Sintec Optronics

Pockels Cells (EO Q-switches)

Technical Overview

The Electro-Optic Effect

The linear electro-optic effect, also known as the Pockels effect, describes the variation of the refractive index of an optical medium under the influence of an external electrical field. In this case certain crystals become birefringent in the direction of the optical axis which is isotropic without an applied voltage.

When linearly polarized light propagates along the direction of the optical axis of the crystal, its state of polarization remains unchanged as long as no voltage is applied. When a voltage is applied, the light exits the crystal in a state of polarization which is in general elliptical.

In this way phase plates can be realized in analogy to conventional polarization optics. Phase plates introduce a phase shift between the ordinary and the extraordinary beam. Unlike conventional optics, the magnitude of the phase shift can be adjusted with an externally applied voltage and a $\lambda/4$ or $\lambda/2$ retardation can be achieved at a given wavelength. This presupposes that the plane of polarization of the incident light bisects the right angle between the axes which have been electrically induced. In the longitudinal Pockels effect the direction of the light beam is parallel to the direction of the electric field. In the transverse Pockels cell they are perpendicular to each other. The most common application of the Pockels cell is the switching of the quality factor of a laser cavity.

Q-Switching

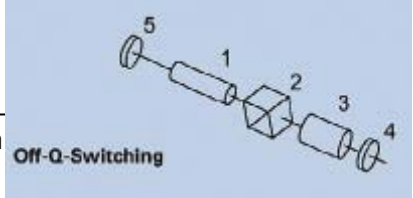
Laser activity begins when the threshold condition is met: the optical amplification for one round trip in the laser resonator is greater than the losses (output coupling, diffraction, absorption, scattering). The laser continues emitting until either the stored energy is exhausted, or the input from the pump source stops. Only a fraction of the storage capacity is effectively used in the operating mode. If it were possible to block the laser action long enough to store a maximum energy, then this energy could be released in a very short time period.

A method to accomplish this is called Q-switching. The resonator quality, which represents a measure of the losses in the resonator, is kept low until the maximum energy is stored. A rapid increase of the resonator quality then takes the laser high above threshold, and the stored energy can be released in a very short time. The resonator quality can be controlled as a function of time in a number of ways. In particular, deep modulation of the resonator quality is possible with components that influence the state of polarization of the light. Rotating the polarization plane of linearly polarized light by 90°, the light can be guided out of the laser at a polarizer. The modulation depth, apart from the homogeneity of the 90° rotation, is only determined by the degree of extinction of the polarizer.

The linear electro-optical (Pockels) effect plays a predominant role besides the linear magneto-optical (Faraday) and the quadratic electro-optical (Kerr) effect. Typical electro-optic Q-switches operate in a so called $\lambda/4$ mode.

a) Off Q-Switching

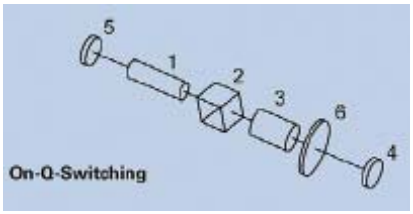
Light emitted by the laser rod (1) is linearly polarized by the polarizer



(2). If a λ/4 voltage is applied to the Pockels cell (3), then on exit, the light is circularly polarized. After reflection from the resonator mirror (4) and a further passage through the Pockels cell, the light is once again polarized, but the plane of polarization has been rotated by 90°. The light is deflected out of the resonator at the polarizer, but the resonator quality is low and the laser does not start to oscillate. At the moment the maximum storage capacity of the active medium has been reached, the voltage of the Pockels cell is turned off very rapidly; the resonator quality increases immediately and a very short laser pulse is emitted. The use of a polarizer can be omitted for active materials which show polarization dependent amplification (eg. Nd:YalO3, Alexandrite, Ruby, etc.).

b) On Q-Switching

Unlike off Q-switching, a λ/4 plate (6) is used between the Pockels cell (3) and the resonator mirror (4). If no voltage is applied to the Pockels cell the laser resonator is blocked: no laser action takes place. A voltage pulse opens the resonator and permits the emission of laser light.



Pulse Picking

Typically Femto-Second-Lasers emit pulses with a repetition rate of several 10MHz. However many applications like regenerative amplifying require slower repetition rates. Here a Pockels cell can be used as an optical switch: by applying ultra fast and precisely timed λ/2-voltage pulses on the Pockels cell, the polarization of the Laser light can be controlled pulse wise. Thus, combined with a polarizer the Pockels cell works as an optical gate.

Selection Criteria

The selection of the correct Q-switch for a given application is determined by the excitation of the laser; the required pulse parameters, the switching voltage, the switching speed of the Pockels cell, the wavelength, polarization state and degree of coherence of the light.

Type of Excitation

Basically, both off and on Q-switching are equivalent in physical terms for both cw and for pulse pumped lasers. On Q-switching is, however, recommended in cw operation because a high voltage pulse and not a rapid high voltage switch-off is necessary to generate a laser pulse. This method also extends the life time of the cell. Over a long period of time, the continuous application of a high voltage would lead to electrochemical degradation effects in the KD*P crystal. We advice the use of an on Q-switching driver. Off Q-switching is more advantageous for lasers stimulated with flash lamps because the λ/4 plate is not required. In order to prevent the electrochemical degradation of the KD*P crystal in the off Q-switching mode we recommend a trigger scheme in which the high voltage is turned off between the flashlamp pulses and turned on to close the laser cavity before the onset of the pump pulse. The cell CPC and SPC series are recommended for diode pumped solid state lasers. These cells are ultra compact and will operate in a short length resonator: this is necessary to achieve very short laser pulses.

Pulse Parameters

The series LM n, LM n IM, and LM n SG cells are recommended for lasers with a power density of up to 500MW/cm². The LM n and LM n SG cells are used for lasers with very high amplification. The SG cells with sol-gel technology have the same transmission as the immersion cells and both are typically used when a higher transmission is required. At high pulse energies LMx cells are preferred.

Brewster Pockels cells are recommended for lasers with low amplification, such as Alexandrite lasers. The passive resonator losses are minimal due to a high transmission of 99%.

The CPC and SPC series cells are suitable for small, compact lasers and especially for OEM applications. They are available as dry cells and immersion cells.

The level of deuterium content in an electro-optic crystal influences the spectral position of the infrared edge. The higher the deuterium level the further the absorption edge is shifted into the infrared spectral region: for Nd:YAG at 1064nm, the laser absorption decreases. Crystals, which are deuterated to >98%, are available for lasers with a high repetition rate or a high average output power.

Pockels Cell Switching Voltage

Using double Pockels cells can half the switching voltage. This is achieved by switching two crystals electrically in parallel and optically in series. The damage threshold is very high and the cells are mainly

used outside the resonator.

Electro Optic Material
The selection of the electro-optic material depends on its transmission range. Further on the Laser parameters and the application as well have to be taken into account.

For wavelengths from 0.25µm to 1.1µm, longitudinal Pockels cells made of KD*P and a deuterium content of 95% should be considered. If the deuterium content is higher the absorption edge of the material is shifted further into the infrared. KD*P crystal cells with a deuterium content >98% can be used up to 1.3µm.

KD*P can be grown with high optical uniformity and is therefore recommended for large apertures. The spectral window of BBO also ranges from 0.25µm to 1.3µm, but besides BBO also provides a low dielectric constant and a high damage threshold. Therefore BBO is recommended for Lasers with high repetition rate and high average powers. RTP, with an optical bandwidth from 0.5µm up to 1.5µm combines low switching voltage and high laser induced damage threshold. Together with its relative insensitivity for Piezo effects RTP is best suited for precise switching in high repetition rate lasers with super fast voltage drivers.

For wavelengths from 1.5µm up to 3µm we recommend LiNbO3.

Suppression of Piezo Effects
Like any other insulating material electro optical crystals show Piezo effects when high voltage is applied. The extend of the Piezo ringing depends on the electro optic material and usually its effect on the extinction ratio is negligible when used for Q-switching. However for pulse picking applications, which require highly precise switching behaviour, we offer specially Piezo damped Pockels cells which suppress these ringing effects efficiently.

State of Polarization
The MIQS and CIQS series cells are supplied with an integrated polarizer: the alignment of the Pockels cell relative to the polarizer thus becomes unnecessary. The rotational position of the cell relative to the resonator axis can be chosen at will. However, should the polarization state of the light in the resonator be determined by other components, such as anisotropic amplification of the laser crystal or Brewster surfaces of the laser rod, then the rotational position of the cell will be determined by these factors. Thin film polarizers are used and the substrate is mounted at the Brewster angle. A parallel beam displacement of 1mm results from this configuration and can be compensated by adjusting the resonator.

Pockels Cell (EO Q-switch, Electro-optic Q-switch)

A Pockels cell alters the polarization state of light passing through it when an applied voltage induces birefringence changes in an electro-optic crystal such as KD*P and BBO. When used in conjunction with polarizers, these cells can function as optical switches, or laser Q-switches. Frequently, Q-switches are employed in laser cavities for the purpose of shortening the output pulse, resulting in a light beam with enhanced peak intensity. In order to provide the device best suited to your purpose, we offer the industry standard QX series, economical IMPACT cells, BBO-based LightGate, and large-aperture TX Pockels cell lines. High-speed electronic drivers properly matched to the cell produce the best results for short pulse applications.

You can operate the cell with either a pull-up voltage or a pull-down voltage. Changing the polarity will only change the direction of the phase rotation. You should not, however, operate the cell with a constant applied voltage potential between the terminals, or a duty cycle greater than ~ 2%.

1. IMPACT Series EO Q-switches

From the world leader in nonlinear materials and electro-optic devices comes the ideal Pockels cell for OEM applications, the IMPACT. Once again, we set the industry standard - and at an exceptional price. In general, it operates below 1kHz.

The IMPACT employs the finest strain-free, highly deuterated KD*P available. Ceramic apertures ensure robust performance in demanding applications. Ultra-high-damage threshold Sol Gel and dielectric AR coatings are offered for a variety of laser wavelengths. The standard pin-type connectors (superior for high-voltage applications) provide quick connections and simplified design and assembly. Conventional threaded connectors are available as an option. The IMPACT is back-filled with dry nitrogen.

Applications:

- OEM laser systems
- Medical/cosmetic lasers
- Versatile R&D laser platforms
- Military & aerospace laser systems

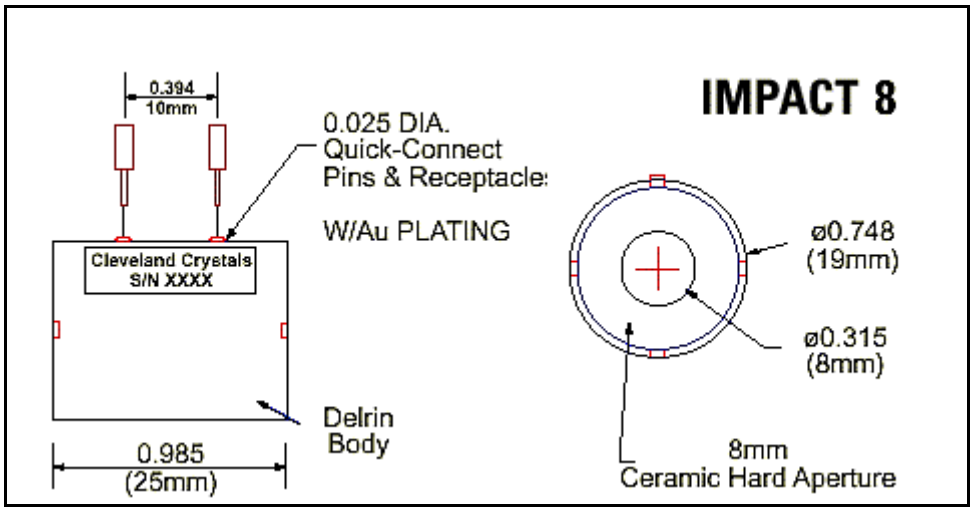
FEATURES	BENEFITS
CCI Quality - economically priced	Exceptional value
Finest strain-free KD*P	High contrast ratio High damage threshold Low 1/2 wave voltage
Single pass optical transmission	>98%
Space efficient	Ideal for compact lasers
Ceramic apertures	Clean and highly damage-resistant
High contrast ratio	Exceptional hold-off
Quick electrical connectors	Efficient/reliable installation
Ultra-flat crystals	Excellent beam propagation

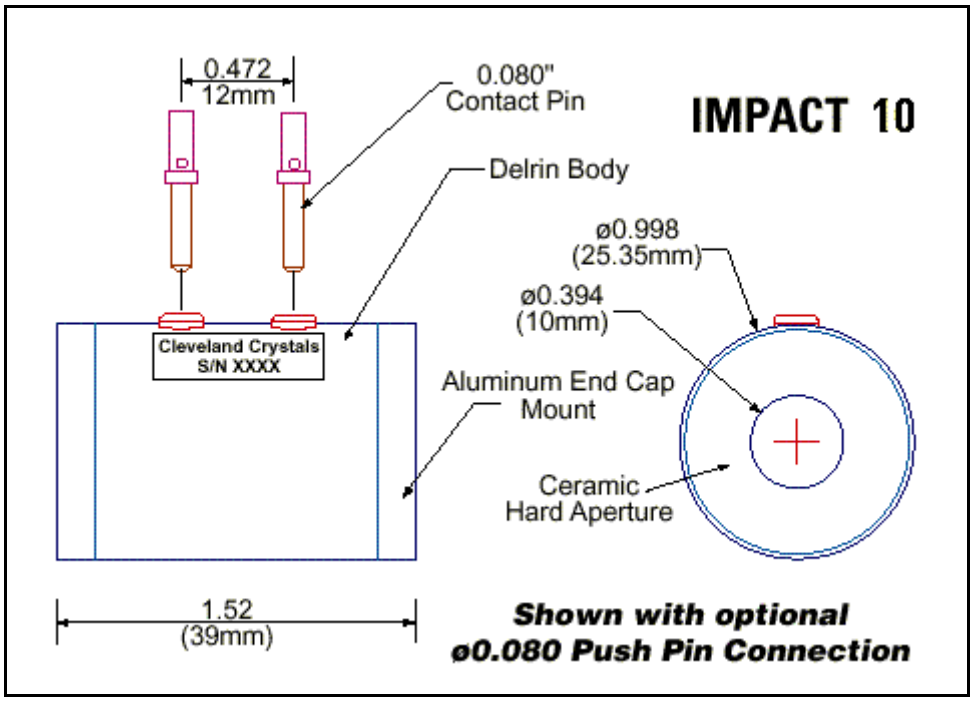
Remark:

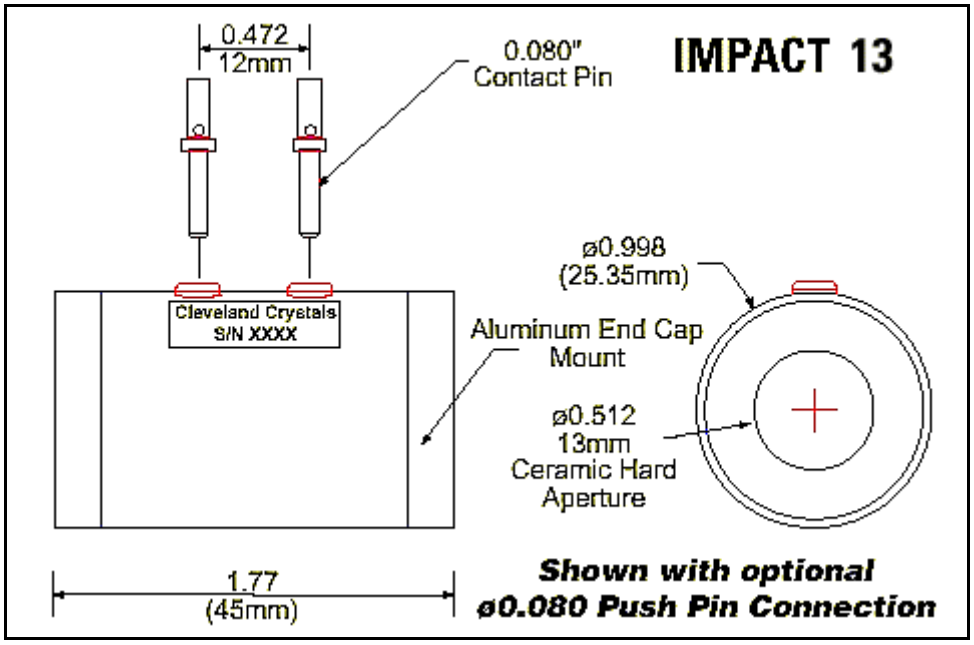
- Impact 8 standard wavelength: 1064nm & 800nm
- Impact 10/13 standard wavelength: 1064nm & 755nm
- The 1/4 wave voltage for any of our KD*P cells, @ 800nm, will be ~2.5KV, +/- 10%

Typical Specification

Electro-optical @ 1064nm			
1/4 Wave Voltage: 3.3 kV			
Transmitted Wave Front Error : <1/8 Wave			
ICR>2000:1			
VCR>1500:1			
Capacitance: 6 pF			
Sol Gel Damage Threshold @ 1064nm, 10ns pulse: 40J/cm^2			
Housing Dimensions	**IMPACT 8**	**IMPACT 10**	**IMPACT 13**
Aperture	8 mm	10 mm	13 mm
Length	25 mm	39 mm	45 mm
Diameter	19 mm	25.35 mm	25.35 mm







2. QX Series EO Q-switches

The QX series sets the standard for KD*P electro-optic Q-switches. These devices provide reliable, stable performance for a diverse range of laser applications.

We offer a unique rebuild program that extends the QX lifetime. All rebuilt units are upgraded with the latest product improvements and are returned with a new one-year warranty.

The standard configuration employs a broad band, high damage threshold Sol Gel AR coating for improved durability and performance. The QX series is also available with index matching fluid and a choice of end caps. All units are tested for optic and electric function and are supplied with a QA inspection report.

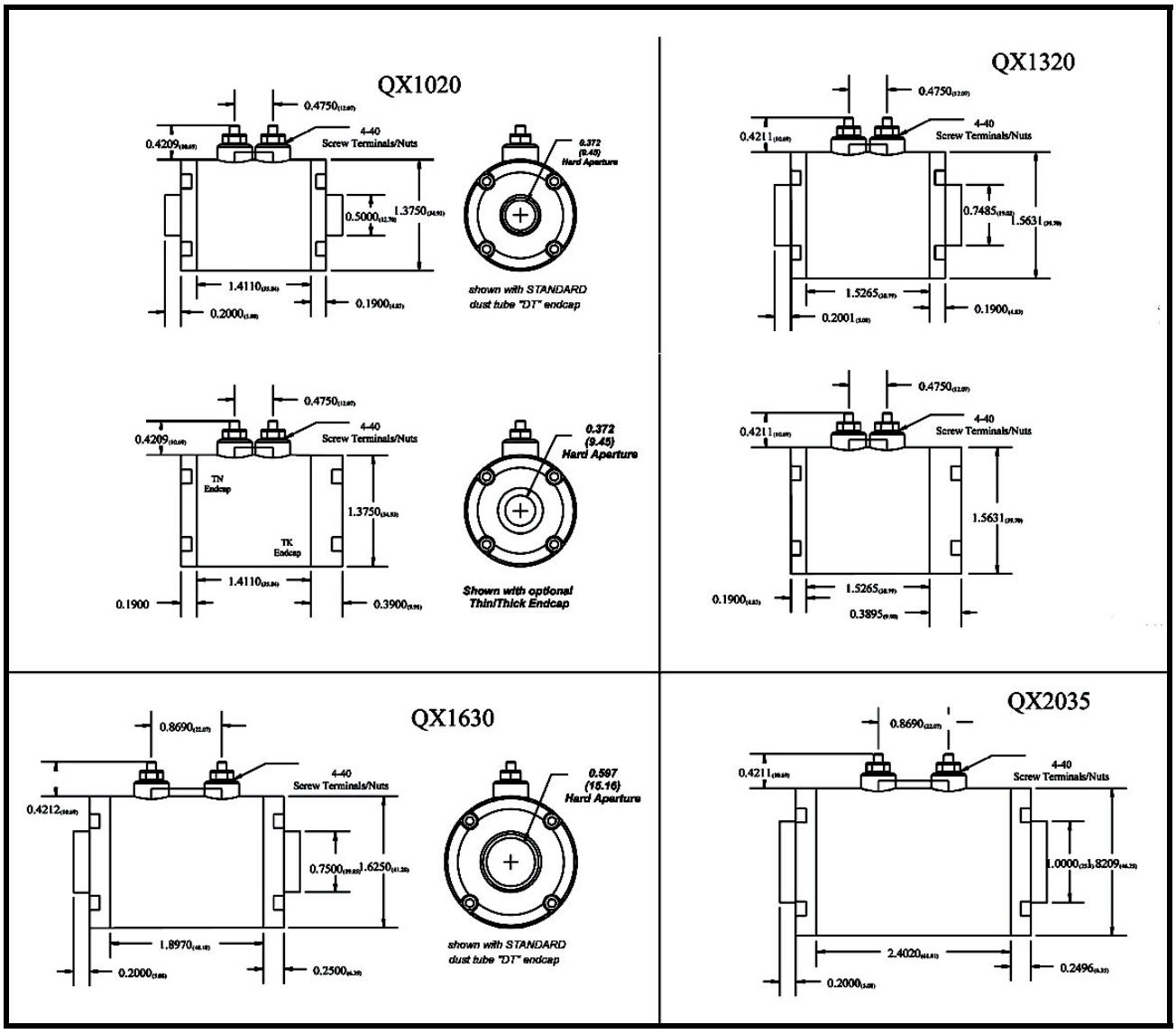
Features

- Industry-proven performance
- Dry or fluid-filled
- Highest (99.9% KD*P) deuteration levels in industry
- Adhesive/Epoxy-free assembly
- Premium UV-grade fused silica windows
- Apertures from 9.25mm diameter up to 19.5mm diameter
- Lowest absorption in industry
- High-reliability
- Economical upgrade/rebuild program
- Highest optical damage thresholds
- Accessible technical support
- Standard performance documentation
- One-year limited warranty
- Operation up to 10kHz (special order)

Performa Data

Typical Specification 99% KD*P	QX1020	QX1320	QX1630	QX2035
Physical				
Hard aperture diameter	9.25 mm	12.3 mm	15.1 mm	19.5 mm
Single Pass Insertion Loss	<1.4%	<1.4%	<1.8%	<2.0%
Voltage Contrast Ratio				
(Cross polarizers)	5000:1	4000:1	3500:1	3000:1
(Parallel polarizers)	2500:1	1500:1	1800:1	1600:1
DC Quarter wave voltage @1064nm	3.2 kV	3.5 kV	3.3 kV	3.5 kV
Single Pass Distortion @ 633nm	<λ/8	<λ/8	<λ/8	<λ/8
Electrical				
Capacitance @ 1 kHz	6pF	9pF	9pF	13pF
10-90% Rise time (50Ω line)	0.8 ns	1.1 ns	1.1 ns	1.5 ns

Note: Specifications are subject to change without notice.



3. LiNbO3 Pockels Cells

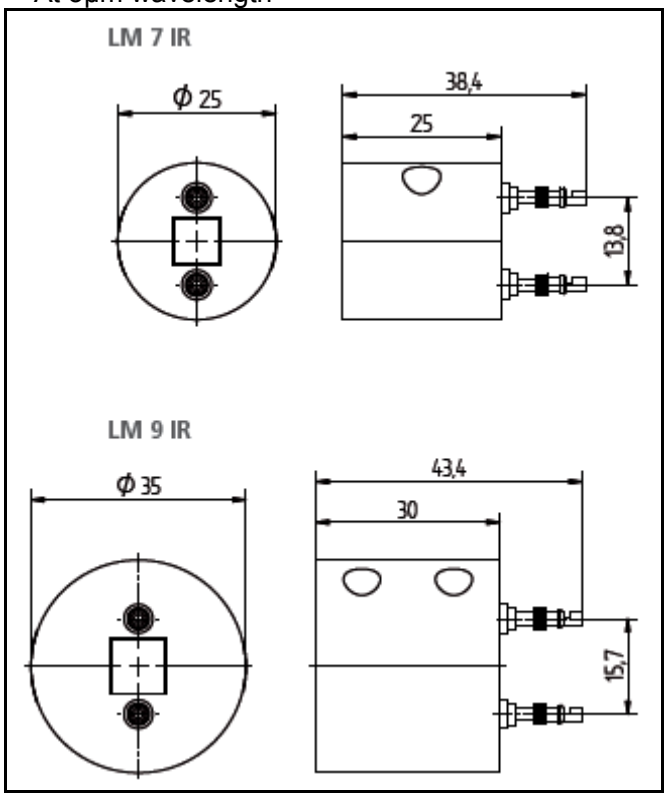
- LiNbO3-based Pockels cell
- Preferably for Er:YAG-, Ho:YAG-, Tm:YAG laser
- For wavelengths up to 3μm
- Brewster cells BPZ 5 IR for laser with low amplification
- Compact design

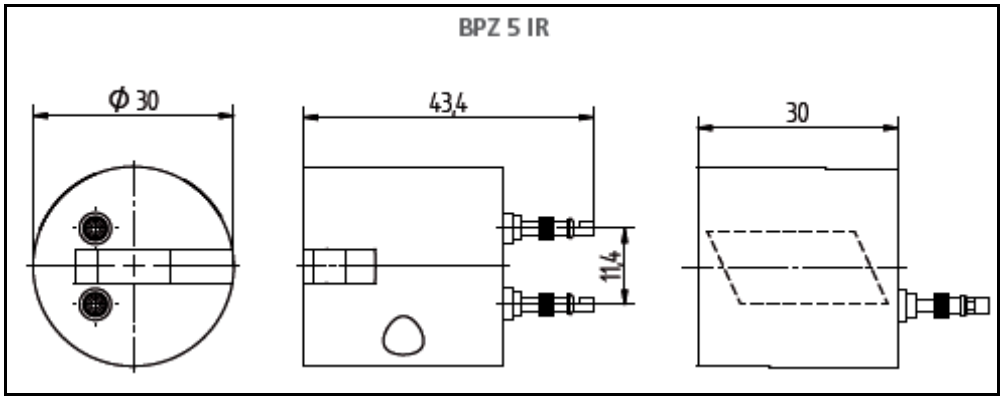
• Wave front deformation: < λ/4
• Damage threshold: > 100MW/cm2 at 1064nm, 10ns, 1Hz (typical, not guaranteed)

Please state the applied wavelength when ordering.

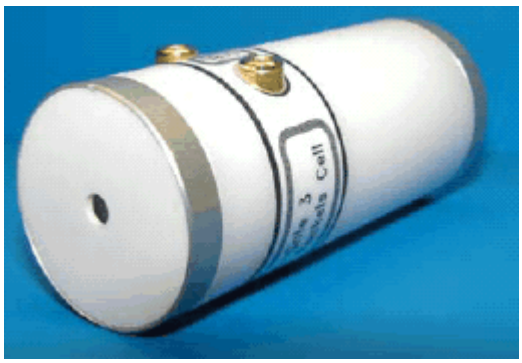
Order No.	Product	Clear Aperture (mm)	Transmission typical (%)	Extinction ratio (voltage-free)	λ/4 voltage
8450-3030-001	LM 7 IR[1)]	7,45 x 7,45	98	> 100:1	3 kV
8450-3032-001	LM 9 IR[1)]	9 x 9	98	> 100:1	3 kV
8450-3036-000	BPZ 5 IR[1)]	5 x 5	99	> 100:1	3 kV
8450-3038-000	BPZ 5 IR[2)]	5 x 5	99	> 100:1	3 kV

[1)] At 2µm wavelength
[2)] At 3µm wavelength





4. LightGate Series BBO Pockels Cell

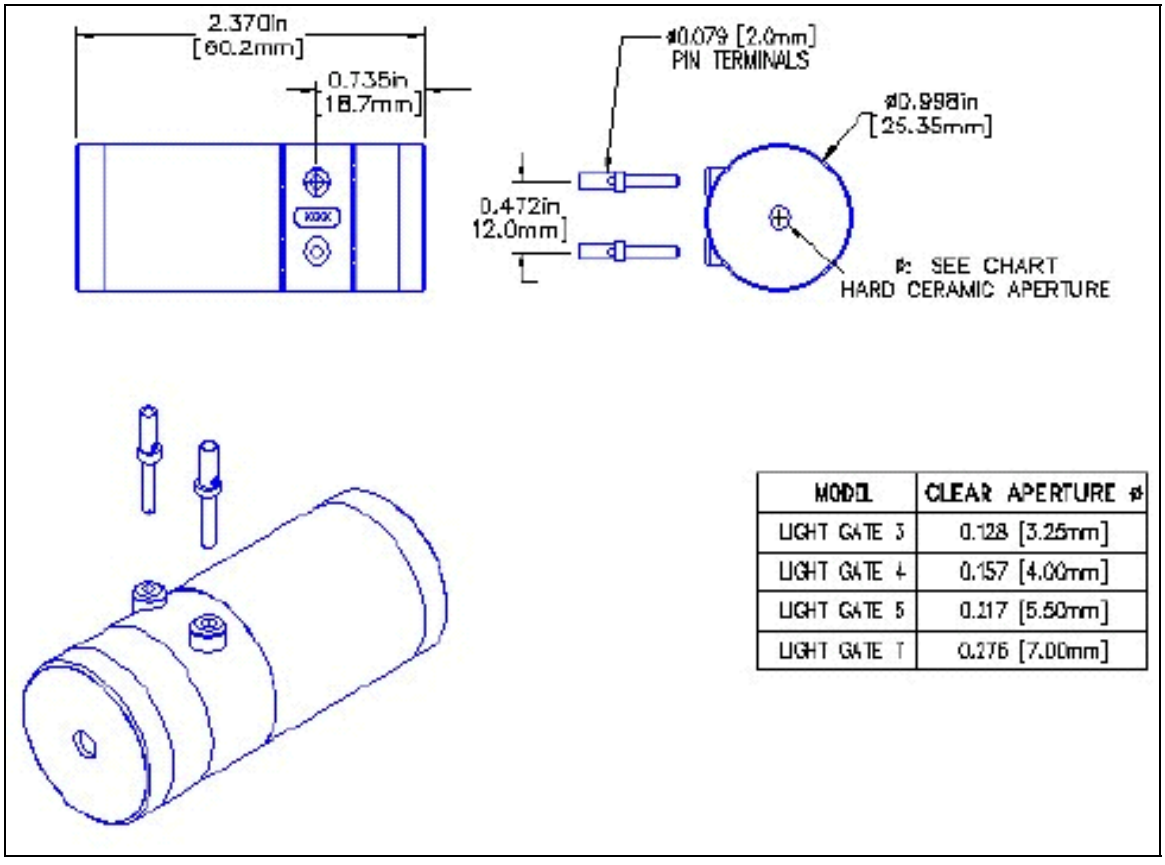


LightGate BBO Pockels cells are the preferred alternative to KD*P Pockels cells for high-average power and high repetition rate applications. The LightGate series BBO Pockels cell employs dual crystal geometry to minimize drive voltage (~3.4kV quarter-wave voltage @ 1064nm for 4mm aperture LightGate 4). BBO is transparent from approximately 0.2 to 2.1mm and is not subject to tracking degradation. It also shows low piezoelectric ringing, which is useful for repetition rates of hundreds of kilohertz. LightGate Pockels cells are useful for regenerative amplifiers and in high pulse repetition rate micro-machining lasers and high-average power lasers for material processing and metal annealing. We also offer special single crystal cells, extra-long, reduced voltage cells and cells attenuated for ultra-low ringing, for special applications.

Features:

- High Repetition Rate as high as 1MHz
- Low Acoustic Noise
- Damage Resistant Ceramic Apertures
- High Average Power Applications
- Compact design
- Q-switch and Regen-amp Applications

ICR VCR	>2500:1 >500:1
Apertures	3.25mm, 4mm, 5.5mm & 7mm
Spectral range of operation	~200-2100nm (must specify single wavelength of operation)
Single Pass Optical Transmission	>98%
DC quarter-wave Voltage	2.8KV, 3.4KV, 4.4KV & 5.4KV
Capacitance	4pF (all)
Transmitted Wavefront Error	< λ/6



5. BBO Pockels Cells

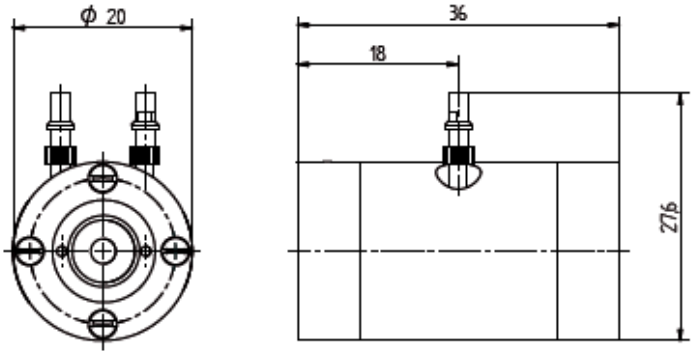
• BBO-based Pockels cell
• Suited for Q-switch applications with high repetition rates
• Wave front deformation: < λ/4
• Damage threshold: > 300MW/cm2 at 1064nm, 10ns, 1Hz (typical, not guaranteed)
• Optionally available with integrated Brewster polarizer: BBPC n BP
• Optionally available with integrated λ/4 disk: BBPC n WP
• Optionally available with Piezo attenuator: BBPC n pp

Please state the applied wavelength when ordering.

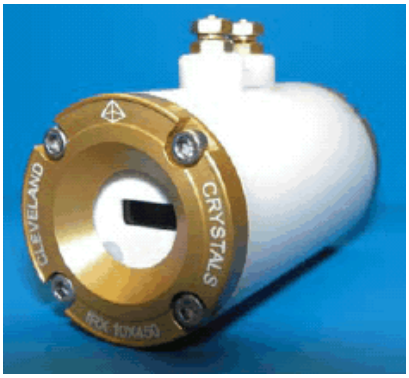
Product Number	Wavelength (nm) [1)]	Clear Aperture (mm)	Transmission typical (%)	Extinction ratio (voltage-free)	λ/4 voltage[2)]	Capacity (pF)
BBPC 3	1064	Ø 2.8	98	> 1000:1	3.6 kV	4
BBPC 4	1064	Ø 3.6	98	> 1000:1	4.8 kV	4
BBPC 5	1064	Ø 4.6	98	> 1000:1	6.0 kV	4

[1)] other wavelength available upon request. [2)] DC at 1064nm

DBBPC 4 Pockels Cell at 355nm
- BBO crystal: AR/AR coated at 355 nm
- Clear aperture: 3.6 mm
- Transmission: > 98 %
- Extinction ratio without voltage applied: > 500:1
- l/2 voltage at 355 nm: approx. 1.6 kV
- Wavefront distortion at 633 nm: l/4
- Windows: wedged, AR/AR at 355 nm



6. IRX Series CdTe Pockels Cell



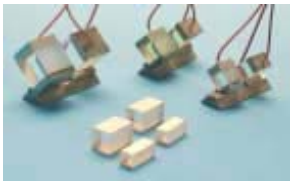
Initially designed to address the Q-switched CO2 laser market at 10.6μm, the cadmium telluride - based IRX Q-switch may be configured to operate from 3-12μm. Its' high electro-optic coefficient and non-hygroscopic nature makes CdTe well-suited for this purpose. Through more than 30 years of electro-optic device design experience, we provide IRX Pockels cells with application-specific AR coatings or Brewster-cut ends, in apertures ranging from 3mm-10mm. The IRX Pockels cells are able to address applications beyond the spectral range of traditional oxide Pockels cells.

ICR	>500:1 @ 10.6μm
Apertures	3mm, 5mm, 7mm & 4 x 10mm*
Spectral range of operation	3-12μm (must specify single wavelength of operation)
Optical transmission	>98% at 10.6μm (other wavelengths available)
DC half-wave Voltage(for nominal 5mm aperture x 50mm length)	~ 5kV** @10.6μm

* Custom aperture sizes available
** Voltage is a function of electrode spacing and crystal length and will vary with application. Voltage shown is for the 4x10mm configuration.

7. RTP Electro-optic Q-Switch

The Q-Switch is built using 2 RTP (Rubidium Titanyl Phosphate) elements in a temperature compensating design. The unique properties of RTP, including high electrical resistivity (~10^{12} Ω-cm) and a high damage threshold, result in a Q-switch with excellent properties.



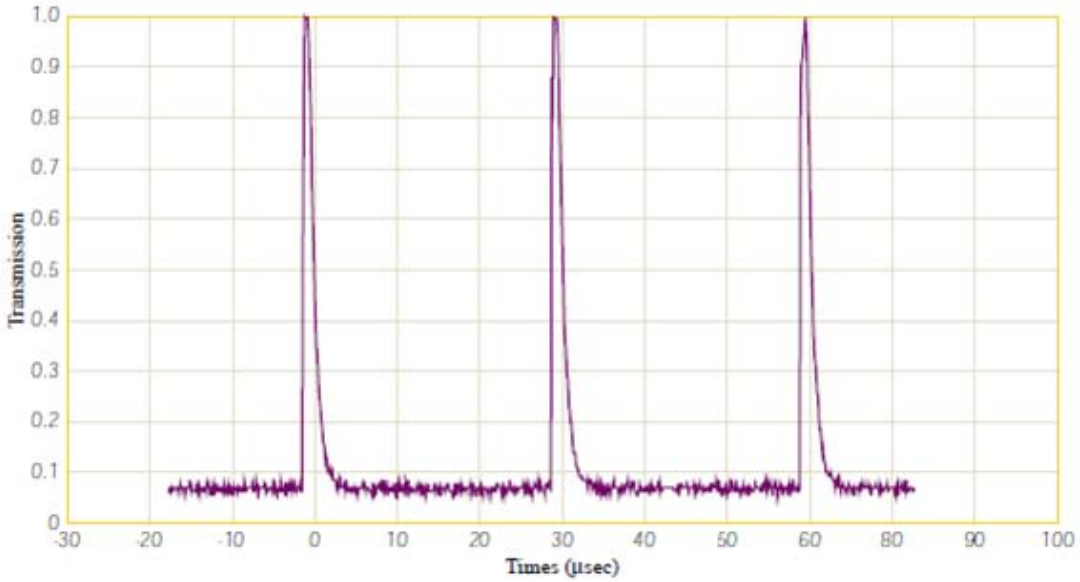
Advantages:

- High Damage Threshold: No Piezoelectric Ringing
- Low Insertion Loss: Thermal Compensating Design
- Non-hygroscopic

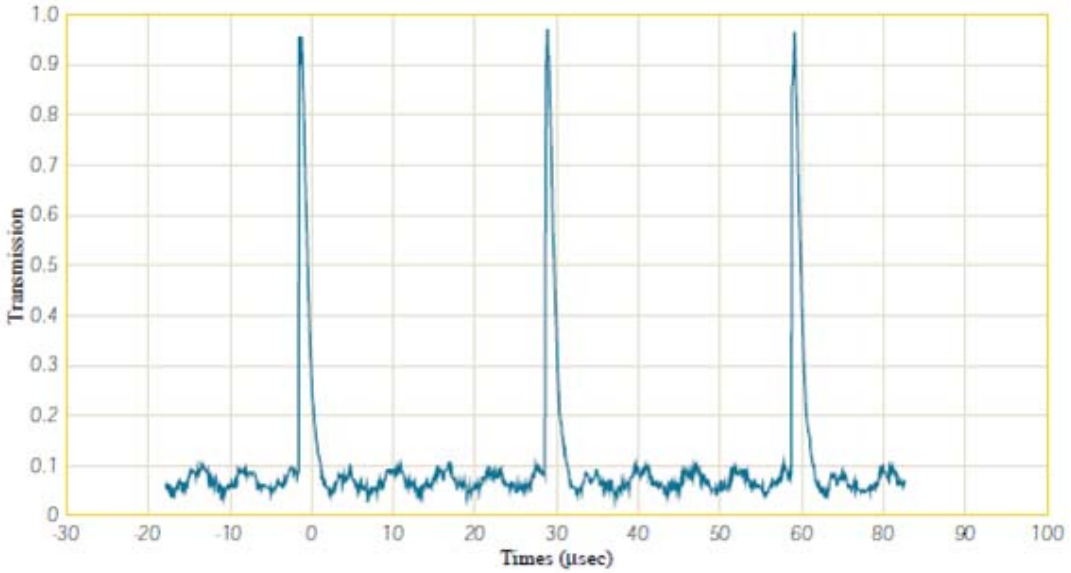
Specifications:

- Transmission at 1064 nm: > 98.5 %
- Half Wave Voltage at 1064 nm, for 9x9x25 nm Q switch: 1.3 - 1.5 KV
- Contrast Ratio: > 20 dB
- Clear Aperture: From 2x2 to 15x15 mm
- Acceptance Angle: > 1 degree
- AR coatings: R < 0.2% at 1064 nm
- Damage threshold: > 600 MW/cm^2 at 1064 nm (τ=10 ns)

RTP Q-switch working at 30kHz



BBO Q-switch working at 30kHz



The graphs above show the behaviour of RTP and BBO Q switches at high repetition rates. In particular, the BBO shows Piezoelectric ringing at 30 kHz, while the RTP Q switch shows no ringing at this frequency.
The BBO Q switch has a 2.5x2.5x25 mm element, while the RTP Q switch has two 6x6x7mm elements.

8. Electro-optic Modulators

E-O modulators and modulation systems are used for pulse selection, regen-switching, video disk mastering and data recording. Products include E-O phase modulators, beam deflectors, associated drivers, transverse field modulators, laser noise-reduction systems, and optical isolators. We also manufacture, on a custom basis, intensity modulation systems with high frequency capabilities beyond 400MHz.

Most modulators are transverse field type Pockels Cells. In the original Pockels Cell design the optical beam is longitudinal to the electric field. In the new transverse design the optical beam is orthogonal to the electric field. The advantage of the transverse design is that it requires approximately 100 volts as opposed to the kilovolts required by the original design.

Features:

- 2 or 4 crystal configurations
- Designed to minimize the natural net birefringence
- Require DC offset voltage to set the quiescent operating point
- Supplied with an output polarizer, pre-aligned to the crystal axes
- Require either that the input laser is polarized or use of an auxiliary polarizer at the input
- Filled with index matching fluid

Note: Window assemblies should not be removed

Configurations:

ADP Crystal Series Wavelength Limits (240 to 800 nm)*

Model Number	V ½ wave @ 500nm	V ½ wave @ 830nm	Aperture Diameter	Resonances	Contrast Ratio @ 633nm	Length w/ Polarizer
STM370	184	306	2.5mm	No	500:1	158mm
STM370 LA	263	437	3.5mm	No	500:1	158mm
STM380	92	153	2.5mm	No	500:1	253mm
STM390	115	190	3.5mm	No	500:1	272mm

KD*P Crystal Series Wavelength Limits (240 to 1100nm)*

Model Number	V ½ wave @ 500nm	V ½ wave @ 830nm	V ½ wave @ 1064nm	Aperture Diameter	Resonances	Contrast Ratio @ 633nm &1064nm	Length w/ Polarizer
STM350-50	455	757	970	3.1mm	Yes	500:1,700:1	106mm
STM350-80	261	433	522	2.7mm	Yes	500:1,700:1	137mm
STM350-80LA	360	600	720	3.5mm	Yes	500:1,700:1	137mm
STM350-105	226	376	472	3.1mm	Yes	500:1,700:1	162mm
STM350-160	130	216	275	2.7mm	yes	300:1,500:1	215mm
STM350-210	113	188	240	3.1mm	Yes	300:1,500:1	268mm

LTA Crystal Series Wavelength Limits (700 to 2000nm)

Model Number	V ½ wave @ 830nm	V ½ wave @ 1064nm	V ½ wave @ 2500nm	Aperture Diameter	Resonances	Contrast Ratio @ 1064nm	Length w/ Polarizer

STM360-40	213	400	950	2.7mm	Yes	200:1	95mm
STM360-80	143	183	430	2.7mm	Yes	100:1	137mm
STM360-120	107	138	323	2.7mm	Yes	100:1	174mm
STM360-160	71	92	215	2.7mm	Yes	100:1	215mm

Amplifier Details

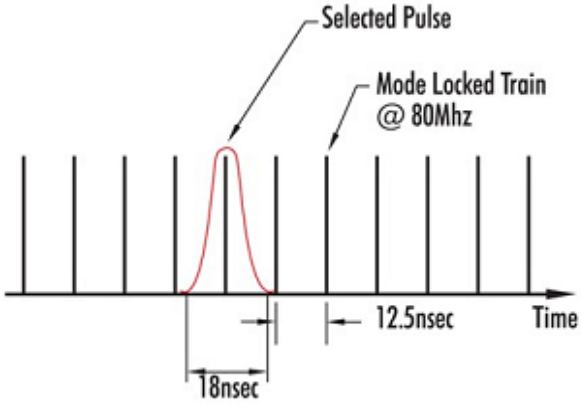
Model	Bandwidth	Rise/Fall Times	Max. Output V	Typical Drive Configuration	Output
ST25A	DC-to-25MHz	14ns	145	100 Ohms B.L.	Linear
ST25D	DC-to-30MHz	8ns	175	100 Ohms B.L.	Digital
ST50	DC-to-50MHz	7ns	90	50 Ohms B.L.	Linear
ST100	DC-to-100MHz	3.5ns	90	50 Ohms B.L.	Linear
ST200	10Khz-to-200MHz	2ns	170	50 Ohms S.E.	--
ST275	DC-to-8MHz	50ns	275	Lumped Capacitance	Linear
ST302RM	DC-to-250KHz	1 micro-sec	750	Lumped Capacitance	Linear
ST302A	DC-to-1MHz	350ns	350	Lumped Capacitance	Linear
ST307	DC-to-50KHz	8ns	800	Lumped Capacitance	Digital
ST505	5MHz-to-100MHz	3.5ns	44	50 Ohms S.E.	--
ST550	20MHz-to-500MHz	1.5ns	140	50 Ohms S.E.	--

9. Electro-optic Pulse Picker

We have developed a complete line of Pulse Selection Systems for use with Ti:Sapphire, YAG, YLF and OPO's from 350nm-to 1600nm applications. Customized options are also available.

Features:

- Pulse selection: select from single pulse to 30MHz from mode locked lasers
- Rep. Rate: Up to 30Mhz
- Transmission: >85%
- Pulse width: Min. pulse width of 18ns measured at zero
- Pulse width limit: no limit
- Rise/Fall time: 8ns
- Offset: centre in and centre out operation. No office or angular change
- Dispersion: no spatial dispersion.



Specifications of Electro-Optic Modulators:

Ti:Sapphire (350nm-to-500nm)	Model 350-105 KD*P Series Modulator
Ti:Sapphire (700nm-to-1064nm)	Model 350-160 KD*P Series Modulator
OPO's (1000nm-to-1600nm)	Model 360-120 LTA Modulator
YAG Laser (1064nm)	Model 360-80 LTA Modulator
YLF Laser (1300nm)	Model 360-120 LTA Modulator

Specifications of Associated Amplifiers:

Model	Bandwidth	Rise/Fall Time	Max Voltage	Diver Configuration	Output
ST25D	DC-to-30MHz	8ns	175	100ohms B.L.	Digital
ST50	DC-to-50MHz	7ns	90	50ohms B.L.	Analog
ST100	DC-to-100MHz	3.5ns	90	50ohms B.L.	Analog
ST307A	DC-to-50MHz	8ns	800	LC	Digital

Specifications of Model 305 Synchronous Countdown System:

Input Clock Rate	Mode Locker Input, 10MHz Min, 70MHz Max; External Input, 10Hz min, 140MHz Max
Countdown Range	F(clock)/2 min, f(clock)/1*10^6 max
Input-Output Jitter	<100ps, any count
Input Requirements	Mode Locker Input – sine wave, -6dbm min (112mv RMS), +15dbm, max (1.3v RMS), Zi=50ohms External Input – 100mv peak min, 1.5ns min pulse width. +/- 2v peak max. Zi=50ohms Gate Input = TTL levels, min width one clock period. Burst ends one count after negative edge of gate input signal. Zi=50ohms Single Shot Input = TTL levels, 10ns min pulse width. Zi=50ohms.
Delay	Variable – 0-to-8ns, 7bit digital delay line. 62ps min resolution. Controlled by linear, single turn front panel control. Fixed – 8ns Switch selectable on front panel (in/out)
Outputs	TTL – 50 ohm line driver, Voh type 2.5v into 50ohm load. Pulse width 1us type (Pulse with is set internally by discrete components). Tr, Tf, <3ns type Analog – Tr, Tf, <2ns, Unipolar 0-to-+1v fixed amplitude. Designed to drive DC coupled 50ohm load to ground. Pulse width – 8ns, set internally by 50ohm coax delay line. Sync – 50ohm TTL line driver, 1.3v into 50ohms. Negative edge.
Threshold Adjustment	+/- 200mv applied to input comparator via single turn front panel control.
Input Power	85-250VAC, 47-63Hz, 50W
Dimensions	133 H x 430 W x 343 D mm. Rack Mountable. 5.25" x 16.88" x 13.5"
Weight	Net 6.8 Kg, (15lbs)

10. Electro-optic Deflector

ST Series electro-optic deflectors are the most efficient mechanisms for changing the angle of a laser beam. EOD can scan a laser beam over a range of angles, or control the output angle of a laser beam with great accuracy. We employ a quadrapole electric field in an electro-optic material to produce a linear refractive index gradient proportional to the applied signal voltage.

Specifications of EODs:

Model	ST310A	ST311A	ST312	ST312-2	ST412-2Axis
Aperture (mm)	2.5	2.5	2.7	2.7	2.0
Deflection efficiency	1.5urad/volt	3.0urad/volt	0.6urad/volt	1.2urad/volt	4urad/volt
Capacitance (pF)	100	185	50	100	40
Standard Spectral Range	400-750nm	400-750nm	400-1100nm	400-1100nm	700-1000nm/ 1000-2000nm
Length (mm)	118	219	71	125	110
UV/DUV Options	Yes	Yes	Yes	Yes	No
Collinear Configuration	NA	Center In/ Center Out	Center In/ Center Out	Center In/ Center Out	Center In/ Center Out

Specifications of Amplifiers:

Model	ST302RM
Cabinet	Driver and power supply in single cabinet
Test feature	Built-in test feature allows testing for max transmission of Pockel Cell without adjusting bias voltage
Input impedance	Choice of amplifier input impedance by rear panel switch (50ohm/1K ohm)
DC Bias	Improved DC biasing of Pockel Cell provides greater linearity at higher bias voltages.
Voltage range	+/- 450VDC controlled by ten-turn front panel pot. Digital meter monitors differential bias applied to E.O. Modulator
Linearity	10bits referenced to full scale (.1%)
Bandwidth	DC-200kHz with 90pF load and 3M (RG-62) cables.
Max output drive level	750Vpp into 90pF load
Amplifier input signal	2Vpp max into 50/1k ohm delivers 750Vpp out
Input signal format	Options include Unipolar positive, negative or bipolar
Input power (AC)	60W typical, both load(modulator) & frequency dependent
Dimensions	19” rack mountable, 5.25”H(133mm)(3U)x14”D(356mm)
Cooling	Forced air
Operating environment	Laboratory(indoor only), +5-+50°C, RH20-80%
Weight	20lbs (9.07kg)

Model	ST412 2-axes	ST25D
Cabinet	Driver and power supply in single cabinet	Driver and power supply in single cabinet
Input impedance	Choice of amplifier input impedance by rear panel switch (50ohm/1K ohm)	50ohms
Gain	375V/V Each Amplifier	+/- 400vDC
Max output drive level	750V P-P, each amplifier, driving 60pf load, 3m RG-62 cables	175V
Detected rise/fall time	Typically 2.5us driving 60pf with 3m RG-62 coax	8ns
Input signal format	Options include Unipolar POS/NEG or bipolar set by rear-panel slide switch	TTL or Analog
Input power (AC)	Typically 70W (load and frequency dependent)	300W
Dimensions	19” Rack Mountable, 5.25”H (133mm) (3U) x 14”D (356mm)	45cm W x 44cm L x 17.5cm H
Cooling	Forced air	Forced air
Operating environment	For laboratory use (indoor only), +5-+50°C, RH 20%-80% up to 32°C, Altitude <3000m	Designed for laboratory use (indoor only)
Weight	20lbs (9.07kg)	32lbs (14.51kg)

11. Electro-optic Noise Eater

Laser Stabilization System (ST-LASS-II) is designed as an electro-optic feedback loop capable of reducing the amplitude variations commonly associated with lasers. The ST-LASS-II system enhances the signal to noise ratio of the laser over a broad bandwidth. Both an internal and external reference input is provided, allowing analog programming of the laser throughput.

The ST-LASS-II is particularly convenient for use in recording systems where laser power must be varied as a function of position on the recording medium (i.e. video disc, flat bed recorders, etc.). The system is composed of feedback electronics, power supply and electro-optic modulator with integrated beam-splitter and photodiode amplifier.

Specifications:

Performance Characteristics	
Wavelength	514nm, laser power 50mw, lo= .5 lmax
Laser power	50mw, low = .5lmax
Beam diameter	1.4mm (1/e 2) TEM00
Noise reduction	1/1@ 500kHz (Int. Ref. Mode) 5/1 @ 100kHz 18/1 @50kHz 100/1 @10kHz 200/1 @1kHz 250/1 @200hz
Noise floor	458nm, -100db Relative to F.S.
DC stability-short term	<1% Relative to Full Scale (@.5lmax, T=0 -> 1hr.)
External input impedance	1k nominal
External input voltage	0 -> +1 V Max
Electrical input power	-20W (100-230 VAC)
The amount of light for calibration output of beam-splitter to diode	@633nm – 300uw; @514nm – 450uw; @488nm – 540uw; @458nm – 820uw *Two different types of beam splitters are available to optimize efficiency and finesse
Static transmission	85% (excluding beam-splitter)
Useable aperture	2.5mm2
Optical bandwidth	400-900nm
Max throughput power	3.5w/mm2 TEM00
System options	
Standard system (532nm)	ST-LASS-II with Model 370 E-O Modulator
Large aperture (532nm)	ST-LASS-II with Model 370LA E-O Modulator
532nm-1064nm fs laser	ST-LASS-II with Model 350-105 E-O Modulator
800nm-2000nm ps laser	ST-LASS-II with Model 360-80 E-O Modulator
Rack mount	RM Option
UV & DUV options	325nm-to-515nm, 257/266nm

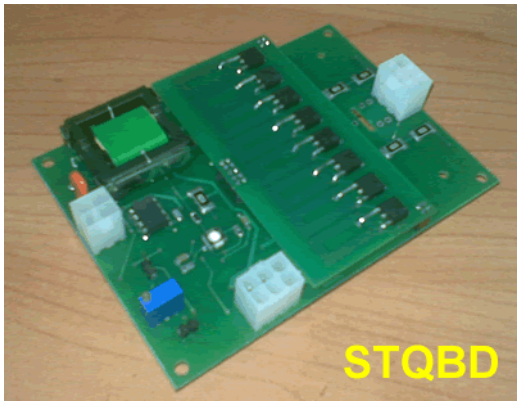
EO Q-switch Drivers

1. STQBD Series OEM Driver

STQBD is the series of high repetition rate Pockels cell drivers allowing simple and reliable operation of Q-witched lasers. Devices provide wide range of output direct voltages (up to 6 kV). It allows operation with Pockels cells assembled on different electrooptical crystals from low quarter-wave voltage Lithium Niobate and BBO to DKDP that requires much higher voltage levels for proper operation. QBD-series Pockels Cell Drivers have modifications both for pull-up and pull down schemes.

STQBD-Series devices provide high repetition rates (up to 100 kHz) that makes them a good solution for electro-optical Q-switched lasers with CW pumping. On the other hand a short rising (falling) time allows operation in short pulsed systems with high peak output power and energy (flashlamp-pumped Nd:YAG lasers).

Another advantage is the ability of operation with extremely high loads (up to 0.5 nF). This feature leads to higher reliability of the device and permits remote operation of Pockels cell in laser head that can be connected to driver using long cables (correct and effective operation has been approved with cables up to 3 meters). This allows the designing of Q-switched laser systems with compact remote laser heads where close placement of Pockels cell and driver is impossible because of volume insufficiency or other causes.



Features

- Compact OEM design
- Up to 6 kV output voltage
- Long cable operation
- Up to 100 kHz repetition rate
- Up to 0.5 nF load
- Pull-up and pull-down scheme modifications

Specifications

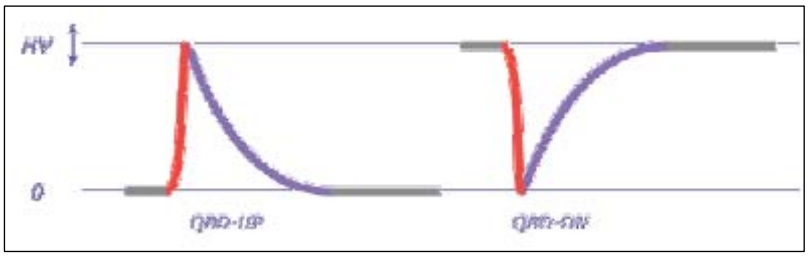
Input:	
Voltage	+24VDC
Output:	
Working modes	pull-down (= normally on) or push-up (= normally off)
Voltage, high level	regulated, up to 6 kV [1]
Voltage, low level	fixed, 0 V
Repetition rate	up to 50 kHz (CW), up to 100 kHz (burst-mode) [1, 2]
Load	up to 0.5 nF [1]
Rise time (Fall time)	< 20 ns [3]
Recovery time	5-10 us (depends on load)
Jitter	10 ns
Delay time	1 us
Leakage current	not more than 150 uA
Environment:	
Operation temperature	0 … +40 °C (-40 : +50 °C in HE modification)
Storage temperature	-20 … +60 °C
Humidity	90 %, non-condensing
Size (LxWxH)	110x80x25 mm
Weight	0.1 kg

[1] These parameters aren't indepenent and cannot achieve their maximum at the same time...
[2] forced air cooling is required for operating with high repetition rates...
[3] 10-90% level; warranted at load capacitance 23 pF and below...

Part Number Description:
STQBD-XXYY-ZZ
STQBD – STQBD series EO Q-switch driver

XX – maximum output voltage from 20 to 60 (2 - 6kV)
YY – minimum output voltage from 12 to 20 (1.2 – 2.0kV)
ZZ – UP: modification for pull-up scheme; DN: modification for pull-down scheme

We offer five standard solutions:
STQBD-6024-UP/DN
STQBD-5020-UP/DN
STQBD-4016-UP/DN
STQBD-3012-UP/DN
STQBD-2008-UP/DN



Options

Adjustment range of output voltage (see figure) can be selected within the following model series: STQBD-6024 (2.4-6 kV), STQBD-5020 (2-5 kV), STQBD-4016 (1.6-4 kV), STQBD-3012 (1.2-3 kV), STQBD-2008 (0.8- 2 kV).

STQDB-series Pockels cell drivers have two modifications: working by pull-up scheme or working by pull-down scheme.

Most of time gate is retained under voltage that is indicated in grey on figure; time of rapid growth/slump (20 ns) is indicated in red; time of relatively slow recovery (~10 us) is indicated in blue. Adjustable voltage level is designated by the arrow.

Applications

STQBD-Series Pockels Cell Drivers are available in standard and special versions. Standard modification is a relatively simple OEM device designated for operation in laboratory or medical laser systems at normal temperature and humidity conditions. These modules are designed in accordance with IEC60601-1 medical safety standard requirements. Output parameters (direct high voltage) are controlled by use of analog interface.

Special version is available for laser systems designated for operation in harsh environment. These devices are distinguished due to wide operation temperature range, humidity and vibration steadiness. In this version all parameters are controlled by simple and reliable internal multi-turn trimpots.

2. STQBU Series OEM Drivers

STQBU is a series of multi-functional Pockels cell drivers of hi-end class. In contrast to analogues, they can provide rapid switching of input voltage in two directions: both up and down. STQBU-Series Pockels Cell Driver is extremely flexible solution for driving of the Pockels cell that works upon any user-defined scheme (that may be pull-up, pull-down schemes or any combinations of them).

Modules provide wide range of output direct voltages (up to 5 kV). It allows operation with Pockels cells assembled on different electrooptical crystals from low quarter-wave voltage Lithium Niobate and BBO to DKDP that requires much higher voltage levels for proper operation.

Moreover, STQBU-Series modules provide high repetition rates (up to 100 kHz) that makes them a good solution for electro-optical Q-switched lasers with CW pumping. On the other hand a short rising (falling) time allows operation in short-pulsed systems with high peak output power and energy (flashlamp pumped Nd:YAG lasers).

Another advantage of STQBD-series drivers is an ability of handling with extremely high loads (up to 0.5 nF). This feature leads to higher reliability of the device and permits remote operation of Pockels cell in laser head that can be connected to driver using long cables (correct and effective operation has been approved with cables up to 3 meters). This allows the designing of Q-switched laser systems with compact remote laser heads where close placement of Pockels cell and driver is impossible because of volume insufficiency or other causes.

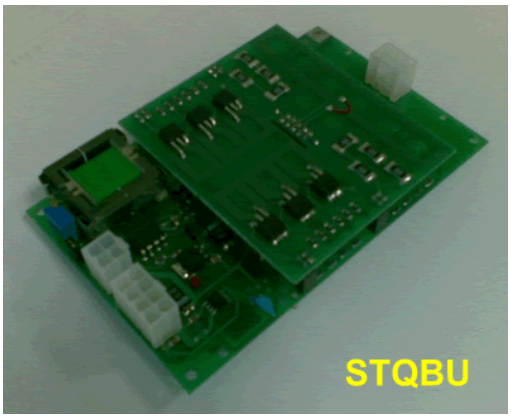
Features

- Extremely flexible solution

- Pull-up and pull-down schemes
- Up to 5 kV output voltage
- Up to 0.5 nF load
- Compact OEM design
- Long cable operation
- Up to 100 kHz repetition rate

Specifications

Input:	
Voltage	+24VDC
Output:	
Voltage	up to 5 kV
Repetition Rate	from single pulse to 100
Load	up to 0.5 nF
Rise time / Fall time	20 ns
Safety:	
Leakage Current	not more than 150 uA
Environment:	
Operation Temperature	-20…+45 C
Storage Temperature	-40…+85 C
Humidity	90%, non-condensing
Size (LxWxH)	130x80x20 mm
Weight	0.1 kg
Options	Harsh environment version

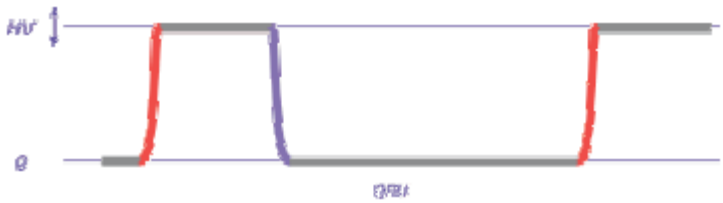


Part Number Description:

STQBU-XXYY

STQBU – STQBU series EO Q-switch driver
XX – maximum output voltage from 20 to 60 (2 - 6kV)
YY – minimum output voltage from 12 to 20 (1.2 – 2.0kV)

We offer four standard solutions:
STQBU-6024
STQBU-5020
STQBU-4016
STQBU-3012
STQBU-2008



Options

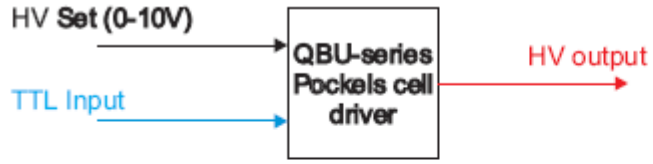
Adjustment range of output voltage (see figure) can be selected within the following model series: STQBU-5020 (2-5 kV), STQBU-4016 (1.6-4 kV), STQBU-3012 (1.2-3 kV), STQBU-2008 (0.8-2 kV). Time of rapid pulse growth (20 ns) is indicated red on figure time of same rapid slump is indicated blue (20 ns). Adjustable voltage level is designated by the arrow.

Application

STQBU-Series Pockels Cell Drivers are available in standard and special versions. Standard modification is a relatively simple OEM device designated for operation in laboratory or medical laser systems at normal temperature and humidity conditions. These modules are designed in accordance with IEC60601-1 medical safety standard requirements. Output parameters (direct high voltage) are controlled by use of analog interface.

Special version is available for laser systems designated for operation in harsh environment. These devices are distinguished due to wide operation temperature range, humidity and vibration steadiness. In this version all parameters are controlled by simple and reliable internal multi-turn trimpots.

Working Scheme



3. STQBU-BT Series EO Q-switch Drivers

STQBU-BT-series consist of five Pockels cell drivers differ with their output voltage range and covering range up to 6.0 kV. High repetition rates and fast transition times are additional benefits.

Modules allow operations in three different modes (pull down scheme (= normally on), push up scheme (= normally off) and external synchronization mode (= repetition of external low voltage signal)) and therefore suit ideally for the laboratory usage.

Features

- Extremely flexible solution
- Push-up and pull-down schemes
- Up to 6 kV output voltage
- Up to 50 kHz (CW) repetition rate
- Pulses width from 1us to DC
- 20 ns rise/fall times
- RS-232 interface

Specifications:

Input:	
Voltage	110/230 VAC; 50/60 Hz
Current	1 A max
Output:	
Working modes	Pull-down scheme, push-up scheme, repetition of external signal
Voltage, high level	regulated, up to 6 kV
Voltage, low level	fixed, 0 V
Pulse width	1 us - DC
Repetition rate	up to 50 kHz (CW), up to 100 kHz (burst-mode)
Rise time	< 20 ns
Fall time	< 20 ns
Jitter	10 ns (1 ns in LJ-modification)
Delay time	1 us (100 ns in LJ-modification)
Load capacitance	up to 0.5 nF
Environment:	
Operation temperature	0 … +40 °C
Storage temperature	-20 … +60 °C
Humidity	90 %, non-condensing
Size (LxWxH)	225x200x60 mm
Weight	2 kg

Performance

For STQBU-BT-5020 continuously operated in internal synchronization mode we warrant the performance table as follows:

11 pF load capacitance							
Voltage, kV	2.0	2.5	3.0	3.5	4.0	4.5	5.0
Max. rep. rate, kHz	56	40	31	24	18	15	12
23 pF load capacitance							
Voltage, kV	2.0	2.5	3.0	3.5	4.0	4.5	5.0
Max. rep. rate, kHz	45	32	24	18	14	12	9

External synchronization mode shows usually a little higher performance.

In the burst-mode (= short time operations) performance is increasing approximately twice and may achieve 100 kHz value at low operating voltages and load capacitance.

High load capacitance decreases the performance.

Part Number Description:
STQBU-BT-XXYY

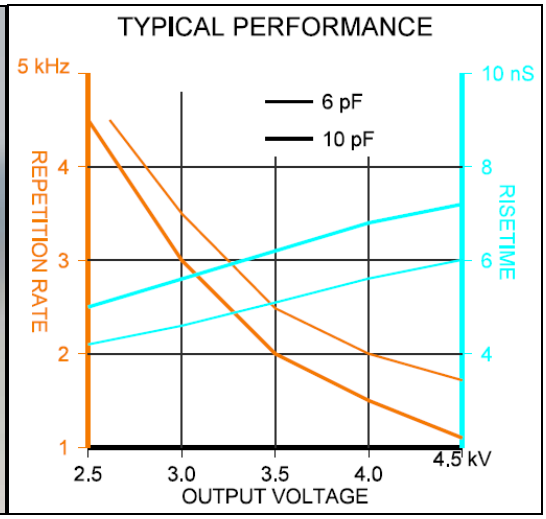
STQBU-BT – STQBU-BT series EO Q-switch driver
XX – maximum output voltage from 20 to 60 (2 - 6kV)
YY – minimum output voltage from 12 to 20 (1.2 – 2.0kV)

We offer five standard solutions:
STQBU-BT-6024
STQBU-BT-5020
STQBU-BT-4016
STQBU-BT-3012
STQBU-BT-2008

Options
Adjustment range of output voltage can be selected within the following model series: STQBU-BT-6024 (2.4-6 kV), STQBU-BT-5020 (2-5 kV), STQBU-BT-4016 (1.6-4 kV), STQBU-BT-3012 (1.2-3 kV), STQBU-BT-2008 (0.8- 2 kV).

4. SGH Series EO Q-switch Drivers

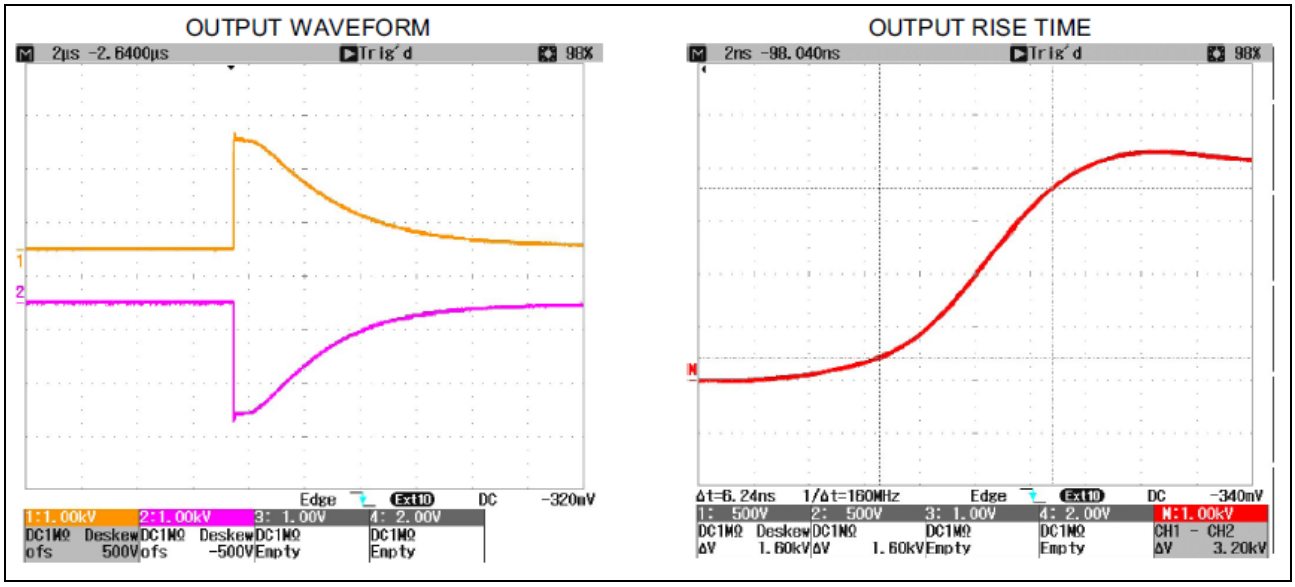
The SGH driver is a Pockels cell driver for Q-switched laser systems. It is meant for laboratory bench use. We supply customized OEM drivers for incorporation into a product.



Output voltage	1.5kV to 4.5kV, adjustable
Output DC	Zero

Output rise time	5-7ns depending on load capacitance and output voltage, see graph below.
Output waveshape	Differential +/- pulses, balanced with respect to ground, exponential decay with a 7us time constant (factory special for other decay times)
Repetition rate	Up to 5 kHz, again dependant on load and voltage - see graph, below
Power input	24VDC, 250mA maximum
Trigger input	5V, 50ohm BNC
Output wiring	Flying leads to cell, ground stud

The OEM version of the Q-Drive has similar specifications to those described in the above description, minus the case, the off-board components and the 24V power
supply.



Pockels Cell (EO Q-switch) Questionnaire

If you would like us to make a Pockels cell recommendation, we would like to know the following information about your application:

- Information needed for any Pockels cell inquiry

1 What is the application of this pockels cell (Q-switch, regenerative amplifier, pulse picker or other)?

Ans :

2 What is the beam diameter or radius (1/e2 value)? Please specify as Radius of Diameter.

Ans :

3 What is the beam profile (Guassian, Pseudo-Gaussian, Top-hat, etc)?

Ans :

4 What is the wavelength of operation (nm)?

Ans :

5 What is the laser repetition rate?

Ans :

6 What is the laser peak power (extra-cavity)?

Ans :

7 What is the energy-per-pulse?

Ans :

8 What is the pulse width (FWHM)?

Ans :

9 Will you use the cell in quarter-wave or half-wave operation?

Ans :

10 What is the cell repetition rate and voltage pulse duration that you intend to use?

Ans :

11 What is your duty cycle?

Ans :

12 What is the operating environment at the cell (temp, atmosphere, humidity)?

Ans :

13 If using a laser cavity, what is the finesse or output coupler reflectivity?

Ans :

14 Do you intend to use a bias or constant on voltage, switching to ground? (This is not typically recommended and may cause short cell life)

Ans :

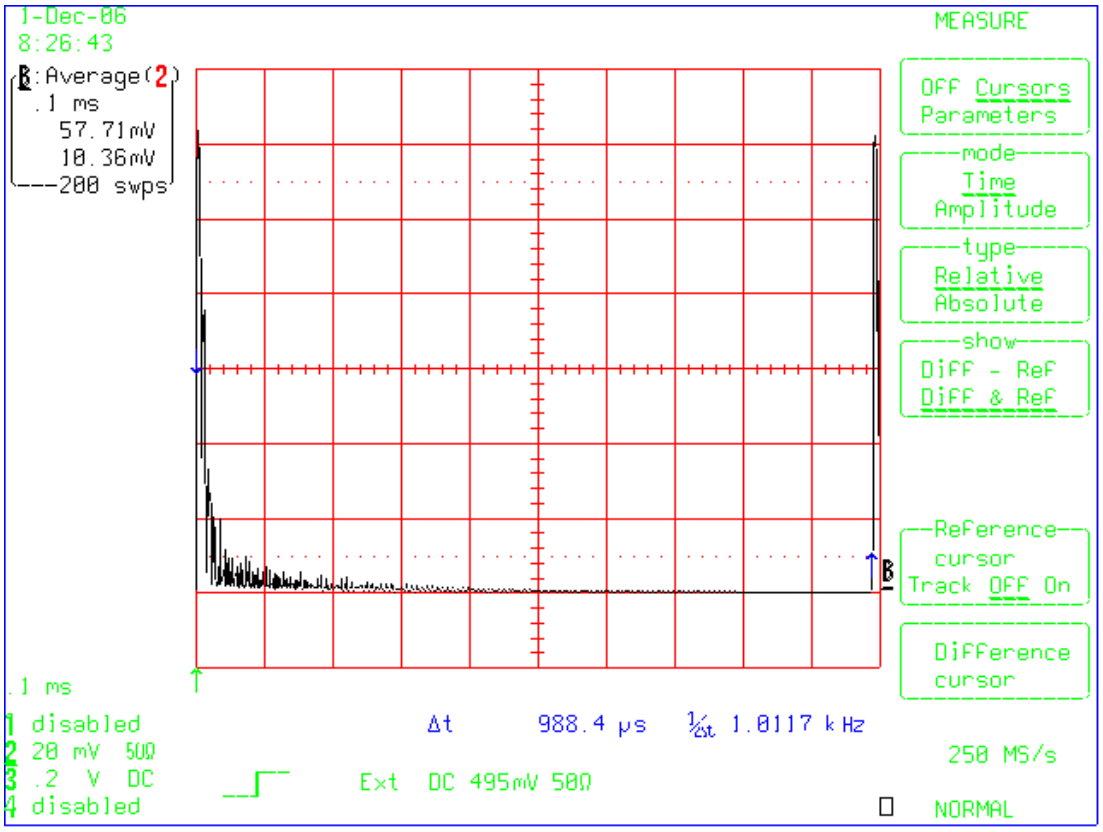
15 What quantity do you require?

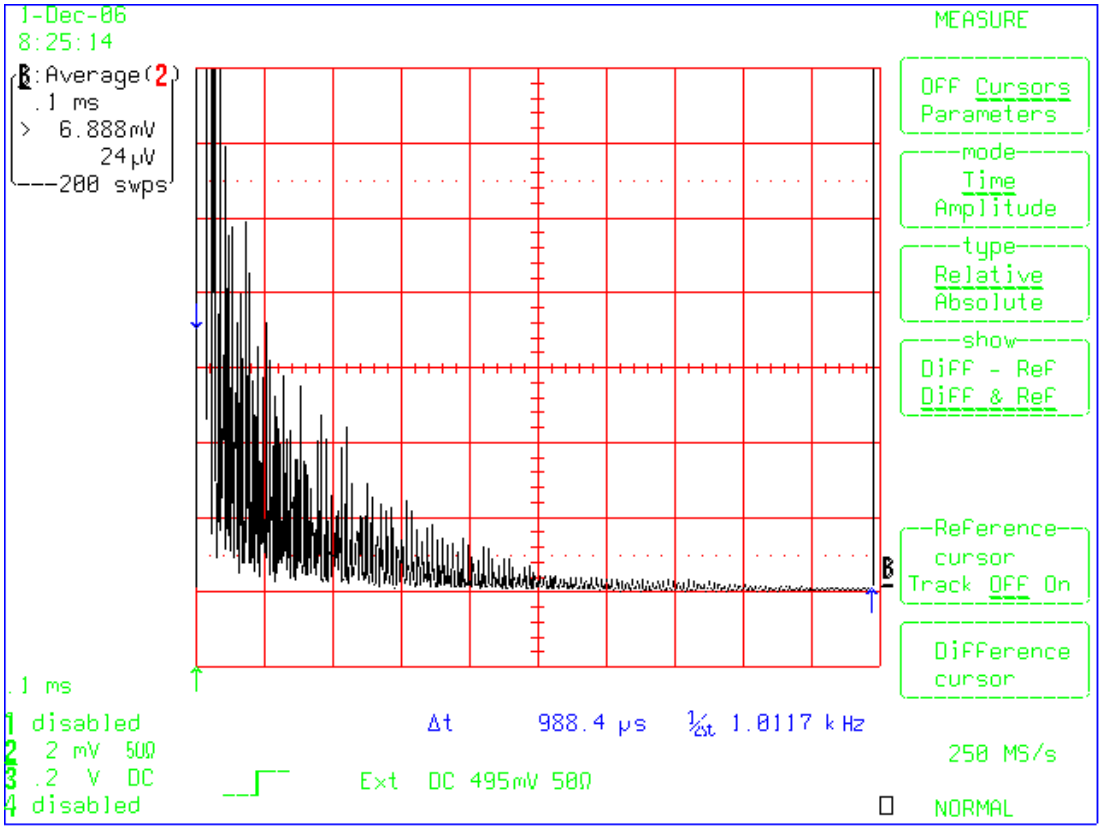
Ans :

1. How to Select an EO Q-switch to Meet Your Switching Frequency Requirement

The simple answer is that the IMPACT Pockels cells are recommended for operation at a maximum of 1-2kHz. This is not to say they will completely fail to operate at 5kHz. The contrast ratio will be sacrificed as the repetition rate is increased beyond 1kHz. The reason for this is contained within the nature of the DKDP crystal, When high voltage is applied, the crystal lattice is distorted, causing the desired Pockels effect. However, the longer that the voltage is applied, either in terms of electric pulse duration or in the repetition rate used, the distortion causes an acoustic resonance to develop. This is commonly referred to as “rining” in the crystal. This is true of any cell that uses KDP/DKDP as its crystal

element. To illustrate this point, the following figures show several optical traces of the acoustic ringing from an IMPACT 8 Pockels cell when operated at 1kHz repetition rate. One trace (time stamp 8:26:43) allows the vertical (y-axis) to autoscale to a maximum of the signal from the electrical pulse. In the second trace (time stamp 8:25:14), we have collapsed the y-axis so that you don't see the maximum of the electrical pulse. Although the collapsed y-axis truncates the initial pulse maximum, it increases the visual appearance of the acoustic ringing following the initial pulse. In either case, you can see the acoustic ringing subsides after about 1millisec.





Although we generally recommend QX series Pockels cells for applications at >2KHz, whether or not the IMPACT 8 will work depends upon how much loss of contrast ratio their system can tolerate. But if you want a cut and dry answer, I'd recommend against operation at 5kHz. The QX and IMPACT cells use the same high quality DKDP crystal in similar sizes. The significant difference is the construction of the cell housing. The QX cell design is such that is provides some suppression of this ringing out to about 5KHz normally and is available in a damped version which will suppress this condition to <10KHz.

The BBO cell will operate into the 500KHz region and higher.

2. How to Select Aperture
In a Gaussian beam there will be ~10% of the laser energy present at a diameter of 2-3 times the 1/e^2 diameter. This will result is a significant loss of energy in the system and this energy can scatter inside of the cell and damage the cell. We would suggest that the aperture of the Q-switch is 2 to 3 times of laser beam diameter (1/e2). If the beam can be modified into something close to a "tophat" profile then the aperture requirement drops substantially.

3. What is maximum allowed laser energy? what is the maximum allowed peak power? What is the maximum peak power beam which can be switched off?
If you have a large, perfect beam you can get much more energy through the cell without damage than if you have a beam with hot spots and caustic retro-reflections, etc. In an 8.5mm beam, "typical" maximum wattages would range from 5-30W but, theoretically, DKDP can be used into the 50-75W region...but EVERYTHING has to be perfect. This is one of those situations where general rules just don't have much use.

4. What is the laser beam pulse width and rise time?
The performance of the cell is directly related to the driver. The cell has a theoretical rise time on the order of 80ps...but the best drivers can only drive a rise time of 2-6ns. Pulse width and fall time are similarly affected. The electronics are fairly simple for a q-switch driver at 1/4 wave and a few Hz. Driver designs get MUCH more complicated for a region or a pulse picker at 10 or 100KHz and 1/2 wave voltage.

5. Do we need a waveplate?
Our cell does not contain a waveplate in it. If the customers application requires a 1/4 waveplate then he will have to add it into the system himself.

6. How to Select a Driver?
Any driver that produces ~3KV (2.6KV) will operate the cell to 1/4 wave. The driver that we offer at http://www.sintecoptronics.com/qswi tcheoDriver.htm should work.

7. How to Select Pulse Shape and Duty Cycle?
You can operate the cell with either a pull-up voltage or a pull-down voltage. Changing the polarity will only change the direction of the phase rotation. You should not, however, operate the cell with a constant applied voltage potential between the terminals, or a duty cycle greater than ~ 2%. "Pull-down" usually involves a constant applied or bias voltage. This type of operation is specifically not recommended. We have had customers that use this method to varying degrees of success. This type of operation usually results in dramatically reduced cell lifetimes. We offer no warranty coverage on cells that have been used in this manner.

8. How about Operation Environment?
Our recommended range would be in the 10-30 deg C range. Higher temps will seriously degrade performance. Voltage requirements will change with temperature as well. Also important is the rate of temperature increase. KDP is quite sensitive to thermal shock KD*P cells should never be warmed or cooled at a rate of more than 1-2 deg per hour.

9. How to Place an order for a QX cell?
Fluid filled cells are provided for legacy systems or special applications only. SolGel dry type cells are recommended for optimal performance in most systems. When you place the order for a QX cell, please define window wedge (0 deg or 1 deg) and endcap stype (DT, TK, TN).