

FAST HIGH VOLTAGE Q-SWITCH DRIVER

General

The Series FQD Q-switch drivers are miniaturized high voltage pulsers for driving Pockels cells in Laser quality switching applications. FQD drivers contain everything necessary for a ready-to-use solution, including a highly reliable Behlke solid-state switch and various passive HV part components. Due to its very small dimensions, the FQD driver can be integrated directly into the laser setup. As a result, the length of the pulse transmission line between Q-switch driver and Pockels cell is reduced to a few inches / cm. The capacitive losses are thereby substantially decreased, keeping the power consumption and, consequently, the thermal emission of the driver very low, especially in cases of higher repetition rates. The standard FQD drivers described here are working in the ON-Mode with positive voltage. Additionally, OFF-Mode types for positive voltage are optionally available (option OFF). OFF and ON-Mode types can be configured for negative high voltage power supplies (option NEG). The internal circuit for the ON-Mode type is shown in Fig. 1 and for the OFF-Mode type in Fig. 2.

Operation

The solid-state switch, SW, is triggered by a positive going TTL pulse at pin 1. A successful triggering is indicated by the yellow LED. The trigger pulse amplitude should be 3 to 6 V and the trigger pulse slew rate should not be less than 100 mV/ns for best jitter results. Apart from jitter behaviour, output pulse rise time or output pulse width can not be influenced by the quality of trigger. The trigger pulse duration is uncritical. Any value between 50 ns and infinity is sufficient. To achieve the lowest possible pulse delay and best long-term stability in respect to jitter, the auxiliary voltage (5.00 VDC) should permanently be applied to pin 3, when the FQD is in operation. After triggering, the switch remains on for about 100 ns. The effective pulse width at the Pockels cell is much longer, because of the time constant $R_L \times C_L$. The effective output pulse width for standard devices is approx. 200 ns at $C_L = 10\text{pF}$ and $R_L = 20\text{k}\Omega$. The time constant can be adapted to the specific requirements by an optional variation of R_L (option M-RL, possible R_L values are from $1\text{k}\Omega$ to $1\text{G}\Omega$). In case of increased demands regarding the top flatness of pulse, the real on-time of the switch can be optionally extended up to 100 μs (options OT-1 μs , OT-10 μs or OT-100 μs). Please note the increased resistive losses at R_L in such a case. The output pulse rise time can also be adapted to specific requirement by means of customized values for the damping resistor R_s (option M-RS, useful values are 0 to 100 Ohm). The FQD standard device is configured so that all the requirements of a typical Q-switch application are met. In case of specific requirements please choose from the above options or consult Behlke. The control circuit of the FQD driver contains a protective circuit, which monitors the auxiliary voltage, the maximum repetition rate and the maximum operating temperature. If a disturbance should occur, the FQD driver is turned off and a TTL fault signal is generated at pin 4. The fault condition is also indicated by a red LED.

Housing Options

Various housing options are available. Generally, the standard plastic case (25 or 19 mm height) is sufficient for low and medium repetition rates (max. 1000 to 2000 pps). At higher repetition rates, the standard plastic case must be combined with a sufficient cooling option. If a liquid cooling is already available in the laser system, the option DLC (direct liquid cooling) maybe adequate. This option is for non-conductive liquids (e.g. GALDEN) only. The use of conductive liquids requires the option DLC-ISO. Heat can also be removed locally by natural or forced convection. For this purpose, the FQD driver can also be fitted with a ceramic cooling surface (option CCS), with non-isolated cooling fins (CF) or with a grounded cooling flange (GCF) for attachment on heat sinks. Please consult Behlke for further details.

FQD 40-03	4000 VDC / 35 A (pk)
FQD 50-02	5000 VDC / 25 A (pk)
FQD 80-01	8000 VDC / 15 A (pk)



FQD 40-03 with option GCF (grounded cooling flange)

- **Rise time 2 - 4 ns**
- **High frequency**
- **Compact design**
- **Very easy to use**
- **Reliable - no avalanche technique!**

Fig. 1 Simplified Circuit, ON Mode

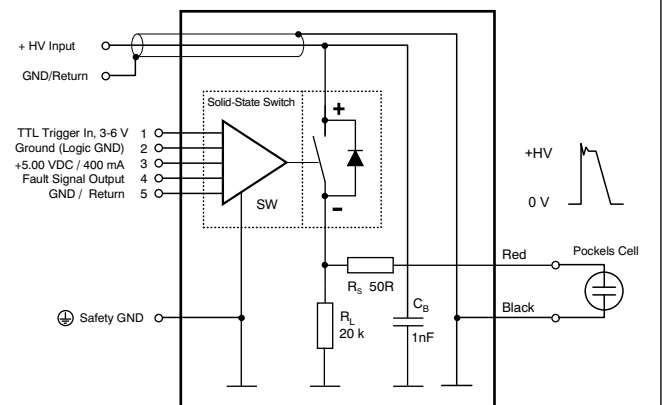
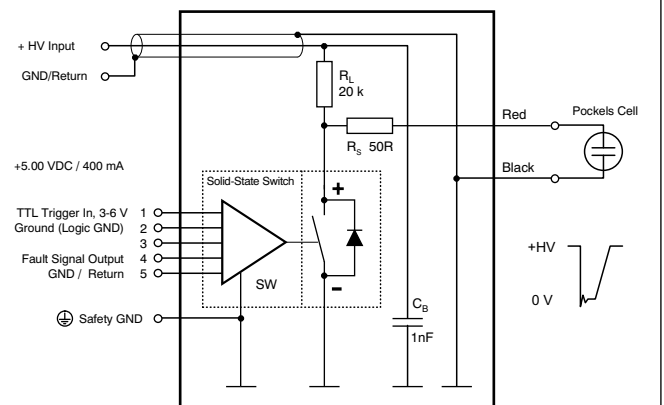


Fig. 2 Simplified Circuit, OFF Mode



TECHNICAL DATA

Specification	Symbol	Condition / Comment	FQD 40-03	FQD 50-02	FQD 80-01	Unit	
Maximum Operating Voltage	$V_{O(max)}$	$T_{case} = 25\text{ °C}$, $I_{off} < 100\text{ }\mu\text{ADC}$	4000	5000	8000	VDC	
Lowest Operating Voltage	$V_{O(min)}$			0		VDC	
Typical Breakdown Voltage	V_{Br}	$I_{off} > 1\text{ mADC}$, $T_{case} = 70\text{ °C}$	4200	5250	8400	VDC	
Galvanic Isolation	V_I	HV side against control side		> 10000		VDC	
Maximum Peak Current	$I_{p(max)}$	Peak current is internally limited	35	25	15	ADC	
Output Impedance	Z_{out}	Standard devices, see option M-RS	75	75	75	Ω	
Maximum Off-State Current	I_{off}	$T_{case} = 25\text{ °C}$, $0.8 \times V_O$. Lower I_{off} on request.		10		μADC	
Typical Turn-On Delay Time	$t_{d(on)}$	Shorter delay on request		50		ns	
Typical HV Pulse Rise Time	t_r	- @ $0.8 \times V_{O(max)}$	$C_L = 5\text{ pF}$	2.5	2.6	3.2	
		- Standard output impedance $75\text{ }\Omega$	$C_L = 10\text{ pF}$	2.9	3.1	4.4	
		- Pockels cell connecting leads < 100 mm (4")	$C_L = 20\text{ pF}$	3.7	4.0	5.6	
Typical Switch On-Time	t_{on}	Switch on-time only. See also options OT-xxxx		100		ns	
Effective HV Pulse Width	$t_{p(HV)}$	$C_L = 10\text{ pF}$, top flatness < 3%. See also option M-RL.		200		ns	
Typical HV Pulse Fall Time	t_f	10-90%, $C_L = 10\text{ pF}$. See also option M-RL.		1.2		μs	
Switch Recovery Time	t_{rc}	Driver recovery only. Trigger pulse $t_p = 100\text{ ns}$		500		ns	
Typical Turn-On Jitter	$t_{j(on)}$	$V_{aux} / V_{tr} = 5.00\text{ VDC}$		100		ps	
Max. Continuous Frequency	$f_{(max)}$	Cooling may be required at higher operating frequency	Standard devices	50		kHz	
			With Option HFS	150			
			Customized units	up to 500			
Maximum Burst Frequency	$f_{b(max)}$	Use option HFB for >10 pulses		2		MHz	
Typical Power Dissipation	P_d	@ $0.8 \times V_{O(max)}$ $C_L =$ Pockels cell capacitance Data valid for cooling option GCF. Standard devices without cooling options have 10% less losses.	$f = 2\text{ kHz}$	$C_L = 10\text{ pF}$	1.1	1.5	3.1
			$f = 20\text{ kHz}$	$C_L = 5\text{ pF}$	8.9	12.5	31.2
			$f = 20\text{ kHz}$	$C_L = 10\text{ pF}$	10.8	15.4	37.8
			$f = 100\text{ kHz}$	$C_L = 20\text{ pF}$	12.8	16.3	44.8
			$C_L = 10\text{ pF}$	54	77	189	Watts
Maximum Continuous Power Dissipation	$P_{d(max)}$	Standard devices & Option FC, $T_{case} = 25\text{ °C}$		5		Watts	
		With Option DLC / ILC, $T_{liquid} = 25\text{ °C}$, 1 liter/min		60-200	(consult Behlke)		
		With Option GCF, $T_{flange} = 25\text{ °C}$		200			
Operating Temperature Range	T_O	Extended range on request		-40...70		$^{\circ}\text{C}$	
Storage Temperature Range	T_{ST}			-50...90		$^{\circ}\text{C}$	
Typical Coupling Capacitance	C_C	HV side against control side		10		pF	
Auxiliary Supply Voltage	V_{aux}	< 2% stability recommended ($\pm 5\%$ max.)		5.00		VDC	
Typ. Auxiliary Supply Current	I_{aux}	$T_{case} = 25\text{ °C}$, $0.8 \times V_O$	@ $0,01 \times f_{max}$	150		mADC	
			@ f_{max}	400			
Trigger Signal Voltage Range	V_{tr}	3-6 VDC recommended for low jitter		2-10		VDC	
Minimum Trigger Pulse Width	$t_{ptr(min)}$	Switching behaviour cannot be influenced by trigger pulse		50		ns	
Fault Signal Output Voltage		Indicates over temperature, over frequency (>100 kHz) and low aux. voltage (< 4.75 V)	„Ready“ = H	4.5		VDC	
			„Fault“ = L	0.8			
Fault Signal Output Current		Source/sink current, short circuit proof		10		mADC	
LED Indicators		Green LED Yellow LED Red LED		„Ready, auxiliary power good“ „Switch triggered“ „Fault condition, switch off“			
Dimensions		Standard case		79.5 x 38 x 19		mm ³	
		Option DLC		79.5 x 38 x 25			
		Option GCF		95 x 50 x 22			
Weight		Standard case		110		g	
		Option DLC		150			
		Option GCF		220			

Ordering Informations

FQD 40-03 Q-switch driver, on mode, 4000 VDC, 35 Amps.

FQD 50-02 Q-switch driver, on mode, 5000 VDC, 25 Amps.

FQD 80-01 Q-switch driver, on mode, 8000 VDC, 15 Amps.

Option OFF Off mode configuration

Option NEG Negative high voltage supply / negative output pulse polarity

Option M-RL Modified working resistor (customized HV pulse, $t_{p(HV)}$ & t_r)

Option M-RS Modified damping resistor (customized HV pulse damping, t_r)

Option OT-1 μ Switch on-time 1 μs

Option OT-10 μ Switch on-time 10 μs

Option OT-100 μ Switch on-time 100 μs

Option PL-HV Plug connector for high voltage connection

Option SPT-C Shielded pigtail for control connection, incl. LEMO plug

Option HFB High frequency burst

Option HFS High frequency switching

Option UL94 Flame retardant casting resin according to UL94-VO

Option GCF Grounded cooling flange (attachment on heatsinks)

Option DLC Direct liquid cooling for non-conductive liquids

Option ILC Indirect liquid cooling for conductive & non-conductive liquids

For further options please refer to the product survey "D – Laboratory and OEM pulser"