



## 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

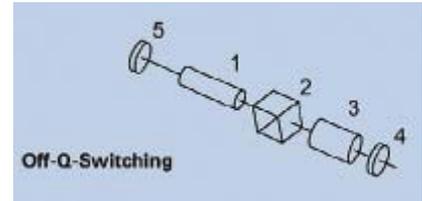
Laser activity begins when the threshold condition is met: the optical amplification for one round trip in the laser resonator is greater than the losses (output coupling, diffraction, absorption, scattering). The laser continues emitting until either the stored energy is exhausted, or the input from 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  $90^\circ$ , the light can be guided out of the laser at a polarizer. The modulation depth, apart from the homogeneity of the  $90^\circ$  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.

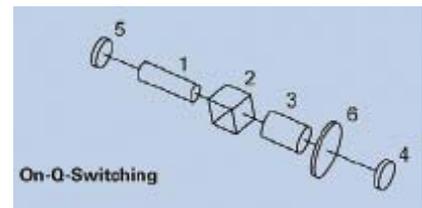
### a) Off Q-Switching

Light emitted by the laser rod (1) is linearly polarized by the polarizer (2). If a  $\lambda/4$  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  $90^\circ$ . 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:YAlO<sub>3</sub>, Alexandrite, Ruby, etc.).



### b) On Q-Switching

Unlike off Q-switching, a  $\lambda/4$  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  $\lambda/2$ -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  $\lambda/4$  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/cm<sup>2</sup>. 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 0.25 $\mu$ m to 1.1 $\mu$ m, 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 1.3 $\mu$ m.

KD\*P can be grown with high optical uniformity and is therefore recommended for large apertures. The spectral window of BBO also ranges from 0.25 $\mu$ m to 1.3 $\mu$ m, 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 0.5 $\mu$ m up to 1.5 $\mu$ m 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 1.5 $\mu$ m up to 3 $\mu$ m we recommend LiNbO<sub>3</sub>.

### **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.

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

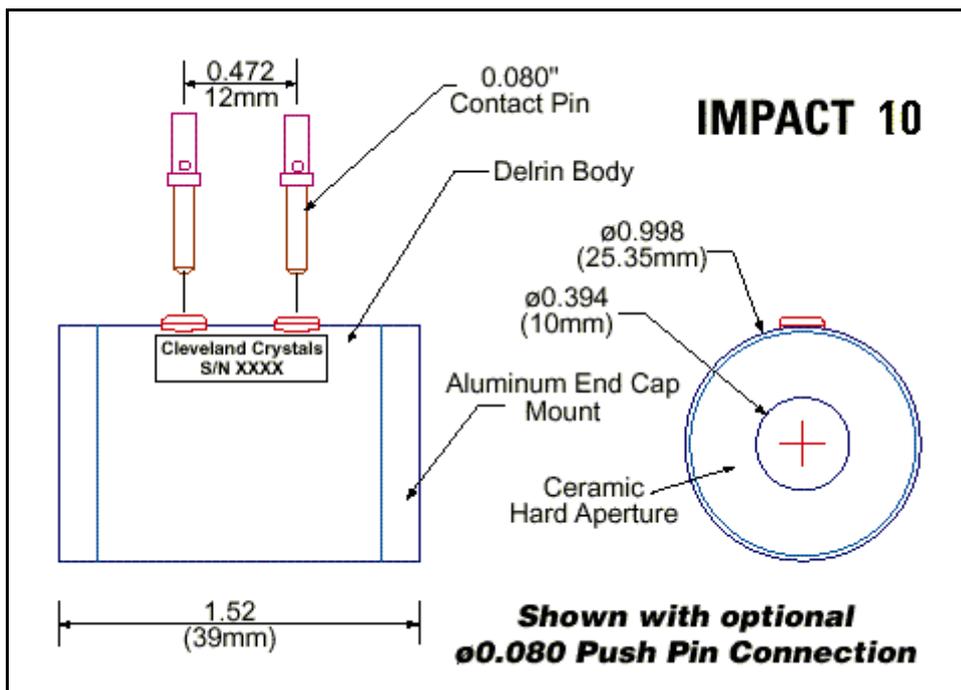
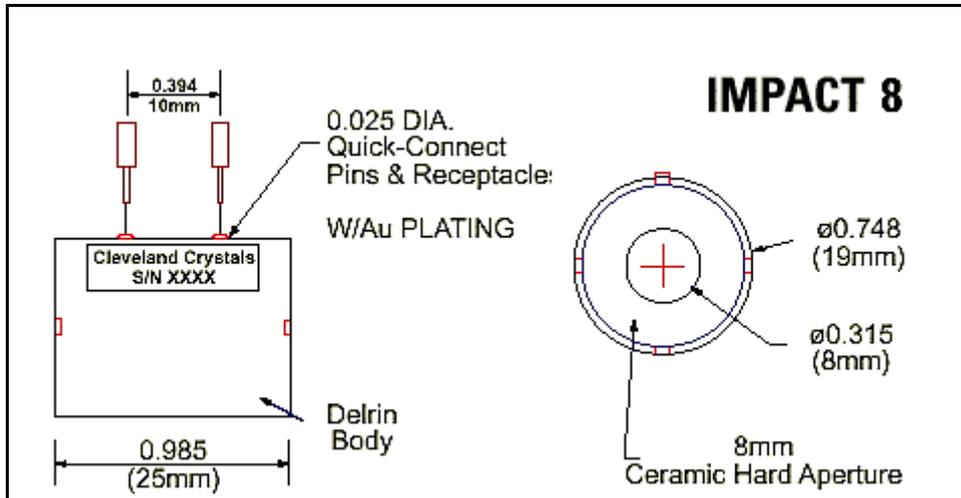
Remark:

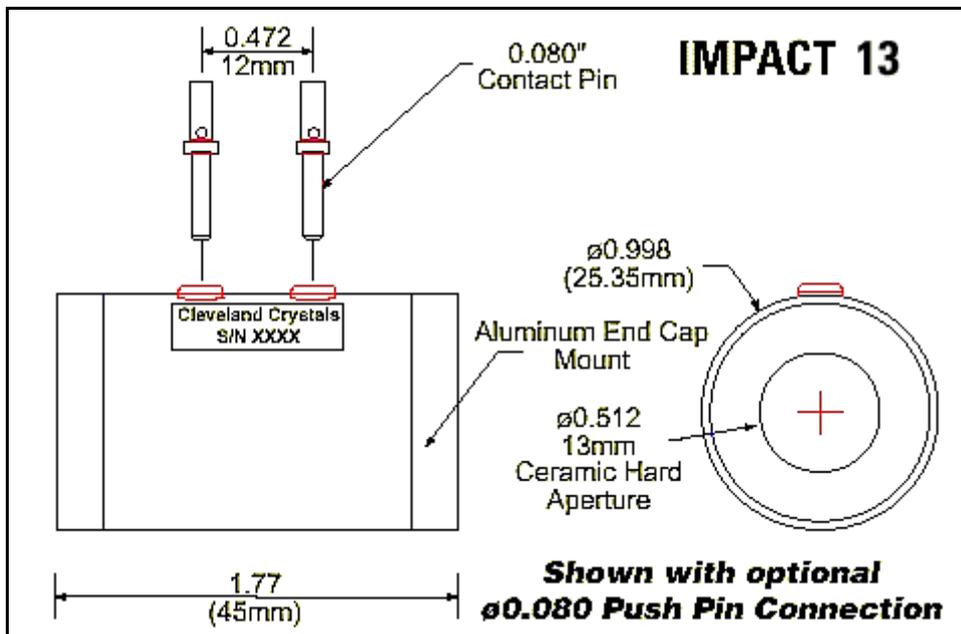
- Impact 8 standard wavelength: 1064nm & 800nm
- Impact 10/13 standard wavelength: 1064nm & 755nm
- The 1/4 wave voltage for any of our KD\*P cells, @ 800nm, will be ~2.5KV, +/- 10%

#### 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 <sup>2</sup>			
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

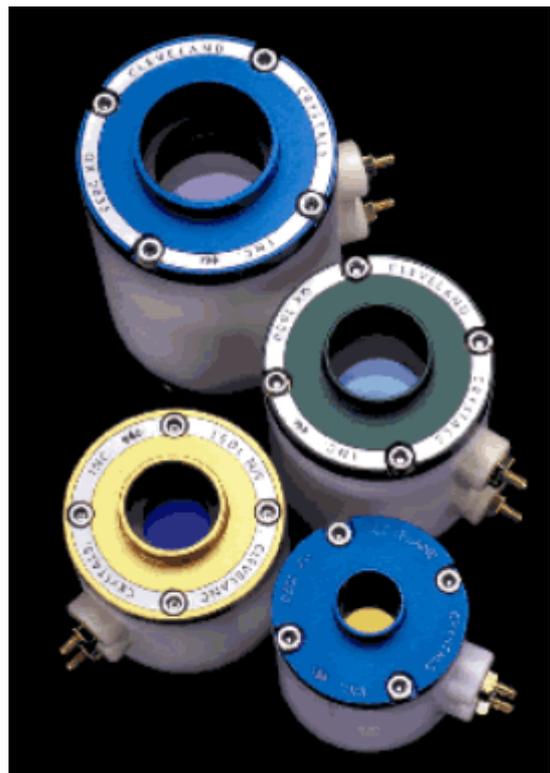
The QX series sets the standard for KD\*P electro-optic Q-switches. These devices provide reliable, stable performance for a diverse range of laser applications.

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

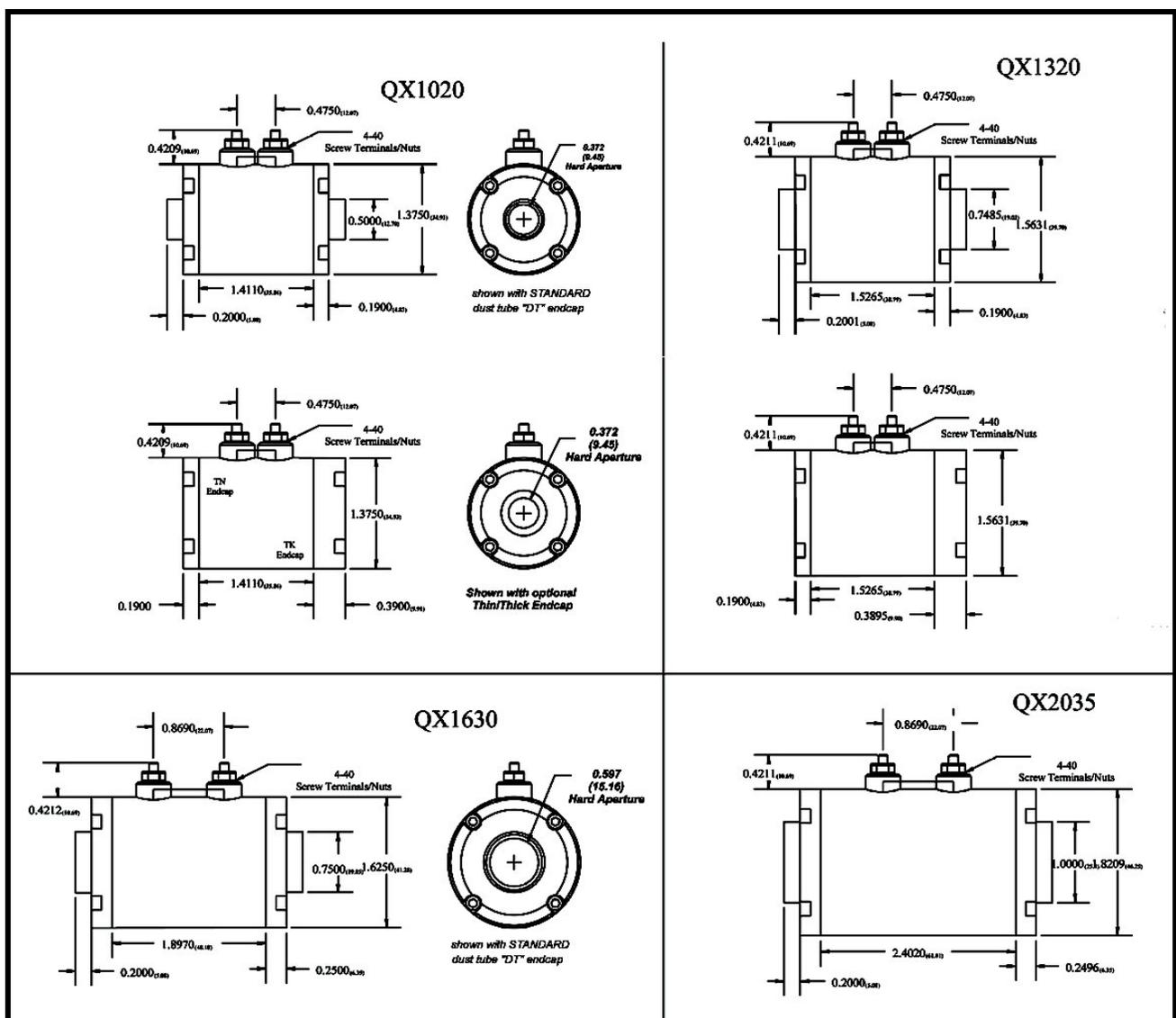
- Industry-proven performance
- Dry or fluid-filled
- Highest (99.9% KD\*P) deuteration levels in industry
- Adhesive/Epoxy-free assembly
- Premium UV-grade fused silica windows
- Apertures from 9.25mm diameter up to 19.5mm diameter
- Lowest absorption in industry
- High-reliability
- Economical upgrade/rebuild 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
<b>Physical</b>				
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%
<b>Voltage Contrast Ratio</b>				
(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	< $\lambda/8$	< $\lambda/8$	< $\lambda/8$	< $\lambda/8$
<b>Electrical</b>				
Capacitance @ 1 kHz	6pF	9pF	9pF	13pF
10-90% Rise time (50 $\Omega$ 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

- LiNbO<sub>3</sub>-based Pockels cell
- Preferably for Er:YAG-, Ho:YAG-, Tm:YAG laser
- For wavelengths up to 3 $\mu$ m
- Brewster cells BPZ 5 IR for laser with low amplification
- Compact design
- Wave front deformation: <  $\lambda/4$

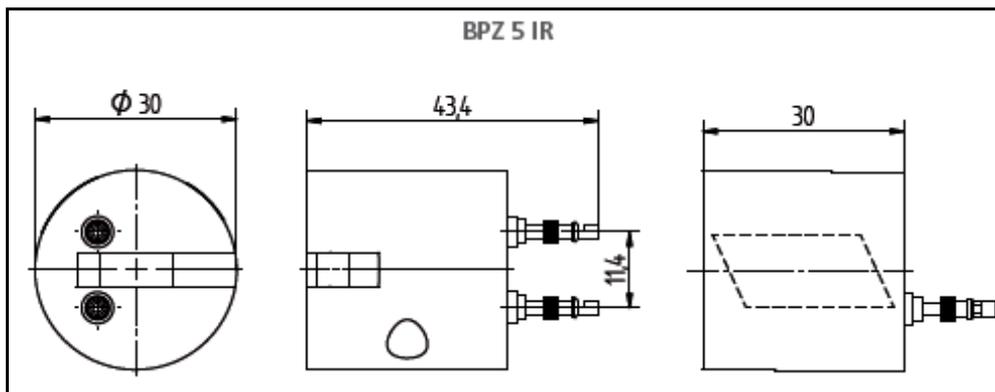
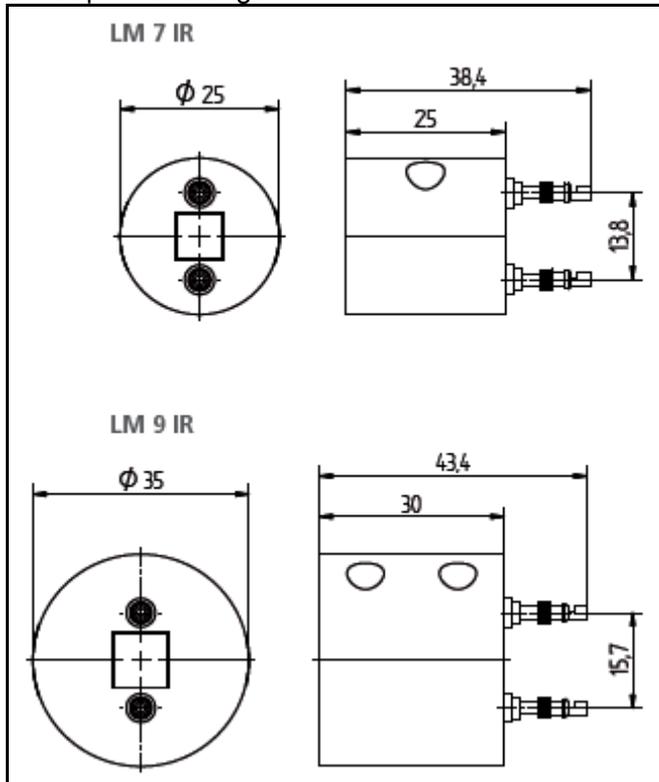
- Damage threshold: > 100MW/cm<sup>2</sup> at 1064nm, 10ns, 1Hz (typical, not guaranteed)

Please state the applied wavelength when ordering.

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

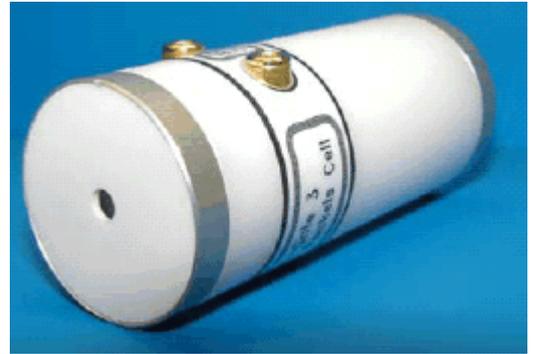
<sup>1)</sup> At 2 $\mu$ m wavelength

<sup>2)</sup> At 3 $\mu$ m wavelength

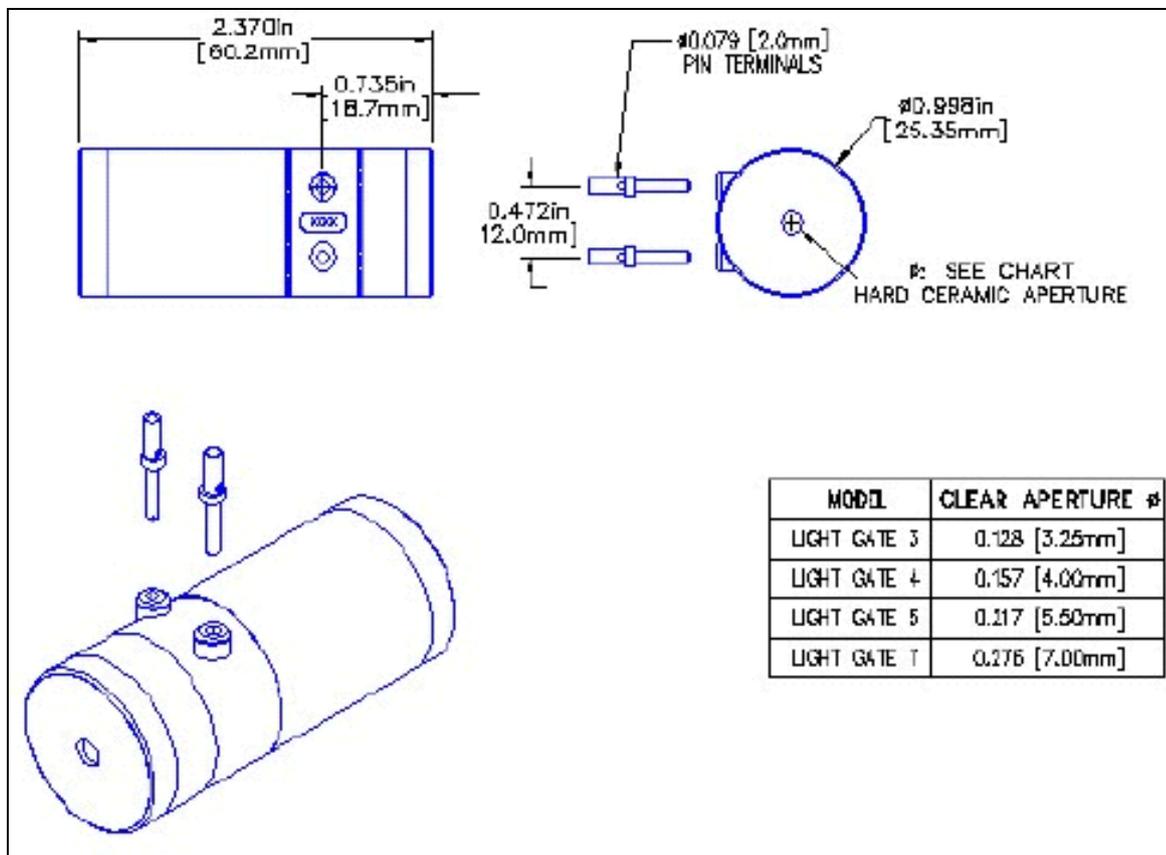


#### 4. LightGate Series BBO Pockels Cell

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



ICR	>2000:1
VCR	>500:1
Apertures	3.25mm, 4mm, 5.5mm & 7mm
Spectral range of operation	3-12 $\mu$ m (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	< $\lambda/6$



#### 5. BBO Pockels Cells

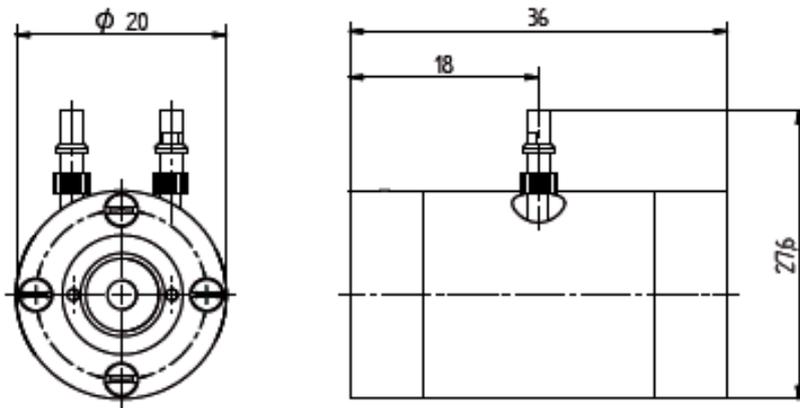
- BBO-based Pockels cell
- Suited for Q-switch applications with high repetition rates
- Wave front deformation: <  $\lambda/4$
- Damage threshold: > 300MW/cm<sup>2</sup> at 1064nm, 10ns, 1Hz (typical, not guaranteed)
- Optionally available with integrated Brewster polarizer: BBPC n BP
- Optionally available with integrated  $\lambda/4$  disk: BBPC n WP
- Optionally available with Piezo attenuator: BBPC n pp

Please state the applied wavelength when ordering.

Product Number	Wavelength (nm) <sup>1)</sup>	Clear Aperture (mm)	Transmission typical (%)	Extinction ratio (voltage-free)	$\lambda/4$ voltage <sup>2)</sup>	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

<sup>1)</sup> other wavelength available upon request. <sup>2)</sup> 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
- I/2 voltage at 355 nm: approx. 1.6 kV
- Wavefront distortion at 633 nm: I/4
- Windows: wedged, AR/AR at 355 nm

#### 6. IRX Series CdTe Pockels Cell

Initially designed to address the Q-switched CO<sub>2</sub> 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.



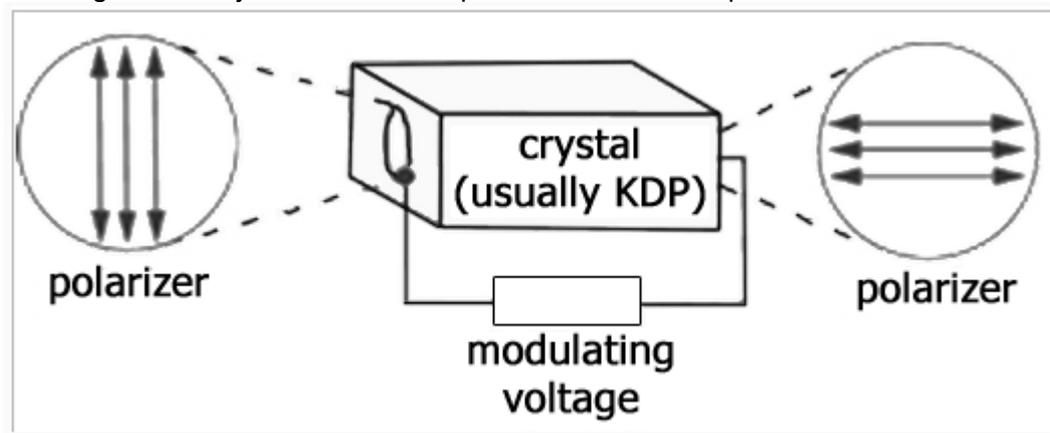
ICR	>500:1 @ 10.6µm
Apertures	3mm, 5mm, 7mm & 4 x 10mm*
Spectral range of operation	3-12µm (must specify single wavelength of operation)
Optical transmission	>98% at 10.6µm (other wavelengths available)
DC half-wave Voltage(for nominal 5mm aperture x 50mm length)	~ 5kV** @10.6µm

\* 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.

## EOQ Series Pockels Cell (EO Q-switch)

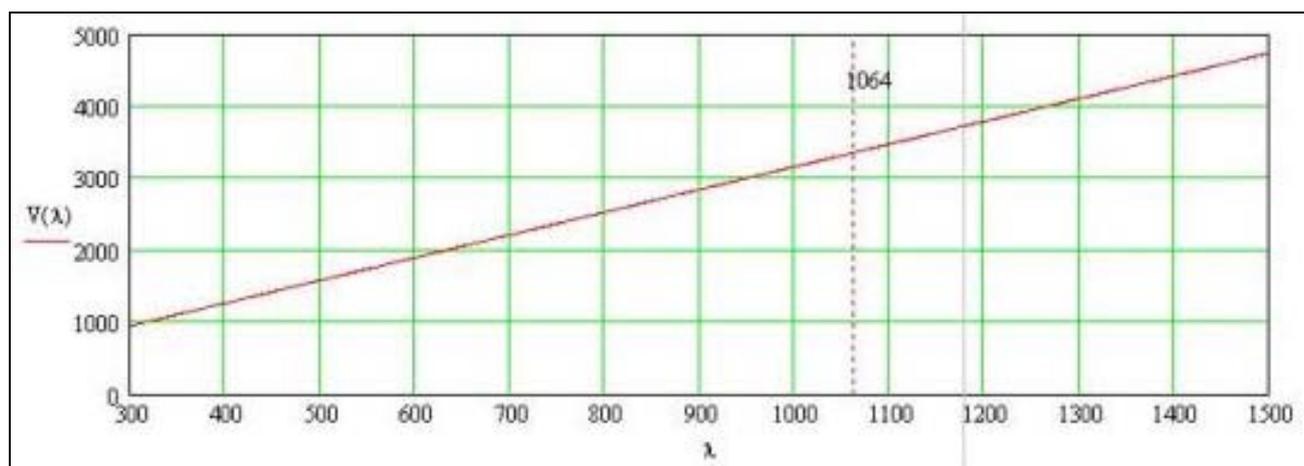
It is a device containing an electro-optic crystal and using the Pockels effect. A voltage applied across the crystal generates birefringence, causing plane-polarized light propagating through the crystal to be resolved into two orthogonal vectors. The change in retardation between the two vectors (ellipticity) is proportional to the magnitude of the electrical field. A crossed polarizer analyzes the output beam, resulting in intensity modulation. Response time can be in picoseconds.



### 1. EOQ Series KD\*P EO Q Switches

An E-O Q Switch 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. When used in conjunction with polarizers, these cells can function as optical switches, or laser Q-switches.

Our EO Q-switch employs the finest strain-free, highly deuterated KD\*P available. Based on our advanced crystal fabrication and coating technology, we can offer a variety of laser wavelengths EO Q switches which exhibit high transmission ( $T > 97\%$ ), high damaged threshold ( $> 500 \text{ W/cm}^2$ ) and high extinction ratio ( $> 2000:1$ ).



1/4Wave Voltage Vs Wavelength

### Applications:

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

FEATURES	BENEFITS
Quality - economically priced	Exceptional value
Finest strain-free KD*P	High contrast ratio
	High damage threshold
	Low 1/2 wave voltage
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
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
Damage Threshold	> 500 MW / cm <sup>2</sup> @1064nm, 10ns

#### Specifications:

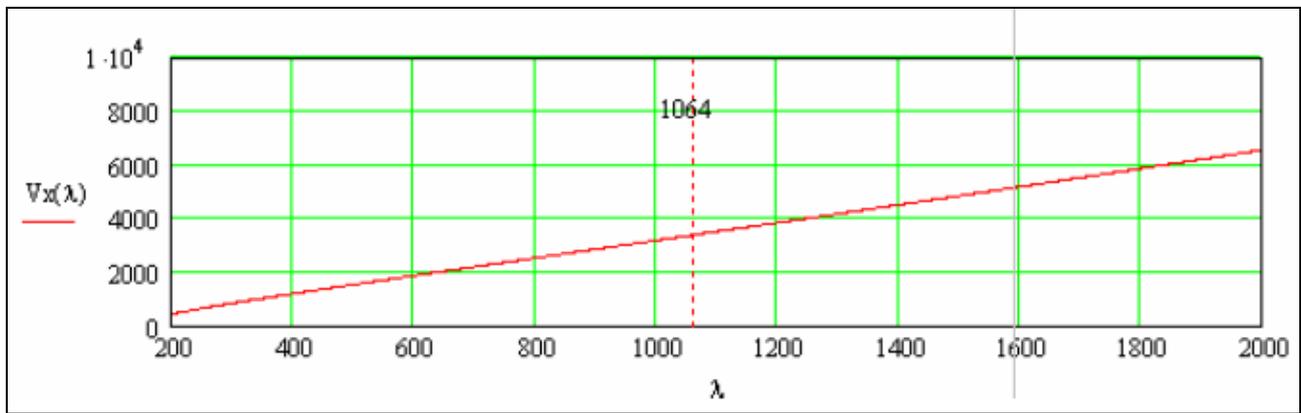
Housing Dimensions	EOQK-08	EOQK-10	EOQK-13
Aperture	8 mm	10 mm	13 mm
Length	39 mm	39 mm	45 mm
Diameter	25.35 mm	25.35 mm	25.35 mm

## 2. EOQ Series BBO EO Q Switches

BBO is one of the electro-optic material choices for high average power E-O Q Switch applications. BBO has significant advantages over other materials in terms of laser power handling abilities, temperature stability, and substantial freedom from piezoelectric ringing. Because it relies on the electro optic effect, switching time - aided by the low capacitance of the E-O Q Switch is very fast. The wide transparency range of BBO allows it to be used in diverse applications.

E-O Q Switch of EOQB series are transverse field devices. Low electro-optical coefficient of BBO results in high operating voltages. The quarter-wave voltage is proportional to the ratio of electrode spacing and crystal length. As a result, a smaller aperture device has lower quarter-wave voltage. However, even for 3mm aperture devices quarter-wave voltage is as high as 3.4KV@1064nm. Double crystal design is employed in order to reduce required voltages and allowing operation in half-wave mode with fast switching times.





1/4 Wave Voltage VS Wavelength

**FEATURES:**

- High Repetition Rate
- High peak power damage resistance
- Low absorption
- UV Transmission
- Low Acoustic Noise

**Applications:**

1. High repetition rate DPSS Q-Switch
2. High repetition rate Regenerative Amplifier control
3. Cavity Dumping
4. Beam Chopper

Part Number	EOQB-03	EOQB-04
Aperture Diameter	2.5mm	3.5mm
Quarter-Wave Voltage@ 1064 nm	3.4KV	4.5KV
Optical Transmission	>98%	>98%
Damage Threshold	> 500 MW / cm <sup>2</sup> @1064nm, 10ns	> 500 MW / cm <sup>2</sup> @1064nm, 10ns
Wavefront Distortion@ 1064 nm	< λ/8	< λ/8
Typical Capacitance	< 3pf	< 4pf
Outline dimension, mm	φ25.4×44	φ25.4×44

## 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-switched 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 <sup>1</sup>
Voltage, low level	fixed, 0 V
Repetition rate	up to 50 kHz (CW), up to 100 kHz (burst-mode) <sup>1, 2</sup>
Load	up to 0.5 nF <sup>1</sup>
Rise time (Fall time)	< 20 ns <sup>3</sup>
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

<sup>1</sup> These parameters aren't independent and cannot achieve their maximum at the same time...

<sup>2</sup> forced air cooling is required for operating with high repetition rates...

<sup>3</sup> 10-90% level; warranted at load capacitance 23 pF and below...

Part Number Description:

STQBD-XXYY-ZZ

STQBD – STQBD series EO Q-switch driver

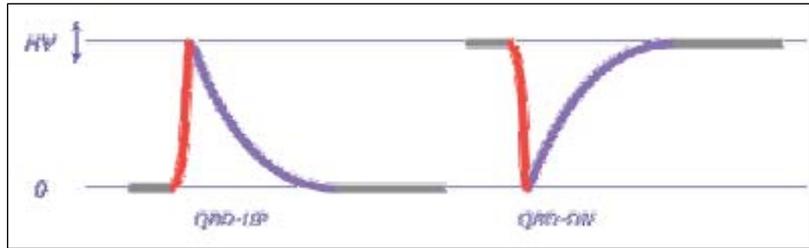
XX – maximum output voltage from 20 to 60 (2 - 6kV)

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).

STQBD-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 $\mu$ A
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 50 (2 - 5kV)

YY – minimum output voltage from 12 to 20 (1.2 – 2.0kV)

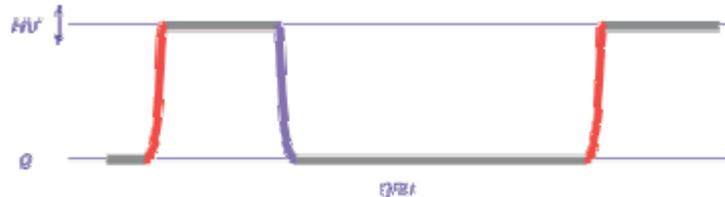
We offer four standard solutions:

STQBU-5020

STQBU-4016

STQBU-3012

STQBU-2008



### Options

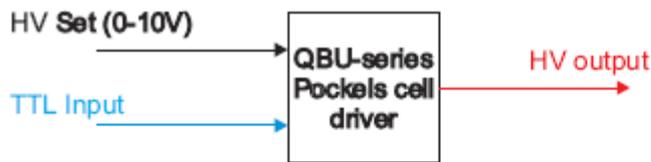
Adjustment range of output voltage (see figure) can be selected within the following model series: STQBU-5020 (2-5 kV), STQBU-4016 (1.6-4 kV), STQBU-3012 (1.2-3 kV), STQBU-2008 (0.8-2 kV). Time of rapid pulse growth (20 ns) is indicated red on figure time of same rapid slump is indicated blue (20 ns).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

## Working Scheme



TTL input of almost arbitrary shape



HV output follows TTL input with short rise/fall times



## 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. STLDF Series Pulsed Lamp Drivers with EO Q-switch Drivers

STLDF series flashlamp-pumped laser power supplies are designed to drive solid state-state lasers and EO Q-switches. Power supplies are complete pumping solutions and include all required modules - bank of storage capacitors, charging module and discharging circuit with triggering and simmer modules.

Power supplies are performed accordingly to 19-inch specification. Height is 4U. Embedded touchscreen controlled computer allows changing of all principal parameters such as output voltage, flashlamp pulse duration and pulse repetition rate.

### Description of Part Number: STLDF-xx-yyy

STLDF: STLDF series drivers

xx : max output power. 17 means 1.75kW; 35 means 3.5kW

yyy : Pockels cell driver. QBD or QBU.

For example, STLDF-35-QBD: 30.5kW output power with an EO Q-switch driver QBD.

Input:

Voltage 230VAC \*

Output:

Max. voltage up to 1000 V \*

Max. output power up to 3.5 kW \*

Pulse width 0.1-20 ms \*

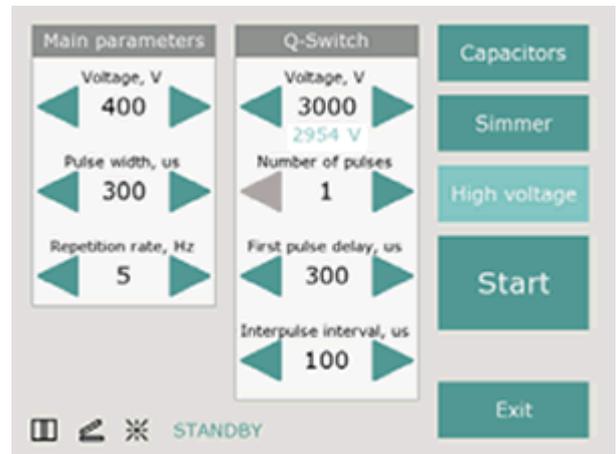
Repetition rate up to 200 Hz \*

Simmer supply:

Simmer current up to 800 mA



Triggering voltage	1000 V
Triggering pulse width	1us
Triggering pulse energy	110 mJ
Restrike rate	approx. 30 Hz
Capacitor bank	28000 uF *
Efficiency	85-90%
Protection	overvoltage, overheating, flashlamp breakdown, interlock
Environment:	
Operation Temperature	0...+40 C
Humidity	90%, non-condensing
Size (LxWxH)	500 x 315 x 172 mm
Weight	10 kg
* -other values are available on request	



By default the laser power supply is supplied in serial triggering and partial discharge modification. Modifications for external triggering or complete discharge are available on request. Also the laser power supply can be equipped with Pockels cell driver (Q-switch driver). In this case user obtains a possibility to control output voltage level and delay between flashlamp pulse start and Q-switch pulse (pulses). This ability is significant for adjusting user system for best performance.

### Options

Three standard output power levels are available:

- 1.75kW, PFC > 0.85
- 3.5kW, PFC > 0.85
- 2 kW, PFC > 0.98

A variety of output voltages, longer pulse duration, complete discharge, parallel or serial triggering, embedded or external Pockels cell driver are available on request.

## 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/e<sup>2</sup> value)? Please specify as Radius or Diameter.

Ans :

3 What is the beam profile (Gaussian, 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 :

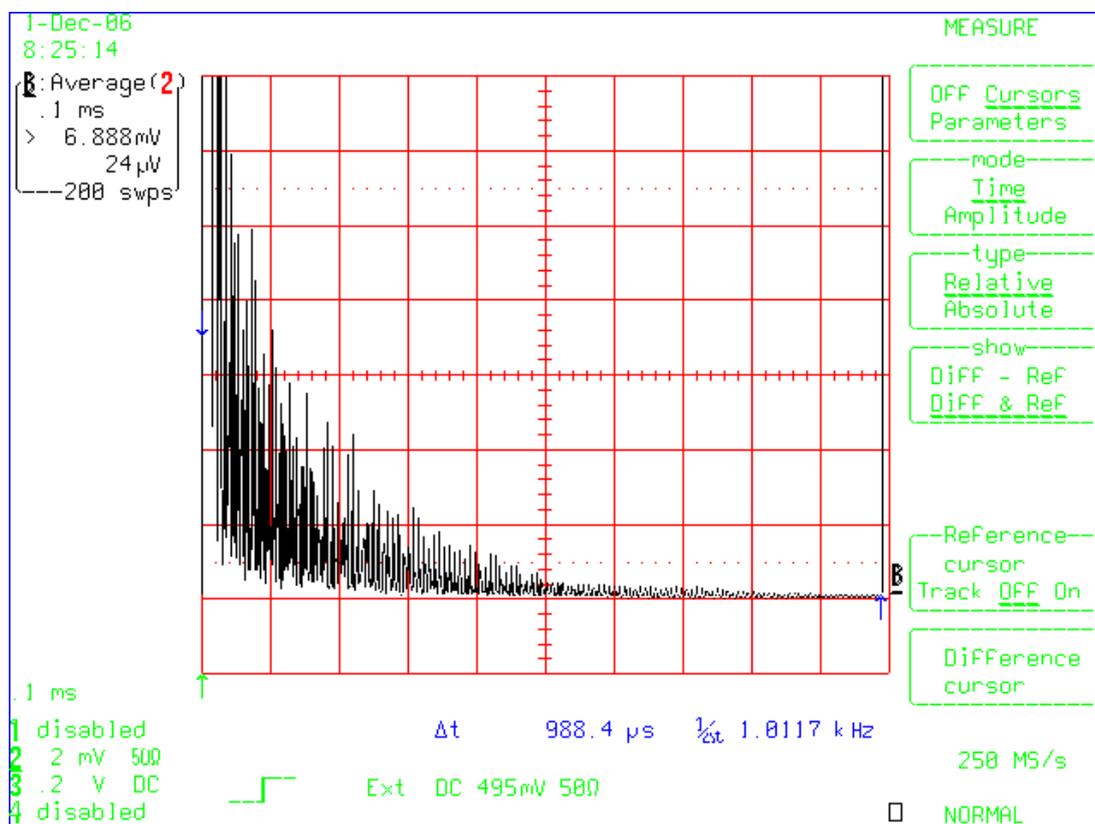
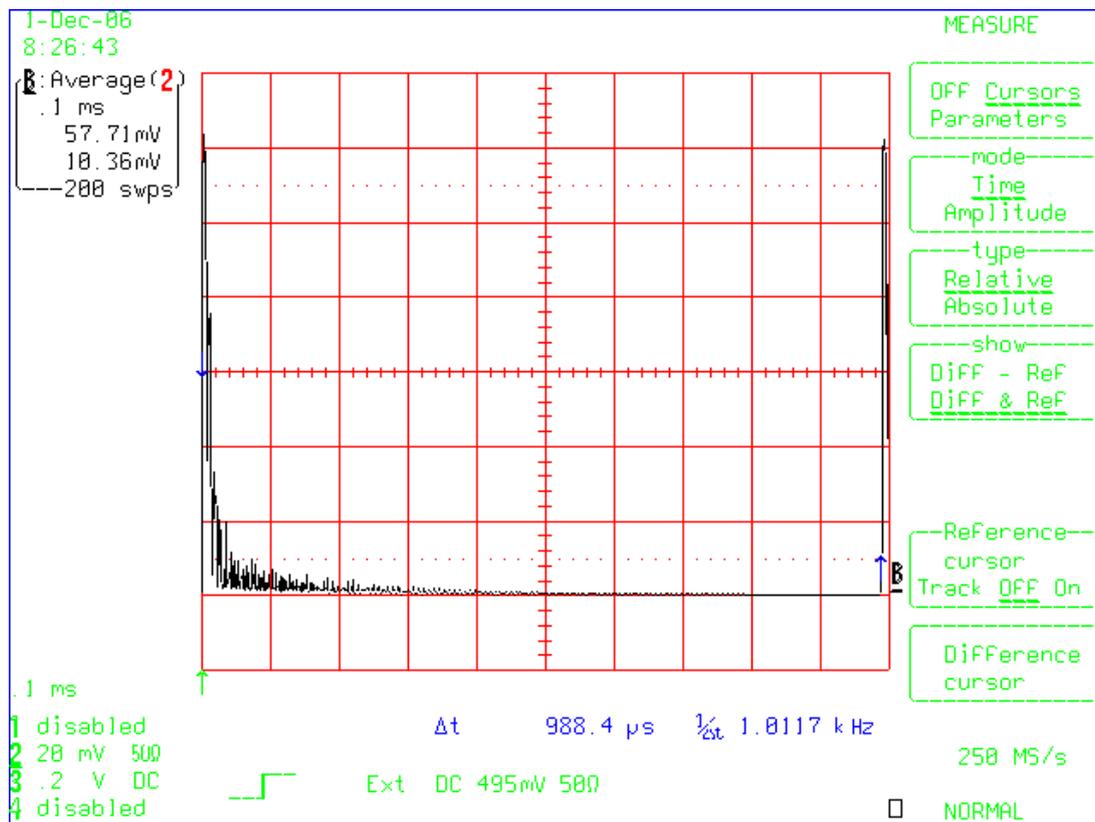
15 What quantity do you require?

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 "ringing" 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 it 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 in 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 ( $1/e^2$ ). 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 customer's 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/qswitchDriver.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. KDP 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 style (DT, TK, TN).