PBC Model

BBO Pockels Cells

FEATURES

- High average power handling
- Minimal acoustic ringing at high repetition rates
- High peak power damage resistance
- UV Transmission

BBO is the electro-optic material of choice for high average power Pockels cell applications.

BBO has significant advantages over other materials in terms of laser power handling abilities, temperature stability, and substantial freedom from piezoelectric ringing.[1,2] Because it relies on the electro optic effect, switching time -- aided by the low capacitance of the Pockels cell -- is very fast. The wide transparency range of BBO allows it to be used in diverse applications.[3]

Electro-optic Pockels cells are used in applications that require fast switching of the polarization direction of a beam of light. These uses include Q-switching of laser cavities, coupling light in to and out from regenerative amplifiers, and, when used in conjunction with a pair of polarizers, light intensity modulation.

Pockels cells are characterized by fast response, since the Pockels Effect is largely an electronic effect that produces a linear change in refractive index when an electric field is applied, and are much faster in response than devices based on acoustic changes in a material, for example.

Because of crystal symmetry and the desire for the light beam to experience no birefringence in the absence of an electric field, INRAD BBO Pockels cells are transverse-field devices.

The quarter-wave voltage, $V_{\lambda/4} = \lambda d / (4\, r_{22}\, n_o^3\, l)$, is proportional to d/l, the electrode spacing divided by the crystal length, is inversely proportional to the electro-optic coefficient[4] r_{22}, and decreases when operated at shorter wavelengths, λ.

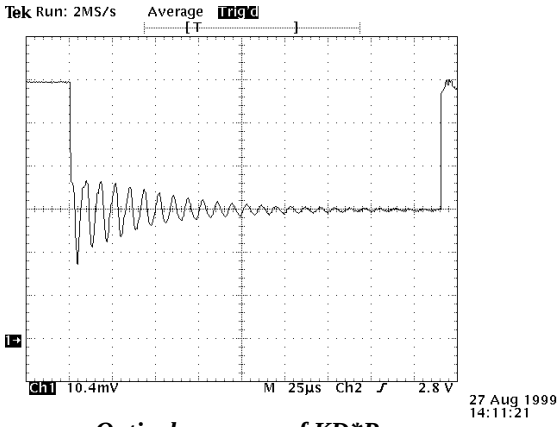
The standard INRAD BBO Pockels cell, PBC05-DC04, is a single-crystal device with a 3.5 mm aperture and a quarter-wave voltage at 1064 nm of 4.8 kV. Single-pass transmission of the cell at the design wavelength is > 98%.

The compact PBC05 Q-switch housing is 1" in diameter and 2" long. Electrical connection is made by way of miniature banana connectors; mating connectors are provided with each BBO Pockels cell.

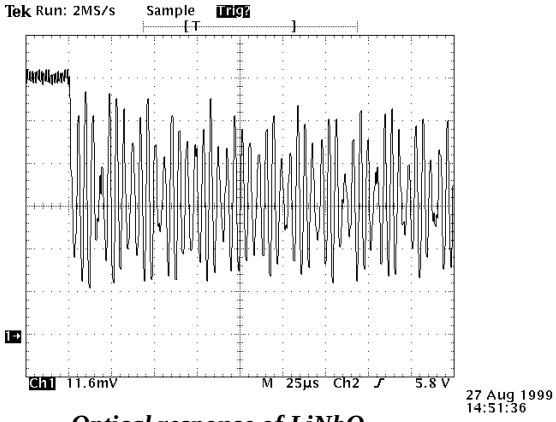
A smaller aperture BBO Pockels cell, the PBC05-DC03, has a 2.5 mm aperture with a quarter-wave voltage of 3.4 kV at 1064 nm. Larger aperture devices, with two crystals in series, are offered under our PBC06 series. In addition, custom-designed Q-switches are available.

Piezoelectric ringing in BBO is small, as evidenced by comparison to KD*P and $LiNbO_3$ Pockels cells. Transmission of a test laser beam at 633 nm, with the Pockels cell placed between parallel polarizers, is shown in the following oscilloscope traces. Application of the quarter-wave voltage for each cell causes the transmitted light intensity to decrease to one-half. Operation at the quarter-wave voltage accentuates the appearance of acoustic ringing. In the traces, the 1→ indicates ground or zero light intensity. Plots are shown using KD*P, $LiNbO_3$, and BBO as the Pockels cell material.

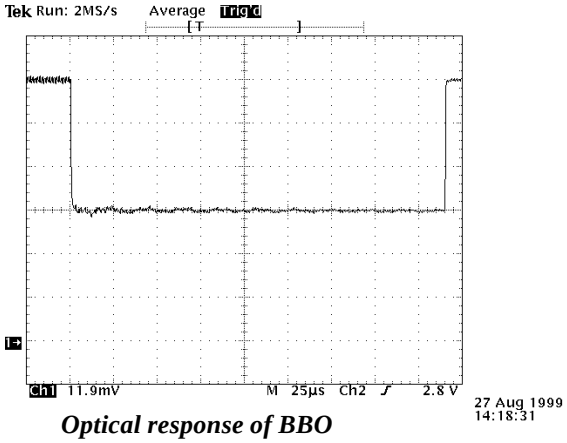
Clearly, ringing associated with use of BBO is much less than when either KD*P or $LiNbO_3$ is used. The last trace shows the transmission with BBO in the typical double-pass configuration at the quarter-wave voltage, switching at 5 kHz -- the maximum rate allowed by the high voltage driver that was used. In this last trace, intensity is a maximum when voltage is applied; the bottom trace was taken with the laser beam blocked.



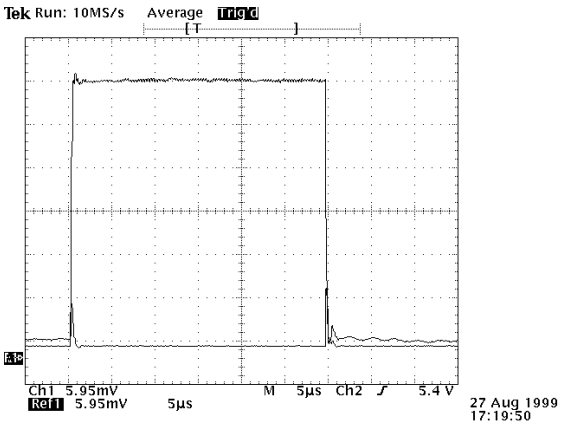
Optical response of KD*P Pockels cell.



Optical response of $LiNbO_3$ Pockels cell.



Optical response of BBO Pockels cell.

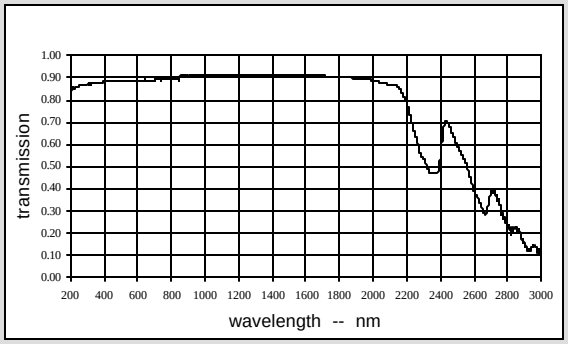


Optical response of BBO Pockels cell. Lower trace is with beam blocked

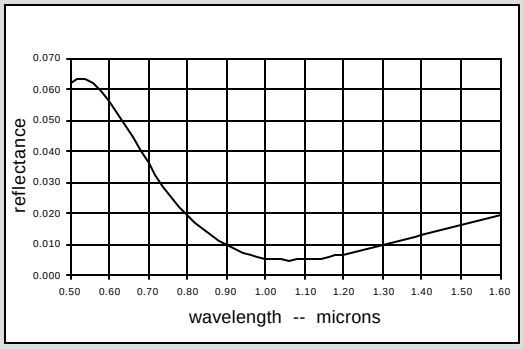
BBO POCKELS CELL SPECIFICATIONS

Model Number	PBC05-DC04/1064	PBC05-DC03/1064	PBC06-DC06/1064	PBC06-DC04/1064
Aperture Diameter	3.5 mm	2.5 mm	5.5 mm	3.5 mm
Number of Crystals	one		two	
Quarter-Wave Voltage @ 1064 nm	4.8 kV	3.4 kV	3.6 kV	2.4 kV
Intrinsic Contrast @ 1064 nm	> 1000 : 1		> 500:1	
Optical Transmission	> 98 % T		> 97 % T	
Damage Threshold* (Nanosecond Pulses)	> 500 MW / cm^2 @1064nm, 10ns *			
Damage Threshold* (cw Power)	> 3 kW / cm^2			
Wavefront Distortion @ 1064 nm	< λ / 8			
Electrical Contacts	two, electrically floating, miniature banana plugs			
Typical Capacitance	3 pF	3 pF	4.5 pF	5 pF
Outline Dimensions	1" Diameter x 2" Long Cylinder		1.25" Diameter x 2.7" Long Cylinder	

**** Damage Threshold values are for reference only and are not guaranteed.***



Transmission of uncoated, 8mm thick sample of BBO. Discontinuity at 850nm is an experimental artifact.



Reflectance of standard 1064 nm AR coating on BBO Q-switch.

INRAD offers a line of high-voltage drivers that are suitable for operating INRAD Q-switches.

The drivers are either of the boxed variety or of the printed circuit board (pcb) type. The boxed variety are powered from line voltage; they have convenient knobs, switches, and connections by which to adjust the driver high voltage level, set the transition time, and access high voltage and timing signals

2-019 and 2-020 Fast Switching driver

These solid-state drivers feature switching times of less than 15 nanoseconds. The 2-019 switches quickly from the high voltage setting to ground with a slower recovery time; the 2-020 switches quickly from ground to the high voltage setting with a slower recovery time. Maximum repetition rate is 100 Hz.

2-021 High Repetition Rate Shutter Driver

This solid state, high voltage driver follows a 5-volt gating signal and features up and down transition times of less than 25 nsec. Maximum repetition rate is 5 kHz. The voltage is adjustable up to 5.5 kV through action of a potentiometer on the front panel of the controller. The lag between gating change and high voltage application is less than 350 nsec. The high voltage pulse can be held high for a minimum of 5 µsec; there is no maximum limit to how long it can be held high.

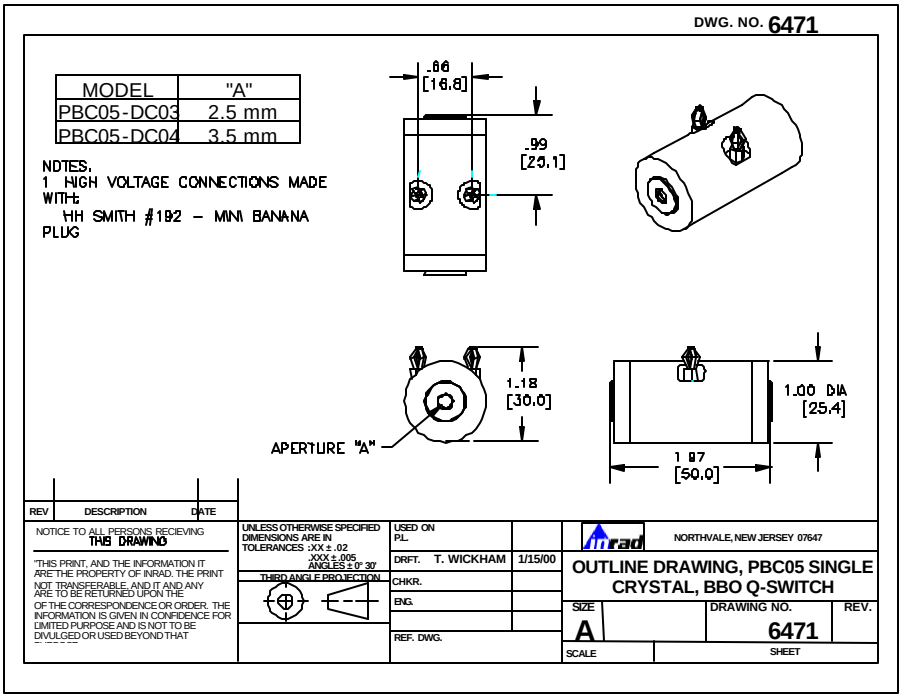
2-022 High Repetition Rate Shutter Driver

This solid state, high voltage driver follows a 5-volt gating signal and features up and down transition times of less than 20 nsec. Maximum repetition rate is 100 Hz. The voltage is adjustable up to 6.0 kV through action of a potentiometer on the front panel of the controller. The lag between gating change and high voltage application is less than 250 nsec. The high voltage pulse can be between 5 µsec and 500 µsec.

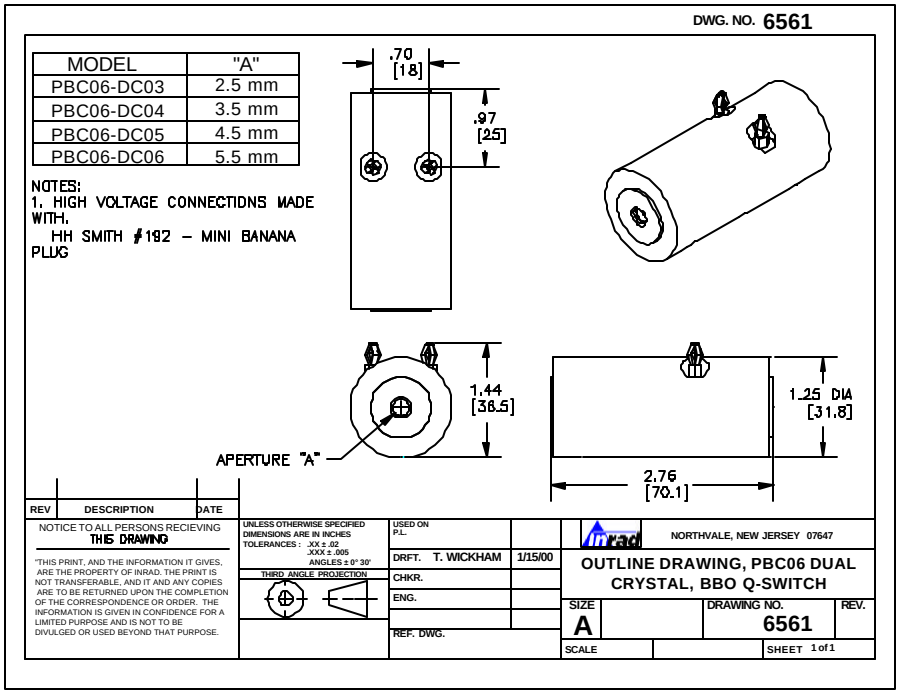
HIGH VOLTAGE POCKELS CELL DRIVER SPECIFICATIONS

Model Number	2-019	2-020	2-021	2-022
Fast Transition	- HV → 0 V	0 V → - HV	0 V → HV and HV → 0 V	0 V → HV and HV → 0 V
HV Output Adjustment	0 to –3.5 kV	0 to –3.5 kV	0 to 5.5 kV	0 to 6 kV
Rise Time	15 nsec	15 nsec	25 nsec	20 nsec
Fall Time (or Recovery Time)	< 150 µsec	< 10 msec	25 nsec	20 nsec
Maximum Repetition Rate	100 Hz	100 Hz	5 kHz	200 Hz
Package	box	box	box	box

PBC05 OUTLINE DRAWING



PBC06 OUTLINE DRAWING



LITERATURE CITED

1. G.D.Goodno, Z.Guo, R.J.D.Miller, I.J.Miller, J.W.Montgomery, S.R.Adhav, and R.S.Adhav, Investigation of β-BaB_2O_4 as a Q switch for high power applications, *Appl. Phys.Lett.* ***66***(13), 1575 (1995).
2. E.Cheung, S.Palese, H.Injeyan, C.Hoefer, J.Ho, R.Hilyard, H.Komine, J.Berg, and W.Bosenberg, High Power Conversion to Mid-IR Using KTP and ZGP OPOs, OSA TOPS Volume 26, page 514, Advanced Solid State Lasers (1999).
3. S.J.Hamlin, R.Wu, L.A.Bosworth, J.A.Hutchinson, L.T.Marshal, and T.Caughey, BBO Electro-optical Q-switch @ 1.54 μm, OSA TOPS Volume 19, page 171, Advanced Solid State Lasers (1998).
4. H.Nakatani, W.Bosenberg, L.K.Cheng, and C.L.Tang, Linear electro-optic effect in barium metaborate, *Appl. Phys.Lett.* **52**(16), 1288 (1988).

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