunable filter which uses the anisotropic interaction inside a tellurium dioxide crystal to control 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 AOTFnC 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 mm ² | 3 x 3 mm ² | 3 x 3 mm ² | 3 x 3 mm ² |
| 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 ³ |
| Operating temperature | 10 to 40 °C |

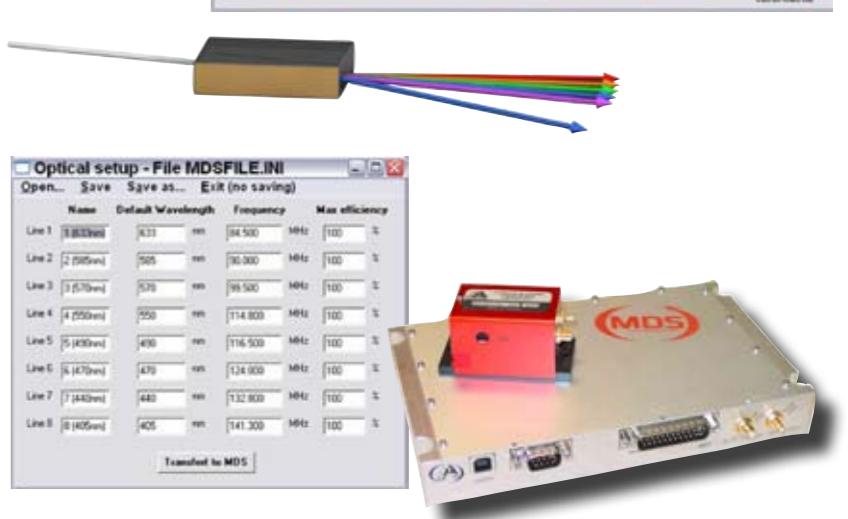
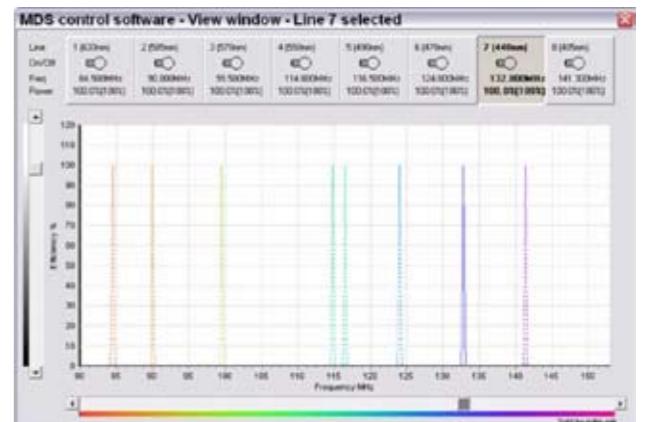
*Available as fiber pigtailed versions

| | |
|----------------------------|---|
| Power Supply | OEM version : 24 VDC - nom 0,85 A Laboratory version : 110/230 VAC - 50Hz |
| 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 |

MDSnCxx

| | |
|---------------------------------|---|
| 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 KΩ or Analog 0-10 V / 10 KΩ |
| Blanking input Control | Analog 0-5 V or Analog 0-10 V / 10 KΩ (optionTTL) |

Multiline modulation



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).



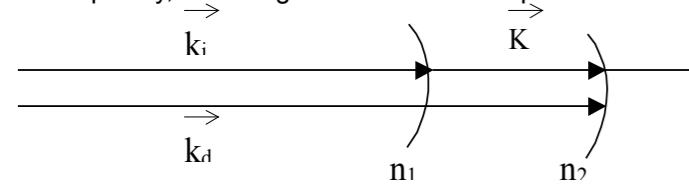
Acousto-optic

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 proportional 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:

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

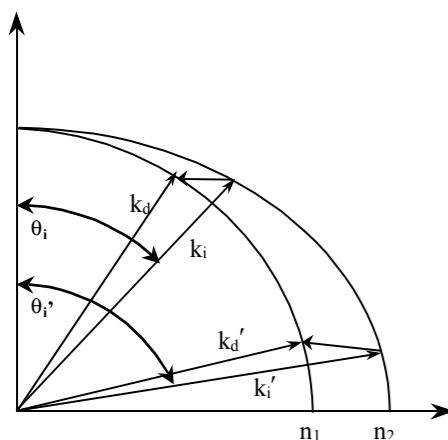
A good resolution ($\lambda_0/\Delta\lambda_0$ high) imposes a large dimension (D) of the light beam. The numerical aperture of such systems is thus obligatorily very low and thus their utilization is very limited. The collinear anisotropic interaction makes it possible to tune the filter by simple variation of the acoustic frequency, under significant numerical aperture:



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

(collinear AOTF efficiency)

The non collinear anisotropic interaction, is also usable under a high angle of incidence ($\Theta_i > 10^\circ$). This last configuration allows the use of materials with high figure of merit coefficients. (TeO₂)

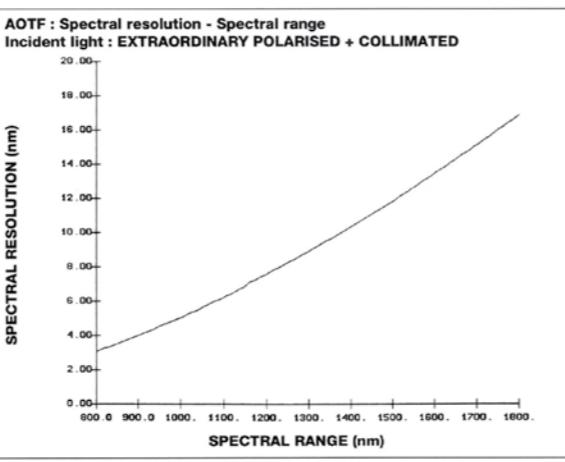
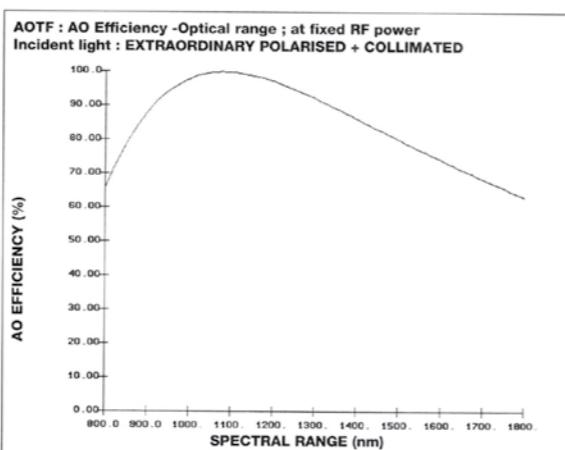
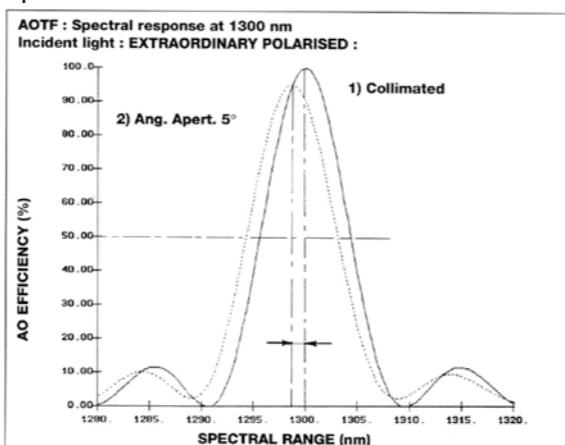


One can show that a large angular aperture is possible as long as the tangents at the point of incidence and synchronism are parallel (the light rays are then parallel in the crystal)

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 ($\Delta\lambda$).

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

Dn: birefringence($=|n_2 - n_1|$)
a and b are parameters which depends of Θ_i and Θ_d
Examples:



AOTF - Tunable Filters

Application example

Confocal Microscopy



Confocal microscopy is an imaging technique used to increase 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.

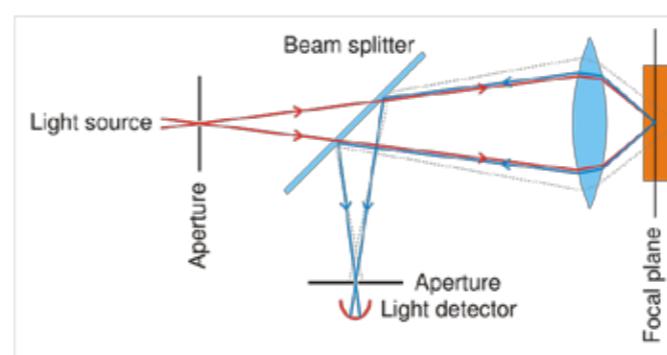


IMAGE FORMATION

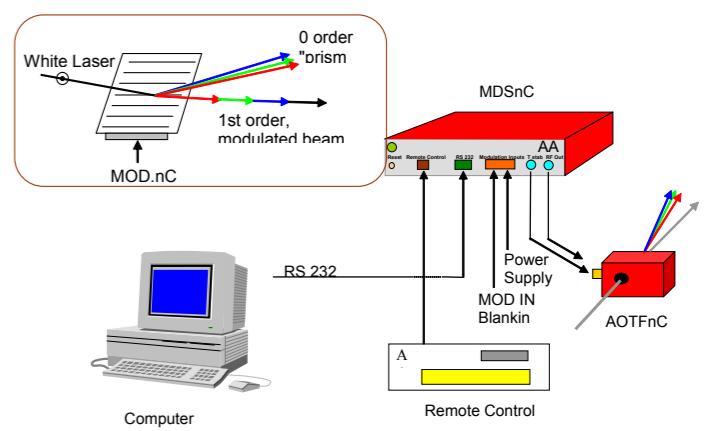
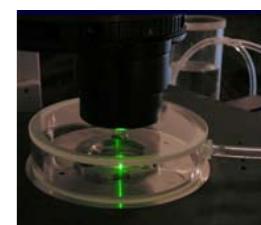
In a laser scanning confocal microscope a laser beam passes a light source aperture and then is focused by an objective lens into a small (ideally diffraction-limited) focal volume within a fluorescent specimen. A mixture of emitted fluorescent light as well as reflected laser light from the illuminated 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 photo-detection 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 fluorescence 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).





Focus on



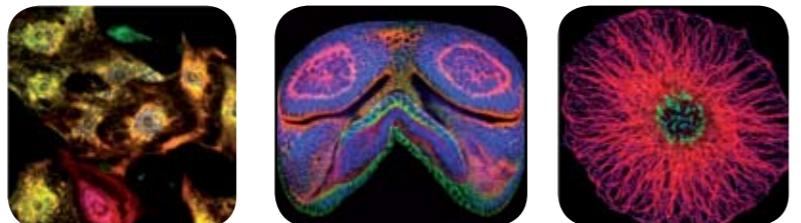
AO TUNABLE FILTERS & Fiber Pigtailed AOTF

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 μ s), accurate and procures high extinction ratio.

AA proposes 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).

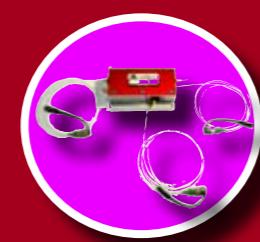
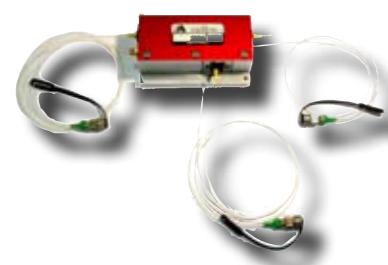


FIBER PIGTAILED AOTF

| 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 |



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.



Focus on



FIBER PIGTAILED Devices - AOMs, QST, Shifters

| Model | Wavelength*** nm | Fibre Type | Configuration | Freq (Shift) MHz | Rise Time ns | Max Laser Power W | Losses nom dB |
|---------------------------|---------------------|---------------|----------------------------|---------------------|-----------------|----------------------|------------------|
| MT180-G430-Fio-MM | 532 | Multimode | 2 ports* | 180 | 430 | 0.5 | 3 |
| MT200-B9-Fio | 400-480 | SM, PM | 2 ports* | 200 | 9 | 0.1 | 4 |
| MT200-BG(9-18)-Fio | 480-630 | SM, PM | 2 ports* | 200 | 9, 18 | 0.5 | 3 |
| MT200-R(9-18)-Fio | 630-700 | SM, PM | 2 ports* | 200 | 9, 18 | 0.5 | 3 |
| MT80-NIR60-Fio | 780-870 | SM, PM | 2 ports* | 80 | 60 | 0.5, 5 | 2 |
| MT200-NIR10-Fio | 780-870 | SM, PM | 2 ports* | 200 | 10 | 0.5 | 3.5 |
| MT80-IR60-Fio | 1000-1100 | SM, PM | 2 ports* | 80 | 60 | 0.5, 5 | 2 |
| MT110-IR20-Fio | 1000-1100 | SM, PM | 2 ports* | 110 | 20 | 0.5, 5 | 2.5 |
| MT200-IR10-Fio | 1000-1100 | SM, PM | 2 ports* | 200 | 10 | 0.5, 5 | 3 |
| MT250-IR6-Fio | 1000-1100 | SM, PM | 2 ports* | 250 | 6 | 0.5 | 3.5 |
| MT110-IR25-Fio-HP | 1000-1100 | SM, PM | 2 ports + 0 order absorber | 110 | 25 | 5 to 8 | 2.5 |
| MT110-IR25-3Fio | 1000-1100 | SM, PM | 3 ports* | 110 | 25 | 0.5, 5 | 2.5 |
| MT80-IIR60-Fio | 1300, 1550 | SM, PM | 2 ports* | 80 | 60 | 0.5, 5 | 2.5 |
| MT110-IIR20-Fio | 1300, 1550 | SM, PM | 2 ports* | 110 | 20 | 0.5, 5 | 3.5 |
| MT160-IIR10-Fio | 1300, 1550 | SM, PM | 2 ports* | 160 | 10 | 0.5, 5 | 4 |
| MA40-IIR120-Fio | 1300, 1550 | SM, PM | 2 ports* | 40 | 120 | 0.5 | 2 |
| MT110-IIR25-Fio | 1300, 1550 | SM, PM | 3 ports** | 110 | 25 | 0.5, 5 | 3.5 |

*2 Ports: INPUT -pigtailed + 1st Order OUTPUT pigtailed
On request: INPUT -pigtailed + 0 Order OUTPUT pigtailed

**3 Ports: INPUT + 0 order + 1st order pigtailed

**All fiber pigtailed devices are optimized at factory for a single wavelength

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 continuous 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 double-clad 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.





Acousto-optic

Q-SWITCHES

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.

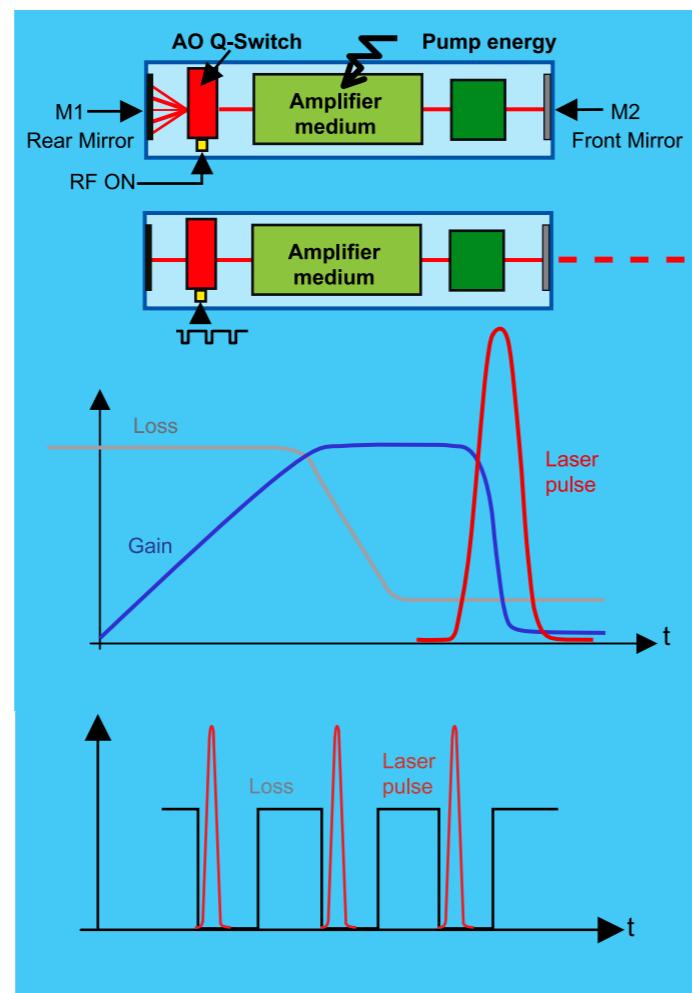
Q-Switching

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 synchro 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 be 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).

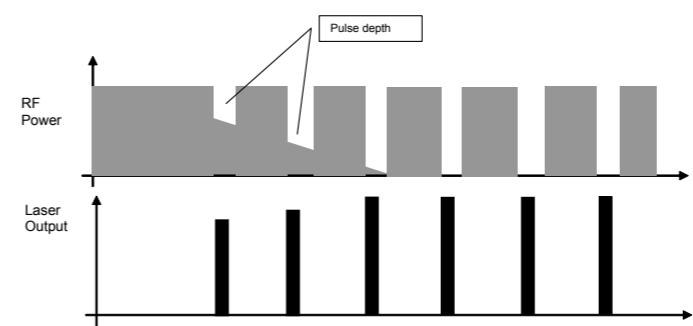
For this reason, user may have to dissipate or suppress the excess of energy of the first pulses. This can be achieved in controlling with a special sequence the Q-switch thanks to the provided RF driver.

General methods to suppress Giant First Pulse

FPS: First Pulse Suppression

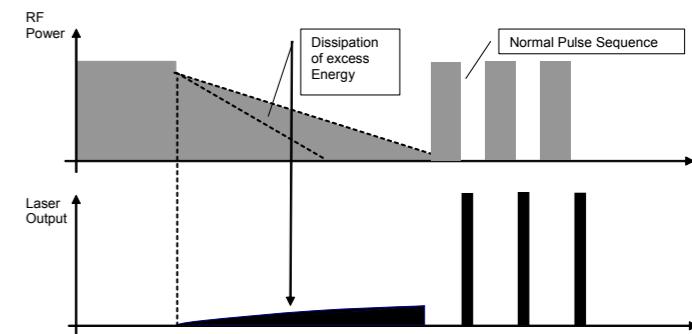
With this method, the pulse depth of the Q-Switch is controlled and limited so as to not open completely the cavity, and thus allow limited Energy to get out of the cavity.

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-switch with two states :

- No losses (TTL=0)= No RF power applied on Q-switch = Laser pulse can evolve
- 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 \Rightarrow Output RF Power = 0 whatever is FAC input (0 or 5 V)
 - If TTL (DPC) = 1 \Rightarrow 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 leakage. 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 \Rightarrow Output RF Power = 0 if PAC=0V Maximum if PAC = 5V, Xx versus PAC input
 - If TTL (DPC) = 1 \Rightarrow Output RF Power = Max whatever is PAC input (0 or 5 V)



Focus on



Q-SWITCHES

and associated RF Drivers



RF Drivers for Q-Switches

| Carrier Frequency MHz | Max RF Power W | Rise Fall/ Time ns | Controls | Extinction Ratio dB | Security Measurement | Power Supply | Class |
|-----------------------|----------------|--------------------|----------|---------------------|----------------------|--------------|-------|
|-----------------------|----------------|--------------------|----------|---------------------|----------------------|--------------|-------|

QMOPD0xx - 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 |
|----------------------------|----------|------|---------------------|----|----|---------------------|---|



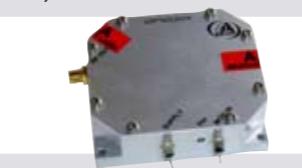
QMOPD1xx - Compact Solution 20, 30, 70 Watts

| | | | | | | | |
|----------------------------|----------------|----------------------|-------------------------|----|---|--------|---|
| 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 |
|----------------------------|----------------|----------------------|-------------------------|----|---|--------|---|



QMOPD2xx - 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 |
|----------------------------|---------------|----------------------|-----|----|----|-----------------|---|



QMOPD3xx - 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 |
|----------------|-----|------|-------------------------|----|---|----------------|---|



QMOPD4xx - 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 |
|----------------------------|------------------|------|-------------------------|----|---|------------------|---|



Air-cooled Q-Qwatches: Compact solutions for short cavities, or low gain cavities

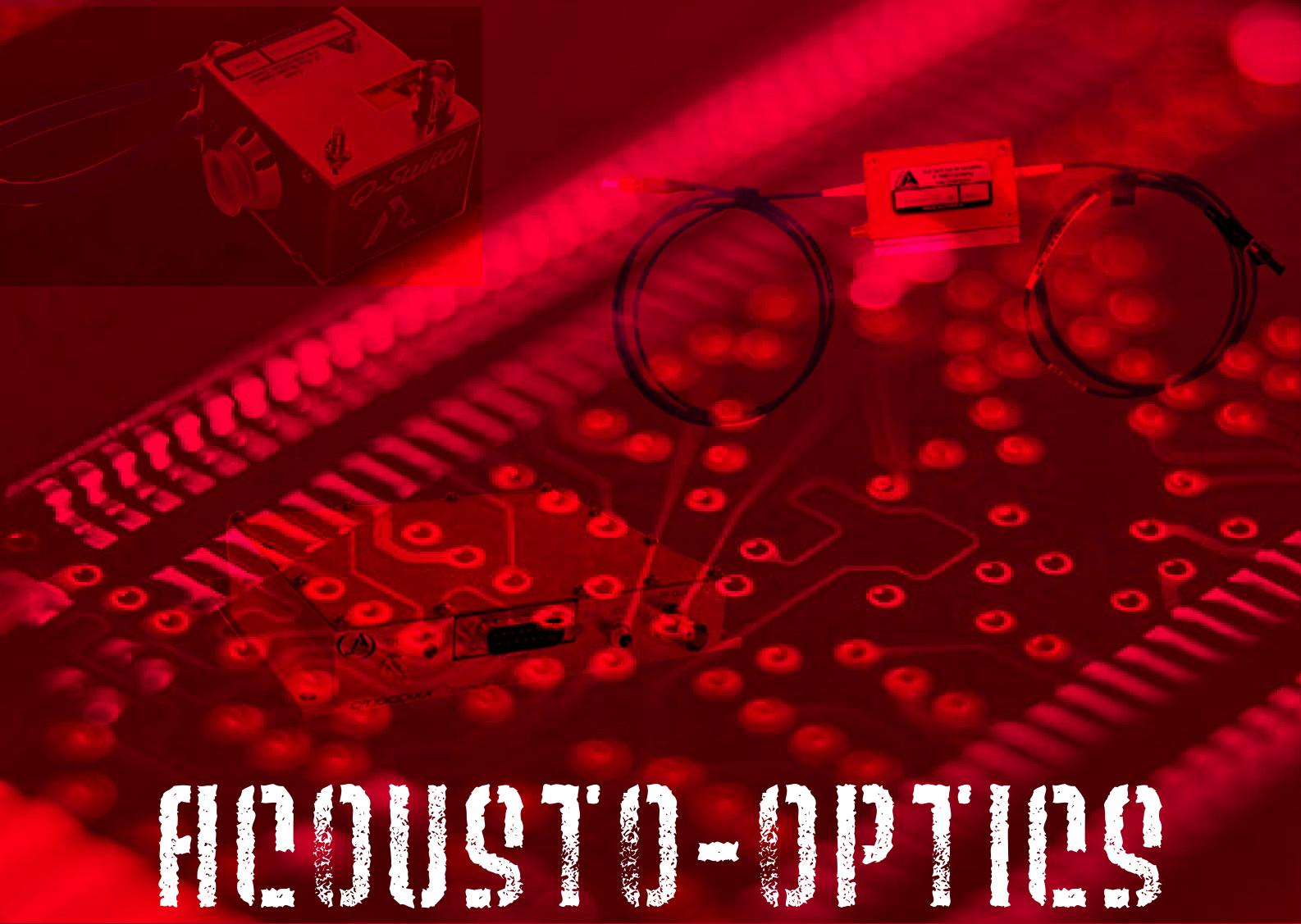
| Model | Material | Polarization | Carrier Freq. MHz | Aperture mm x mm | Losses % | Optional Length mm |
|-------------------------|--------------|--------------|-------------------|------------------|----------|--------------------|
| QS80-A0.7-L1064 | Fused silica | Linear | 80 | 0.7 x 1 | > 60 | 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 | 1 x 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 | Losses % | 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.





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