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USERS' GUIDE
FOR MODEL 5056SC-A-8 HIGH VOLTAGE
Q-SWITCH DRIVER MODULE

SERIAL No. #####

RoHS2 COMPLIANT



**CAUTION: HEAT SINKING IS RECOMMENDED FOR
HIGH VOLTAGE, HIGH FREQUENCY OPERATION**

**WHEN CALLING OR CORRESPONDING ABOUT THIS INSTRUMENT
ALWAYS MENTION THE SERIAL NUMBER.**

1.0 INTRODUCTION

The 5056SC-A HV Q-Switch Driver Module is designed for operation with Pockels Cell Electro-Optic Q-Switches. With the appropriate Pockels cell and polarizer(s), the combination of elements constitute a system that can produce Q-switched laser pulses exhibiting pulse widths as short as 5 nanoseconds and peak power densities of up to 850 Megawatts/cm², depending on the laser cavity configuration. The 5056SC can also be utilized in optical gating applications (intensity or polarization modulation) when the Pockels cell is located extra-cavity. The system is self-contained, requiring only a low voltage DC power input and a trigger signal to activate operation.

The 5056SC HV Q-Switch Driver Module (Module) incorporates a low voltage to high voltage DC to DC converter and the HV pulse generating output circuit. The only power supply voltage necessary is a voltage regulated +24 Volts DC supply with a current capacity of at least 1.5 amperes.

Output pulses are generated by application of a TTL level input trigger signals. Output pulse characteristics are independent of the trigger waveform when the trigger signals are within defined limits. Output pulse amplitude may be adjusted by means of a miniature potentiometer accessible on the pulse module.

HV output pulses are applied to a Pockels Cell Electro-optic Q-switch (PC) which provides the optical polarization transitions for controlling laser cavity gain. In the cavity low gain state, the laser material is forced to store optical energy. When rapidly switched to the high gain state, the laser material releases stored energy in an extremely brief, high intensity optical pulse.

TRIGGER SIGNALS

Only one positive going trigger signal is needed to initiate operation, i.e., one trigger pulse generates one output pulse. The trigger signal voltage can have an amplitude of between $\approx +2$ to +5 volts. To prevent false triggering and to maximize noise immunity, the trigger signal voltage should be set close to 4 volts. Trigger pulse widths between 50 nsec to 1 microsec. are acceptable.

HEAT SINKING & Ground

For continuous operation at room temperature ambient and repetition rates less than 50 Hz, heat sinking the 5056SC Module is recommended but not required. For continuous, long term operation at higher repetition rates and particularly with maximum or near maximum voltage output pulse amplitudes, heat sinking to a thermal sink maintaining a maximum base temperature of $<30^{\circ}\text{C}$ is required. A suitable thermal transfer compound must be used between the 5056SC mounting surface and the sink to maximize heat transfer. When thermal transfer compound material is used between the base and mounting surface, the junction may not provide a reliable electrical ground connection.

We recommend using a separate ground wire connected to the 5056SC. . The knurled Binding post is intended for use to ground the driver. If ground via main enclosure is desired a bolt passing through one of the mounting slots to a grounded mounting surface is possible or utilizing one of the front or rear end plate screws. (Acetone, Ketone or nail polish remover can be used on cotton swab to remove a small area of black paint to insure proper metal connection).



FIG A. 5056SC-A-8 Q-switch driver front panel.

WARNING

HIGH VOLTAGE

HV pulse amplifiers and generators contain voltages which can be dangerous or lethal if contacted. All reasonable safety precautions have been taken in the design and manufacture of this instrument. **DO NOT** attempt to defeat the protection provided.

This equipment should be maintained only by qualified personnel who are familiar with high voltage components, circuits and measurement techniques. If qualified personnel are not available, the equipment should be returned to FastPulse for maintenance and repair.

Power must be removed and high voltage capacitors should be discharged prior to any maintenance work. **Connect and disconnect all connectors only when DC power is turned off.**

Only recommended replacement parts should be used. We suggest that you contact the factory before attempting to make repairs, replacements or internal adjustments. In many instances our engineers can provide information to help diagnose the problem and suggest an appropriate repair procedure.

HV should be turned off by removing the DC Supply voltage when the 5056 is not in active use. Long term, static operation can effect component lifetimes when they are subjected to continuous high voltage.

Nominal Specifications and Data Sheet**SERIAL No. ##### (4 Digit)**

MODEL: **HV PULSE OUTPUT RANGE**
5056SC-A-8 1.0 to 8.0 kV @3000 Hz Max.
Up to 6 kV @5 kHz Max.

DC VOLTAGE REQUIRED (BNC terminated)

Voltage +24 VDC, +4/-0 volt
 Power ~28 watts, typical at max. Rep. Rate
 +24VDC Power Supply MW4024F (+24V, 1.6A Provided if highlighted)

TRIGGER INPUT

Voltage Min. +2 volts to Max. +5.0 volts
 Pulse Width* Min. 50 nsec, Max. 1 μ s, rise <3-5ns optimal
 (*Initiates HV switching unrelated to the fixed HV pulse width to cell)

REPETITION RATE @ 8KV Single Shot to 3 kHz
 REPETITION RATE @ 6KV Single Shot to 5 kHz

HV OUTPUT TRANSITION TIME, 10-90% \leq 3 ns (5-7pF load)

HV OUTPUT PULSE WIDTH Full Voltage ~2 μ s

HV OUTPUT PULSE WIDTH, FWHM ~18 μ s (50%)

HV OUTPUT PULSE RECOVERY TIME** ~60 μ s (10-90%)

**Cell returns to "OFF" state ~100us.

INPUT TRIGGER TO OUTPUT HV PROPAGATION DELAY ~50 ns

NOTES:

1. This unit provided with 15cm HV lead to cell. Long leads 20-25cm can result in large EMI from wires and HV reflections oscillations after pulse. For Q-switch application this is typically not a problem.

In applications which several μ S to 10's μ s of optical beam signal are utilized contact factory for options.

5056SC - A OPERATIONAL AND CONTROL FUNCTIONS

- TRIG Trigger Input Connector: SMA Connector - Provides connection to Positive external trigger source
- +24 VDC BNC Connector: For connecting to an external +24 VDC power source
- PWR Power Applied Lamp: Indicates +24 VDC voltage is applied to the Driver
- HV Adjusts DC High Voltage and HV Output Pulse Amplitude
- HV OUTPUTS - (Length 15cm, Standard termination 2mm gold pin) Red and White Wires:
 White wire PULSED carries the switched HV pulse (from +DCHV to ground)
 Red wire has fixed DCHV. DCHV on both wires is adjusted simultaneously by front panel HV adjustment knob. Single turn Potentiometer.

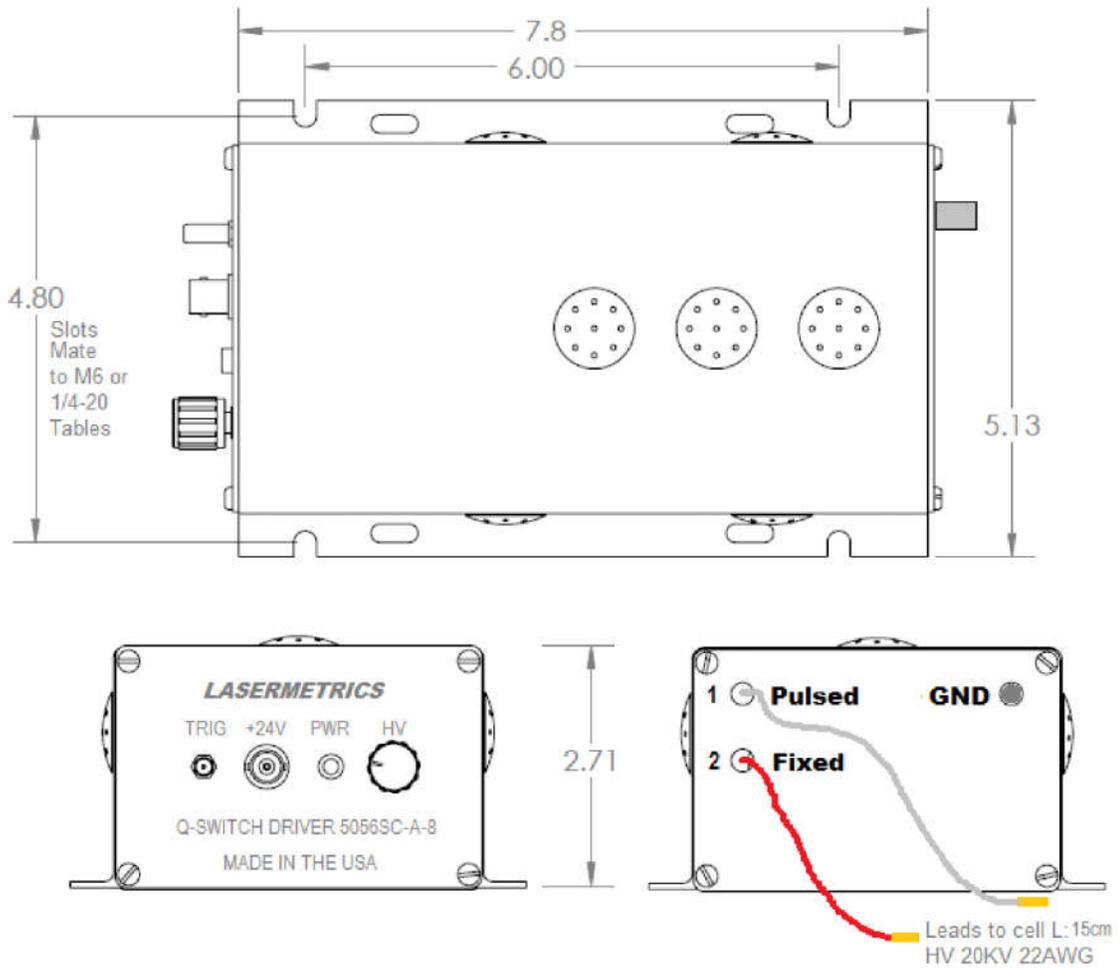


FIG B: 5056SC-A-8 Outline mounting dimensions.

3.0 SYSTEM CONNECTION

NOTE: The 5056SC-A outputs can be connected in three different output configurations to accommodate differing applications. Refer to Figures 1, 1a and 1b to decide which configuration is suitable for the intended application.

Before proceeding with system connection, insure that the DC Power Supply (provided by user) is turned OFF and that the VDC Control knobs (if any) are turned to zero voltage (usually full counterclockwise).

3.01 Connect an appropriate trigger source to the **TRIGGER** input of the 5056SC-A Pulse Module (**PM**). Use a 50 ohm cable (RG-58/U or RG-188A) with SMA connectors. (Cable provided with driver)

3.02 Connect the +24 DC voltage supply to the +24 V BNC connector on the 5056SC front panel. The supply voltage must not exceed +28 volts DC.

3.1 INPUT FUNCTIONS

The input Trigger jack (SMA connector) will accommodate positive pulse sources. Do not exceed 5.0 volts pulse amplitude or pulse widths of more than 1 μ s. Do not exceed max rated kHz trigger repetition rates. (Check your driver specifications)

4.0 OPERATION

NOTE: To initially align the Pockels cell it may be necessary to employ a photodetector with a DC response. It is recommended that alignment be performed with a low power (<10 milliwatt He-Ne laser). Focusing optics may be needed to concentrate the beam if the detector does not have high sensitivity. The focusing optics must be removed from the system when a high power laser is used. Refer to the User Guide For Modulators and Q-switches at the rear of this manual for additional information on alignment and cautionary practices.

After aligning the Pockels cell (PC), adjust the HV potentiometer on the PM to the maximum output level (clockwise rotation and energize the DC Power Supply (+24 VDC). This is a general starting point. Energize the laser and apply a trigger signal to the PM Trigger Input connector. This trigger must be delayed in time from the beginning of the flash lamp pump cycle to allow the laser rod to store adequate energy for generating a Q-switched pulse. The optimum time delay is specific to each laser and pump energy. Typical values range from 100 μ s to 500 μ s. At this time, the output beam of the laser must be monitored by a fast rise time photodetector and the detected waveform displayed on an oscilloscope. A Q-switched pulse may be present. If not, vary the time delay between the flash lamp firing and the PM Trigger Input. If no Q-switched pulse is present, set the delay to approximately 400 μ s (assuming that the flash lamp pulse is at least 500 μ s wide) and then adjust the HV potentiometer counterclockwise until a Q-switched pulse appears. To maximize the Q-switch pulse amplitude, adjust time delay and HV to achieve the desired pulse level.

The value of HV will generally be the quarter or half-wave voltage of the Pockels cell (depending on the cavity configuration and the Q-switch type used). Consult the Pockels cell data sheet for the DC test voltage measured at 633 nanometers. The voltage required to attain any given retardation with a voltage pulse will be approximately 15% higher than the DC test voltage due to the lower AC electro-optic coefficient. Required voltage is directly proportional to wavelength and if operation at a wavelength other than 633 nm is required, the Pulsed Output voltage will have to be adjusted accordingly by increasing or decreasing the HV level.

MODEL 5056 Q-SWITCHING SYSTEM

5.0 GENERAL

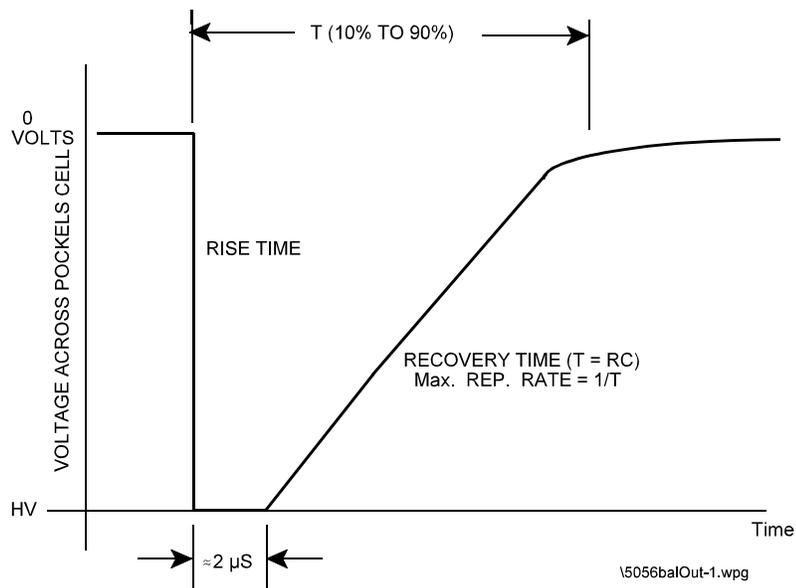
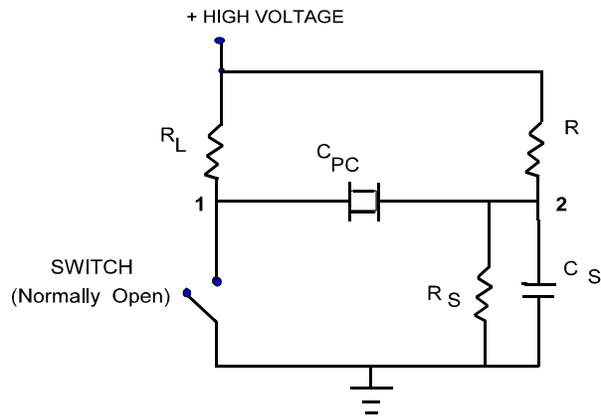
The Model 5056SC-A (5KV and 8KV types) HV Pulse Module are designed to operate with capacitive type Pockels cell Electro-Optic Q-switches (PC) such as the Lasermetrics Q1059, 1145, CF1042 DKDP type and 1147 RTP type , and 1150 BBO series Pockels cell EOM light modulators. The operating voltage range is preset at the factory to correspond to the type of Q-Switch being used and the wavelength of operation. The standard 5056SC-A HV Pulse Module can be used in any of the 3 configurations described below.

Figure 1, MODE 1 indicates the equivalent output circuit of the 5056SC-A HV Pulse Module with balanced output which shows that under static, unswitched conditions, the net voltage across the PC is zero. Upon triggering the unit, the voltage present on Connector 1 and thus across the PC is switched from zero voltage to the high voltage set point.. The resulting output pulse has the form shown below the circuit. The advantage of this circuit is the absence of a net DC voltage across the PC. Continued long term application of net DC voltage may cause ion migration within the crystal resulting in fogged optical surfaces and ultimately, optical and electrical degradation of the device. The balanced output configuration provides for the zero voltage condition needed for continuous, long term operation.

Figure 1A, MODE 2 indicates a setup of the 5056SC-A where HV is applied continuously to the PC (output not balanced). Typically this voltage is the quarter wave retardation voltage. Upon triggering the 5056SC-A, HV is switched to ground which permits the cavity to enter the high gain state with subsequent build up of oscillations and generation of the Q-switched pulse. With this configuration, high voltage must not be left on unnecessarily. DC power to the 5056SC-A should be turned off when the unit is not in active use. In typical applications, +24 VDC is switched on and off during the operating cycle, i.e., just prior to flash lamp firing, +24 volts is applied to the 5056SC-A. High voltage appears across the PC terminals. High voltage is sustained until a trigger signal is applied to the 5056SC-A. The HV output circuits then switch the voltage across the PC terminals to zero volts and a Q-switch pulse is generated. Immediately after, the +24 VDC is turned off and remains off until the next cycle. When the +24 VDC is switched on and off as described above the maximum repetition rate of the 5056SC-A is about 50Hz. When the +24 VDC supply is applied constantly, between each output pulse, high voltage rises and recovers to its preset value in approximately 60 to 70 microseconds and therefore maximum repetition rate for this type operation is about 1 kHz. The 1 kHz limitation is intended to prevent overloading the HV power supply and overheating the switching elements.

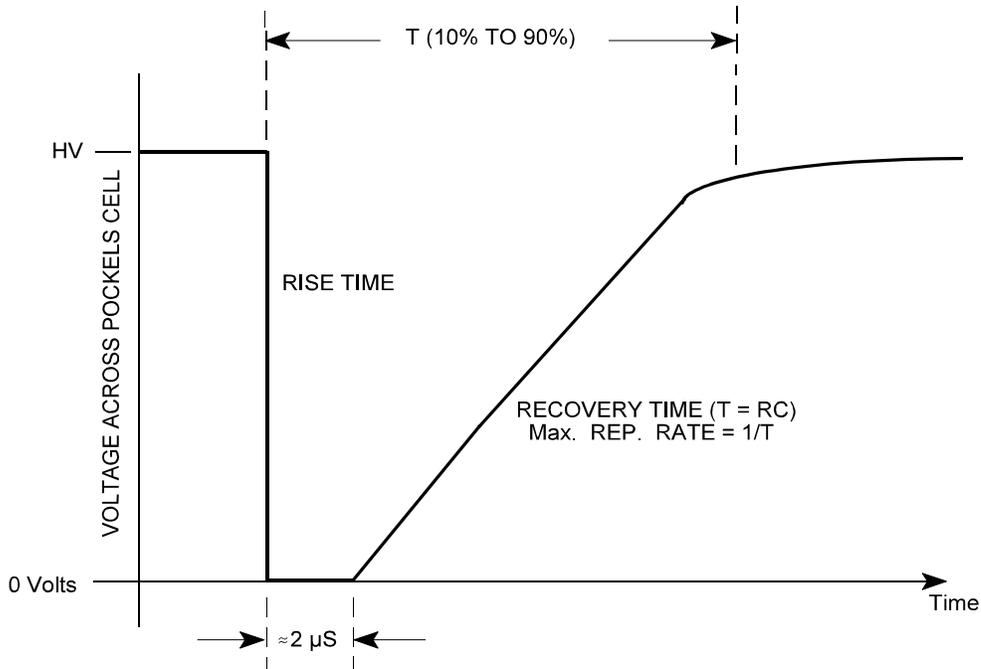
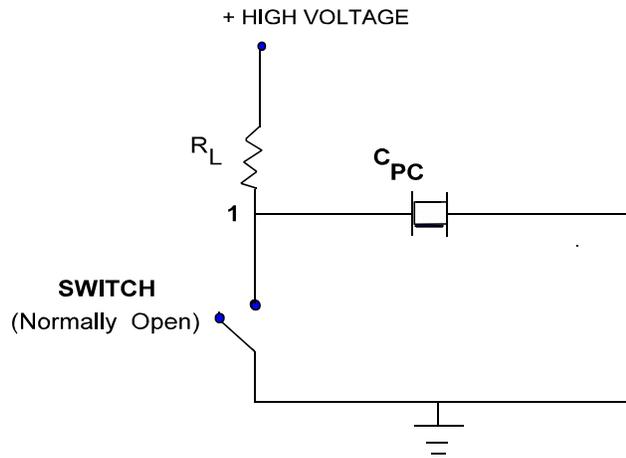
A third configuration, shown in **Figure 1B, MODE 3** is common in low repetition rate lasers (~50 Hz). This arrangement uses a DC voltage blocking capacitor to prevent DC voltage from being applied to the PC. The blocking capacitor must be rated for operation at >25% higher voltage than the maximum available from the HV output connector. Typical values of the required capacitor are in the range of 500 pf with rating 6kV to 10 kV.

Refer to "User's Guide to KD*P & Lithium Niobate Q-switches & Modulators" for additional information on the setup and use of these devices.



Balanced Output: Static voltage across Pockels cell is zero volts when output is not triggered. When output is triggered, voltage across cell switches to the preset high voltage point. The "ON" time of approx. $2 \mu\text{s}$ is a function of RC time constants where R is the internal switching circuit resistances and C is the sum of Pockels cell, circuit and cable capacitance.

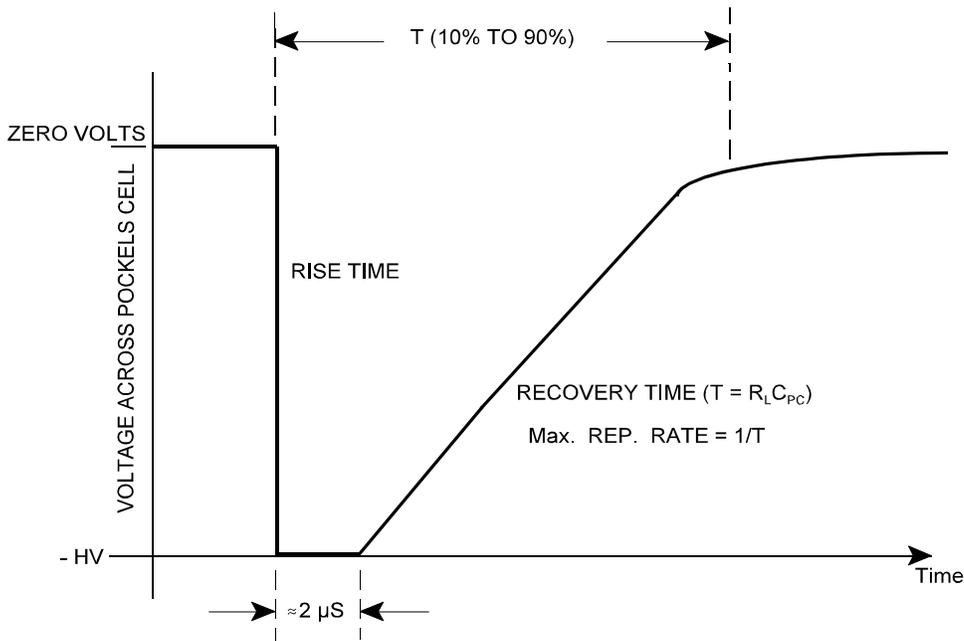
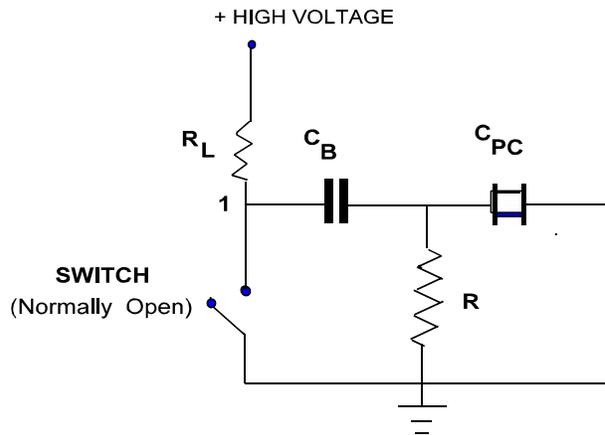
Figure 1: MODE 1 Typical Output Setup of the 5056SC-A - Balanced Output Voltage Connection, indicating zero static voltage across the Pockels cell. STANDARD MOST COMMON OPERATION.



Single Ended Output: DC voltage across Pockels cell is controlled by the HV ADJ knob setting on the front panel. When the output circuit is triggered, voltage across cell switches toward zero volts. The “ON” time of $\approx 2 \mu\text{S}$ is a function of switching circuit elements and the recovery time is a function of RC time constants - where R is the internal switching circuit resistance and C is the sum of Pockels cell, circuit and cable capacitance.

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Figure 1A: MODE 2 Single Ended Configuration - static HV is applied to Pockels cell from Connection 1. Connection 2 is not used and must be covered by electrical tape to prevent arcing or contact.



Zero Voltage Single Ended Output: A blocking capacitor is used to provide zero DC voltage across the Pockels cell. When the output circuit is triggered, voltage at point 1 (across blocking capacitor C_B) is switched to ground. This produces a negative going pulsed voltage across the Pockels cell terminals. The "ON" time of $\approx 2 \mu\text{s}$ is a function of the HV switching circuit elements. Recovery time is a function of $R_L C_{PC}$ time constants, where connecting cable capacitance must be added to the Pockels cell capacitance.

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Figure 1B: MODE 3 - Using a capacitor to block HV from being applied continuously to the PC. The capacitor must have a voltage rating higher than the maximum voltage available from the 5056 internal HV power supply. The blocking capacitor and bleed resistor are usually connected at the PC terminals.

6.0 Electro-Optic Q-Switching

Intense pulses of optical radiation can be generated by Q-Switching a flash lamp or diode pumped laser with an Electro-Optic Q-Switch, also known as a Pockels Cell (PC) light modulator. The technique involves controlling the laser beam polarization direction within the optical cavity which, in combination with a linear polarizer, introduces controllable optical losses. This prevents premature laser emission and allows energy to be stored in the laser material through population inversion of the metastable states. When the inversion is maximized, the voltage on the PC switches and changes the polarization conditions within the optical cavity. The available stored energy is discharged in a single high peak power (Q-switched) pulse.

Typically, the pulse may have a duration of between 5 and 50 nanoseconds and depending on the laser material, pump energy, rod size and other interrelated parameters, the output can attain peak power densities of 50 megawatts/cm² to more than 1 Gigawatt/cm².

Typical arrangements of laser cavity components for three common configurations for accomplishing Q-Switching are shown in Figures 3, 4 & 5. The basic configurations are known as "quarterwave" (3 & 4) and "halfwave" (5). The terminology relates to the optical retardation produced by either the static optical elements or by the voltage applied to the Pockels cell. , i.e., halfwave voltage is the voltage required to produce halfwave retardation between the o and e waves of the beam propagating through the PC crystal. Quarterwave configurations are generally less expensive to implement since only one polarizer is necessary. Halfwave operation is usually preferred when the laser rod material exhibits high gain and there is difficulty preventing premature emission. The use of two (2) polarizers reduces pre-lasing leakage thus improving the low Q, high loss, "Q-Spoiled" condition.

To establish the proper conditions for Q-Switching, the PC crystal must be aligned so that either its X or Y crystallographic axis is parallel to the polarization direction of the laser (some materials such as ruby have a defined polarization axis and some rods of ruby or other materials will have Brewster angle faces which define the polarization axis). Further, the optic axis of the PC crystal must be coaxial and parallel to the laser beam direction to within 2 arc-minutes. The polarizer must also be accurately oriented with its polarization axis parallel to that of the laser rod. In the event that the laser material does not itself define the direction of polarization, the polarizer is the controlling element and the PC crystal X or Y axis must be parallel to the defined direction. In most systems, the plane of polarization is set, for convenience, to either the horizontal or vertical direction.

Inaccuracies in alignment and orientation of these optical elements result in degraded performance, i.e., inability to Q-Switch, inability to hold off lasing action, leakage of conventional mode laser energy, low Q-Switched power, optical pulse jitter and unusual or unstable pulse shapes. These degraded performance characteristics may exist in any combination.

CAUTION

Laser energy deflected out of the cavity through polarizer side escape surfaces can be very intense. Safety glasses or goggles will not provide the attenuation necessary to prevent eye damage. Extreme care should be taken to either diffuse, absorb or block this energy.

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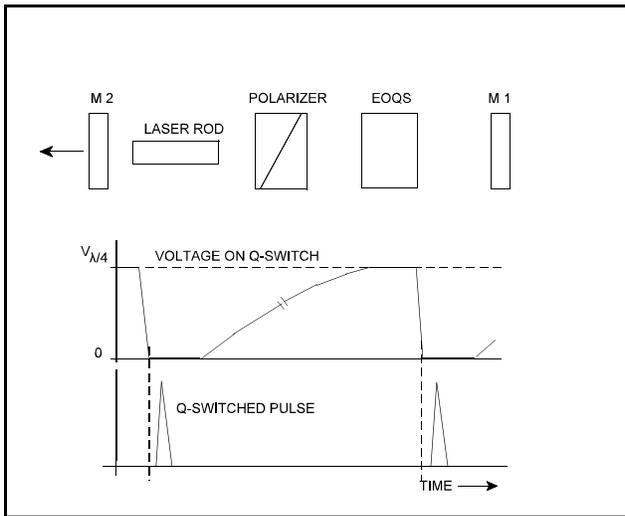


Figure 3. Quarterwave Configuration: DC Quarterwave voltage is applied to prevent lasing. Voltage is then switched to zero volts to generate the Q-switched output pulse.

The quarterwave configuration illustrated in Figure 3, is the most economical, in terms of number of components used, and simplest arrangement for Q-switching with an electro-optic Q-switch. This configuration minimizes the high voltage level required for efficient Q-switching. It also permits operation of the laser in its conventional, non-Q-switched mode by simply removing high voltage from the Q-switch. As explained later (Para. 7.1) certain precautions must be observed.

The configuration employs a Q-switch and a single polarizer. Quarterwave voltage must be applied continuously to prevent lasing. The voltage is switched to zero during the time the Q-switched pulse is to be generated.

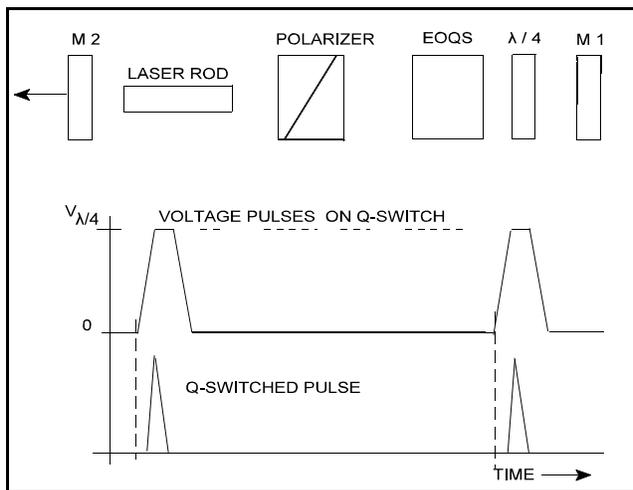


Figure 4. Pulsed Quarterwave Configuration: DC voltage is not required to prevent lasing. Voltage pulses switching from to zero to quarterwave voltage generates the Q-switched optical pulse. Pulse amplitude must be $(\approx 1.25) \times$ (DC Quarterwave voltage). The Figure 4 configuration of elements combines the best features of the half and quarter

wave modes. This arrangement requires a polarizer and quarterwave plate in addition to the Q-switch. Use of a quarterwave plate is equivalent to applying static quarterwave voltage to the Q-switch crystal. Since voltage is applied only as a brief pulse, there is no DC voltage across the crystal, thereby extending Q-switch life indefinitely (para. 7.1). The only disadvantage is that the voltage pulse amplitude must be 20% to 25% higher than the static voltage used in Fig. 3. Fig. 4 configuration has become the preferred mode of operation for many Q-switched laser manufacturers.

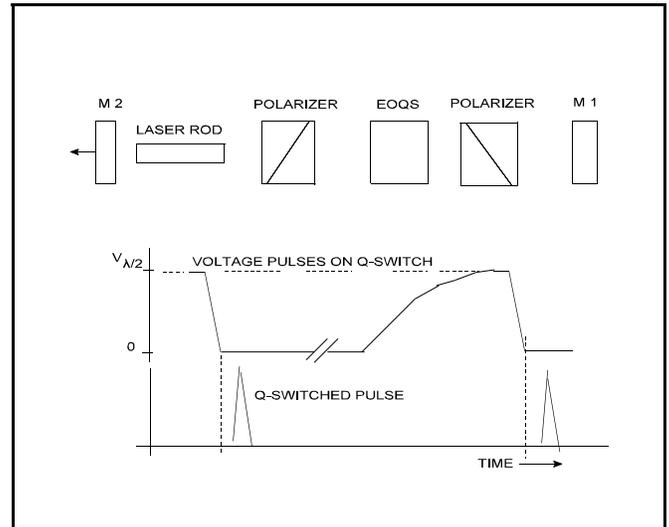


Figure 5. Halfwave Configuration: DC voltage is required to prevent lasing. Halfwave voltage is switched to zero to generate the Q-switched pulse

This mode requires a Q-switch and two polarizers and thus is more expensive to implement than the quarterwave mode. Another disadvantage is that a voltage pulse equal to the halfwave voltage (twice the amplitude of the quarterwave voltage) must be switched to zero volts to generate the Q-switched pulse. The major advantage of using two polarizers is evident in high-gain cavities where the second polarizer provides improved hold-off of conventional lasing.

COMPONENT DESCRIPTIONS

- M1 = 100% Reflective Mirror
- M2 = Output Mirror (partially reflective)
- EOQS or PC= Electro-Optic Q-Switch
- $\lambda/4$ = Quarterwave Plate
- Polarizer = Glan-Air Spaced Calcite Polarizer, thin film or Brewster angle Polarizer

7.0 Q-SWITCHING PRECAUTIONS

Lithium Niobate crystals exhibit a strong piezoelectric effect (KD*P to a lesser extent) that can have an adverse effect when Q-switching. The effect can be neutralized by appropriate timing of the electrical pulse to the Q-switch.

The piezoelectric effect becomes apparent when a crystal such as lithium niobate is excited by a fast rise time electrical pulse. Physically, the crystal is excited into mechanical oscillation--a contraction and extension effecting the indices of refraction. In the case of quarterwave switching, DC high voltage is applied to the crystal to prevent lasing; the voltage is then switched to zero volts to allow the Q-switched optical pulse to be generated. The piezoelectric effect, in the form of a damped oscillation or ringing, appears some time after the voltage is switched to zero level. The actual time at which the ringing occurs and the frequency of the ringing is dependent on the physical dimensions of the crystal. The larger the crystal, the lower the frequency and the longer the time period before ringing occurs.

For instance, the typical ringing frequency of the crystal used in the Model 3905 Q-switch is approximately 350 kHz and the ringing may appear about 700 nanoseconds after the voltage pulse reaches the zero volt level.

The effect of piezoelectric ringing on the laser output may be the generation of multiple Q-switched pulses. If the stored energy remaining in the rod (after generation of the first Q-switch pulse) is insufficient to form additional Q-switched pulses, leakage of laser energy in the form of a lower amplitude conventional mode pulse may occur.

The problem can be overcome by timing the leading edge of the electrical pulse which initiates Q-switching to occur after the peak of the flashlamp pump pulse. This can be experimentally confirmed by monitoring the electrical pulse to the flashlamp or the lamp light energy.

By varying the time delay between the start of the flashlamp pulse and the leading edge of the Q-switch driving voltage, the Q-switching action can be made to occur at a time when the flashlamp energy has decreased to a level that will not support additional lasing and thus, no additional optical pulses will be generated until the next flashlamp pump cycle. Usually, the timing can be chosen such that there is minimal or no decrease in Q-switched pulse amplitude. If the decaying flashlamp pulse has too much amplitude for too long a time after the peak, then secondary pulses will probably occur. The only solution to this characteristic is to shorten the trailing edge of the flashlamp pulse, make its decay time more rapid, or increase the time delay between flashlamp firing and generation of the Q-switched pulse.

7.1 OPERATION WITH DC VOLTAGE

Application of DC voltage to some Pockels cell Q-switches and light modulators for long periods of time may result in permanent damage to the electro-optic crystal(s).

Devices fabricated from KDP, KD*P, ADP and AD*P, in the presence of continuous (DC) high electric fields, are subject to an ion migration effect. With long term application of high voltage, the polished optical surfaces become fogged and etched. All crystal surfaces, including those under the conductive electrodes can be similarly effected. This may result in discontinuities between the crystal and electrode conductors. Application of AC electric fields, even those with a net DC value, appear to minimize the effect and extend lifetimes dramatically.

The effect is independent of the electrode materials used and has been documented for gold, indium, silver and transparent conductive oxide electrode materials. One manufacturer reports that a sustained voltage of 50 volts will eventually have an effect on the crystal. Use of inert index matching fluids does not mitigate the damage. The effect appears with or without the use of fluid.

We recommend that DC voltage not be applied to a Pockels cell when the laser system in which it is employed is not actively in use. When the system is in a standby condition, care must be taken to turn off the DC voltage to the Pockels cell. When this procedure is followed, operational lifetime of more than 5 years is not unusual and where this "voltage off" safeguard has been observed, many Lasermetrics Q-switches have been in active use for more than 20 years.

***From "User's Guide For KD*P & Lithium Niobate Q-Switches and Modulators, For Q-switching, Chopping & Pulse Extraction".**

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WARRANTY

Each standard component and instrument manufactured by FastPulse Technology and/or its **LASERMETRICS®** Division is guaranteed to be free from defects in material and workmanship for a period of one (1) year from the date of shipment to the original purchaser. This warranty does not apply to non-standard equipment or equipment modified to meet customer special requirements. The warranty period for non-standard or modified equipment shall not exceed 90 days after date of invoice. All warranties are voided if such equipment is operated beyond its safe operation limits, without proper routine maintenance, or under unclean conditions so as to cause optical or other damage; or if it is otherwise abused, connected incorrectly electrically, exposed to power line or other electrical surges, or modified in any way.

Our liability under this warranty is restricted to, at FastPulse Technology's option, replacing, servicing or adjusting any instrument returned to the factory for that purpose, and to replacing any defective parts. Specifically excluded from any warranty liability are indicator lamps; vacuum, gas and vapor tubes; fuses, batteries, optical coatings, components in lasers and laser systems such as: focusing lenses and other optical components internal or external to the laser cavity, expendable items such as flash lamps, water filters and the like. FastPulse Technology does not assume liability for installation, patent violation claims, labor, injuries, or consequential damages.

Equipment under warranty must be returned to the factory with transportation charges prepaid and with advance notice to FastPulse Technology. Contact FastPulse Technology's Sales Department for a Return Material Authorization (RMA). Equipment repaired under terms of this warranty will be returned to the purchaser with shipping charges prepaid. If it is deemed impractical to return the equipment to the factory, the purchaser may request the dispatch of a FastPulse Technology service engineer whose services, transportation, and living expenses will be billed at the then current rate.

In many instances, equipment problems can, with the purchaser's assistance, be resolved through brief communications with a factory engineer either by telephone, FAX or e-mail. Should, in FastPulse Technology's opinion, the problem be caused by a component or subassembly failure, the Company shall at its discretion ship a replacement to the user, and/or request that the failed component or subassembly be returned to the factory for analysis or repair.

This warranty does not imply and is expressly in lieu of all other liabilities, obligations, or warranties. FastPulse Technology neither assumes nor authorizes any other person or organization to assume on behalf of FastPulse Technology any other liability in connection with these products. FastPulse Technology disclaims the implied warranties of merchantability and fitness of such products for a particular purpose. It is the purchaser's responsibility to insure that the products are suitable for the purchaser's application.

CLAIM FOR DAMAGE IN SHIPMENT

The equipment should be tested as soon as possible after receipt. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent and this report should be forwarded to FastPulse Technology. We will then advise the disposition to be made of the equipment and arrange for repair or replacement.

Include model number and serial number when referring to this equipment for any reason.