OEM Tech
LASER ELECTRONICS

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Pockels cell driver selection guide (as of Aug. 2022)

A Pockels cell driver is a kind of special high-voltage source, nanosecond pulsed electric field (nsPEF) generator, optimized for operation with capacitive-type of loads, designed to produce a fast-switching voltage pulses to control the birefringence of an electro-optical crystal for manipulating the polarization state of light passing through. By this way, one obtains a voltage-controlled wave plate and a possibility to change optical system parameters.

The most of our devices are bipolar when an output pulse voltage U is formed by applying +U/2 to positive output wire and –U/2 to negative. Exception is unipolar QBU-nano and switches HVSW-03 and -04 with alternate polarity of pulses. The pulse forming circuits of drivers are based on full-bridge topology (MHz rate switches HVSW-03 and -04), or a half-bridge concept (other drivers). All given performance values are valid for continuous mode operation, for burst mode (short pulse sequences separated by pauses) they rise sometimes twice.

APPLICATIONS

- *Q-switching*
- *Cavity dumping*
- *Pulse picking & Pulse slicing*
- *Regenerative amplifier control*
- *Low-energy consumption applications (battery-operated devices)*
- *Beam deflection*
- *Light modulation, piezo and MEMS actuators, ultrasonic devices*

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QBD-series

fast leading edge
ideal for q-switching
pulses up or pulses down
(factory fixed)




	QBD-nano	QBD-mini	QBD	QBD-BT
size, mm	40x30x8	90x50x20	110x80x25	225x180x70
output voltage	up to 5 kV	up to 4.0 kV	up to 6.0 kV	up to 6 kV
max. repetition rate	> 1 kHz @ 5 kV	> 10 kHz @ 4 kV	> 10 kHz @ 6 kV	> 10 kHz @ 6 kV
leading edge	1-3 ns	< 20 ns	< 20 ns	< 20 ns
input	5 V DC	24 V DC	24 V DC	100-240 V AC
	pulses up only			

QBU-series

both edges are fast, operating frequency and pulse width are set by an external pulse generator
suitable for pulse slicing, pulse picking and other advanced applications







	QBU-nano	QBU-mini	QBU-mini-SP	QBU	QBU-BT	QBU-10kV	QBU-BT-10kV
size, mm	80x50x20	140x50x20	102x50x20	130x80x25	225x180x70	132x105x50	300x220x80
out. voltage	up to 5.8 kV	up to 4 kV	up to 4 kV	up to 6 kV	up to 6 kV	up to 10 kV	up to 10 kV
max. rep. rate	>2 kHz @ 3.8 kV	> 8 kHz @ 4 kV	> 8 kHz @ 4 kV	> 10 kHz @ 6 kV	> 10 kHz @ 6 kV	>5 kHz @ 10 kV	>5 kHz @ 10 kV
rise / fall time	1-3 ns	< 15 ns	< 10 ns	< 15-20 ns	< 20 ns	< 20 / 25 ns	< 20 / 25 ns
input	12 V DC	24 V DC	24 V DC	24 V DC	100-240 V AC	24 V DC	100-240 V AC
	unipolar output						

HIGH REPETITION RATE POCKELS CELL DRIVERS

specialized drivers for pico- and femtosecond lasers
suitable for pulse picking and other advanced applications

HVSW-03

- output voltage up to 2 kV
- repetition rate up to 1 MHz @ 1.6 kV
- pulse width 14 ns (short pulse mode), or 100-2000 ns (long pulse mode)
- < 7 ns rise /fall time
- 24 V DC input (integrated HV power supply)

HVSW-04

- output voltage up to 4 kV
- repetition rate up to 4 MHz @ 1.4 kV
- pulse width 15-20 ns (short pulse mode) or 100 - 2000 ns (long pulse mode)
- < 7 ns rise /fall time @ 1 kV
- water cooling

ARBITRARY WAVEFORM POCKELS CELL DRIVER

specialized driver, based on voltage amplifier
for light modulation, beam deflection, piezo and
MEMS actuators, ultrasonic devices

QBX-08

- output voltage up to 800 V (1.6 kV on request)
- repetition rate ~50 kHz @ 0.8 kV, 60pF
- < 1 us rise / fall time
- 24 V DC input (integrated HV power supply)

ENERGY-EFFECTIVE POCKELS CELL DRIVER

specialized driver with extremely low power
consumption, for Q-switching, pulse slicing,
battery-powered equipment

QBY-4050

- output voltage up to 5 kV
- repetition rate ~50 kHz @ 4 kV
- < 40 ns rise / fall (< 20 ns on request)
- pulses 40-1000 ns long
- 24 V DC input
- compact - 112x108x25 mm

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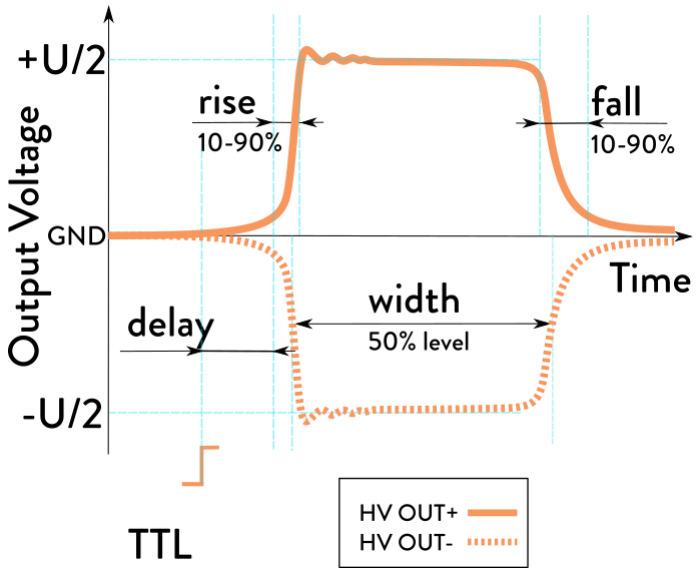
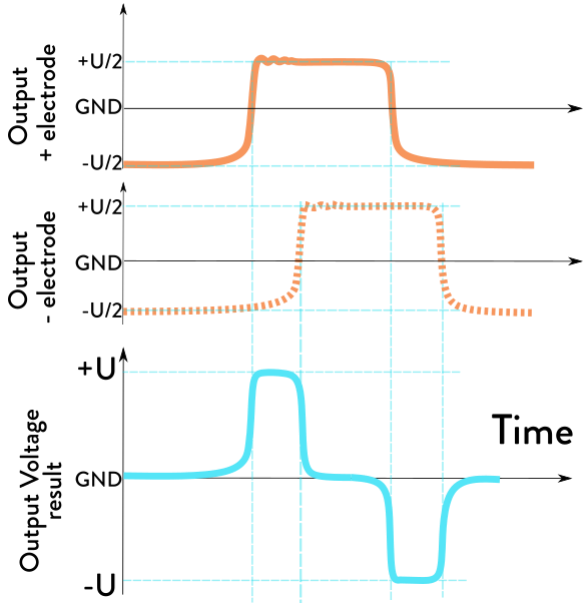
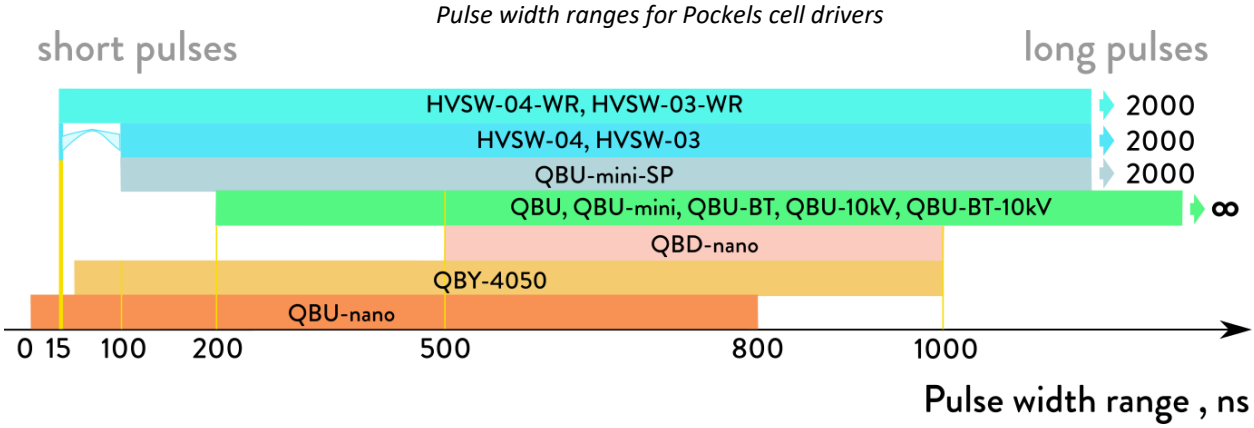
Output pulse U by bipolar module is formed by applying +U/2 to positive output wire and –U/2 to negative



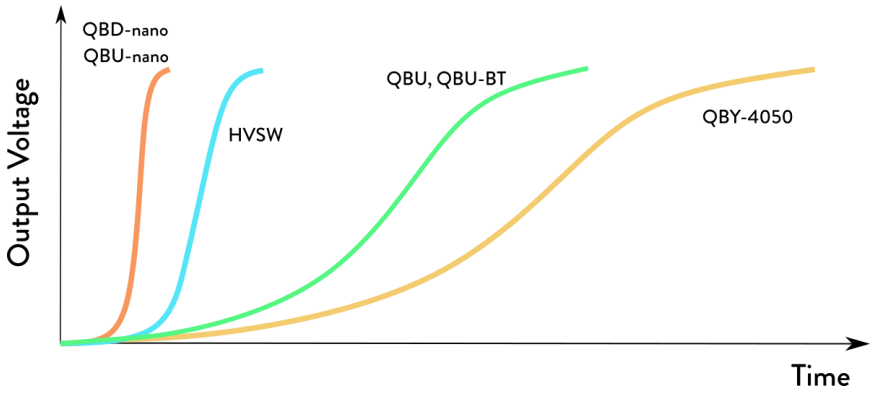
Output voltage result in case of full-bridge driver topology represents pulses of alternating polarity



Pulse width ranges for Pockels cell drivers



Rise-time diagrams for different driver series



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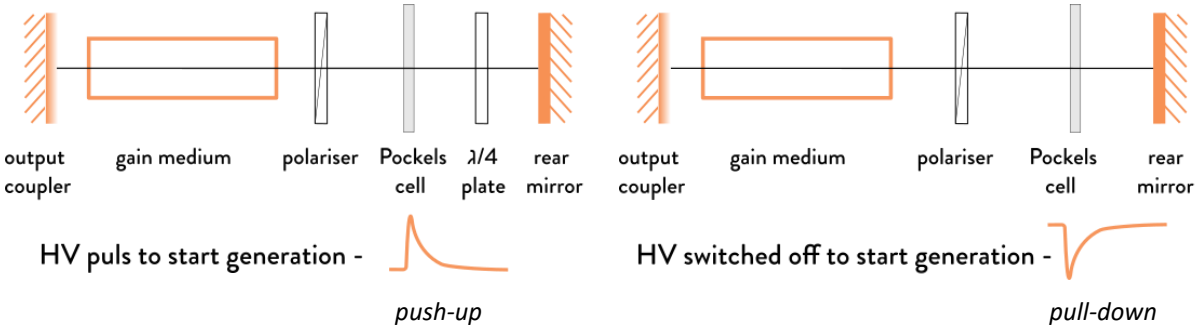
Q-switching

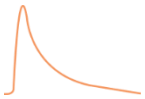
The idea is to vary resonator losses: during the high losses there are no generation, but the gain media is accumulating pumping energy; after fast switching to low losses the generation starting from noise takes place.

As it takes time for the active switched method to build up gain from several resonator passes, the application is not very demanding to the switching time value, some tens of nanoseconds are suitable. Usual repetition rates for Q-switching are tens of kHz. With higher rates gain medium fails to recover, energy of one pulse becomes lower, duration longer, and a pulse drop-out occurs. With lower repetition rates a probability of cavity energy loss due to spontaneous emission rises.

There are different schemas to use Pockels cell driver for Q-switching:



QBD-series drivers for Q-switching are relatively simple, allow to change output voltage level and pulse repetition rate. They provide pulses with fast leading edge (< 20 ns) and relatively slow (some µs) trailing edge. Exact performance depends on actual load capacitance and cooling conditions.



	HV output	repetition rate	pulses	others
Usually we recommend the next series:				
QBD-mini	up to 4 kV	>10 kHz @ 4 kV	push-up or pull-down (factory fixed)	PCB's of reasonable price, rise time < 20 ns
QBD	up to 6 kV	>10 kHz @ 6 kV		
QBD-BT				Bench-top version of QBD
Sometimes compactness is important:				
QBD-nano	up to 5 kV	>1 kHz @ 5 kV	push-up only	avalanche transistor driver, super-fast (1-3 ns rise), fixed pulse duration (~0.7 µs), tiny (40x30x8 mm)
For advanced Q-switching scenarios - ringing suppression or when a high voltage for pull-down scheme should be switched on shortly before generation (to prolongate crystal life-time):				
QBU-mini	up to 4 kV	>8 kHz @ 4 kV	push-up or pull-down pulses	Compact version of QBU, rise/fall <15 ns,
QBU-mini-SP				rise/fall <10 ns, 100-2000 ns pulses
QBU	up to 6 kV	>10 kHz @ 6 kV		quasi-square pulses, rise/fall <20 ns, switching could be controlled by external random TTL signal
QBU-BT				Bench-top version of QBU

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Sometimes a very high voltage is needed to operate a Pockels cell in a half-wave regime:				
QBD-10kV	up to 10 kV	>5 kHz @ 10 kV	push-up or pull-down (factory fixed)	On request, please, ask us for further details
QBU-10kV			push-up or pull-down	quasi-square pulses, rise/fall <25 ns, switching could be controlled by external random TTL signal
QBU-10kV-BT			pulses	Bench-top version of QBU-10kV
Low power consumption driver:				
QBY-4050 (technology demonstrated)	up to 5 kV	>50 kHz @ 4 kV	push-up only	rise/fall < 40 ns (< 20 ns possible), switching by external LVDS signal, < 10 W power consumption @ 5 pF 50 kHz, 150 ns pulse, 4 kV
QBU	On request, please, ask us for further details. We have invented a technology to significant reduction of driver power consumption			
QBD				

Cavity Dumping

If the energy in a high-Q resonator is stored in radiation, not in a pumped gain medium, one can couple it out in a time of resonator round-trip (a few nanoseconds) with a help of some arrangement. Such an effective fast dumping element could be a Pockels cell inducing a rapid polarization change in combination with a polarization selective output coupler.

The Pockels cell switching time in this case should be less than resonator round-trip time, as the radiation is "ready" to be extracted, one doesn't need time to generate a pulse. Drivers for cavity dumping allow to change output voltage level and pulse repetition rate. For HVSW-models a pulse duration is also changeable (~15-2000 ns, please, see detailed information in product manual on the product page).

	HV output	repetition rate	pulses	others
Usually we recommend:				
QBD-nano	up to 5 kV	>1 kHz @ 5 kV	push-up only 1-3 ns rise	avalanche transistor driver, fixed pulse duration ~0.7 µs, tiny - 40x30x8 mm
Sometimes the next fast drivers could be useful:				
HVSW-03	up to 2 kV	1 MHz @ 1.6 kV	push-up only rise/fall < 7 ns	full-bridge topology, pulses 14 - 2000 ns
HVSW-04	up to 4 kV	4 MHz @ 1.4 kV	push-up only rise/fall < 7 ns @ 1 kV	full-bridge topology, pulses 15 - 2000 ns, water cooled, requires an external HV source

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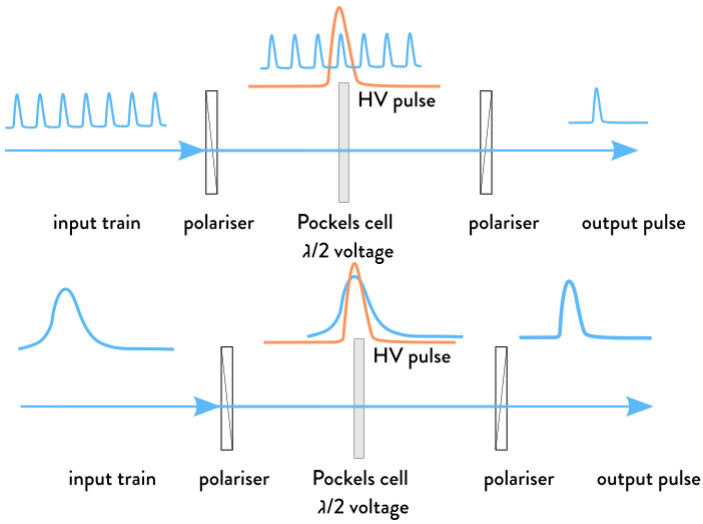
Pulse Picking & Pulse slicing

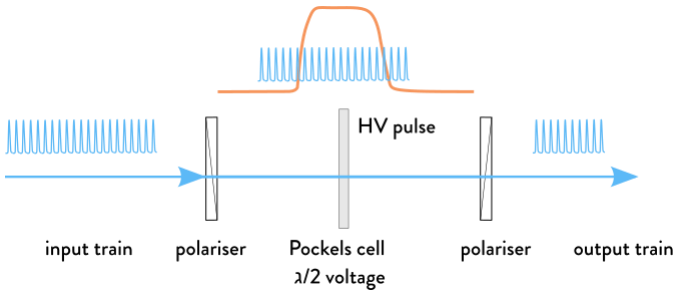
Fast switching of Pockels cell in a half-wave regime for a time enough to single pulse pass through the cell rotates this pulse polarisation and thus allows select a single pulse from pulse train.
The idea could be used for:

- *picking of single laser pulses from a train of pulses*
- *resampling down the repetition rate of a pulsed laser*
- *input/output of pulses into/from the regenerative amplifier*
- *pulse slicing (pulse clean-up), i.e., truncating unwanted radiation before leading edge and after trailing one*
  Typical single pulse duration in mode locked trains is sub 100 ps, the distance between two pulses is 7-12 ns, so one need a fast-switching driver.



	HV output	repetition rate	pulses	others
Usually we recommend:				
HVSW-03	up to 2 kV	1 MHz @ 1.6 kV	push-up only rise/fall < 7 ns	full-bridge topology, pulses 14 - 2000 ns
HVSW-04	up to 4 kV	4 MHz @ 1.4 kV	push-up only rise/fall < 7 ns @ 1 kV	full-bridge topology, pulses 15 - 2000 ns, water cooled, requires an external HV source
Sometimes compactness is important:				
QBU-nano	up to 5.8 kV	>2 kHz @ 3.8 kV	push-up only rise/fall 1-3 ns	avalanche transistor driver, unipolar, pulse duration 0-800 ns, small 80x50x20 mm

By similar way it is possible to select a short pulse train from long input one.



	HV output	repetition rate	pulses	others
Usually we recommend:				
QBU-mini	up to 4 kV	>8 kHz @ 4 kV	push-up or pull-down pulses	Compact version of QBU, rise/fall <15 ns,
QBU-mini-SP				rise/fall <10 ns, 100-2000 ns pulses
QBU	up to 6 kV	>10 kHz @ 6 kV		quasi-square pulses, rise/fall <20 ns, switching could be controlled by external random TTL signal
QBU-BT				Bench-top version of QBU

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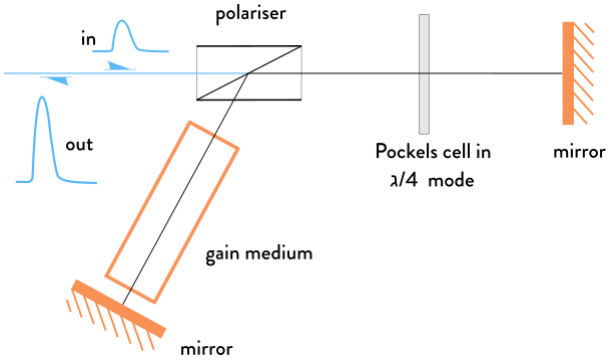
Regenerative amplifier control

Fast switching of Pockels cell in a quarter-wave regime when a pulse is just before Pockels cell for the time enough to pass through the cell, reflect and pass the cell again, rotates the pulse polarisation and makes it trapped in the resonator cavity and circulated inside, amplifying itself. To let the pulse leave the resonator, the quarter-wave voltage should be applied again to the Pockels cell (at the right moment again, the pulse should be to the left towards the cell, see the picture).



Different setup geometry is possible, but the main requirement for the Pockels cell driver remains the same, the switching time should be very fast, much less than resonator round-trip time.

	HV output	repetition rate	pulses	others
Usually we recommend:				
HVSW-03	up to 2 kV	1 MHz @ 1.6 kV	push-up only rise/fall < 7 ns	full-bridge topology, pulses 14 - 2000 ns
HVSW-04	up to 4 kV	4 MHz @ 1.4 kV	push-up only rise/fall < 7 ns @ 1 kV	full-bridge topology, pulses 15 - 2000 ns, water cooled, requires an external HV source
Sometimes the next small and fast QBU-nano driver or QBU-mini-SP could be useful:				
QBU-nano	up to 5.8kV	>2 kHz @ 3.8 kV	push-up only rise/fall 1-3 ns	avalanche transistor driver, unipolar, pulse duration 0-800 ns, small 80x50x20 mm
QBU-mini-SP	up to 4 kV	>8 kHz @ 4 kV	push-up or pull-down pulses	rise/fall <10 ns, 100-2000 ns pulses switching could be controlled by external random TTL signal

Low-energy consumption applications (battery-operated devices)

For a battery-powered system we have developed a special low-energy consumption Pockels cell driver technology. The demo item was constructed for definite client with the next features: compact – 112x108x25 mm, light-weighted – app 0.2 kg, 10 W consumption (50 kHz, 4 kV) – no cooling is needed. The same approaches to reducing the energy consumption could be used for modification of other our existing series.

	HV output	repetition rate	pulses	others
Low power consumption drivers:				
QBY-4050 (technology demonstrated)	up to 5 kV	~50 kHz @ 4 kV	40-1000 ns up only	< 40 us rise / fall time, 5 pF load faster on request
QBU	On request, please, ask us for further details. We have invented a technology to significant reduction of driver power consumption			
QBD				

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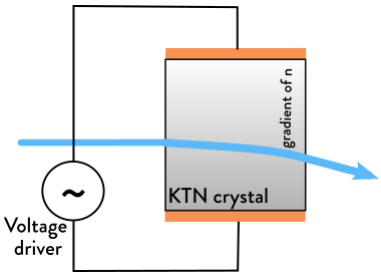
Beam deflection

One of the laser beam deflection technics, using for ex. in optical beam scanners, is based on a change of material refractive index by applied electric field (Electro-Optical Deflector, EOD). The advantage of the EOD is a high speed of deflection and a random-access to target.



Light modulation, piezo and MEMS actuators, ultrasonic devices

For wide range of applications where output voltage should be precisely continuously adjustable, we have designed a special arbitrary output voltage generator. The output is time and amplitude programmable, so a variety of shapes is possible. The shaped voltage could be applied to a Pockels cell to control the transmission of optical system. The other known applications of the device are different actuators driving and ultrasonic device driver.

	HV output	repetition rate	pulses	others
For arbitrary form pulses:				
QBX-08	up to 0.8 kV (1.6 kV on request)	~50 kHz @ 0.8 kV	programmable form	< 1 us rise / fall time, 60 pF load