FastPulse Technology, Inc.

LASERMETRICS® **Division**

220 MIDLAND AVENUE
SADDLE BROOK, NJ 07663
TEL (973) 478-5757
FAX (973)-478-6115
Web Sites: www.lasermetrics.com
www.fastpulse.com

USER'S GUIDE

MODELS 5056SC and 5056VC

HIGH VOLTAGE SWITCHING

PULSE MODULE / Q-SWITCH DRIVERS

SERIAL No. SAMPLE

RoHS COMPLIANT

CAUTION: HEAT SINKING IS NECESSARY FOR HIGH VOLTAGE, HIGH FREQUENCY OPERATION

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

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REV: 10 June 2008 / RLG

1.0 INTRODUCTION

5056 HV Switching Pulse Module / Q-Switch Drivers are designed for operation with Pockels cell Electro-Optic Q-Switches. With 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 3 - 5 nanoseconds and peak power densities in the range of 850 MW/cm^2 depending on laser cavity configuration. When the Pockels cell is located extra-cavity the 5056 can also be utilized as an optical gate (intensity or polarization modulation) The 5056 is self-contained, requiring only a low voltage DC power input and a trigger signal to activate operation.

The 5056 HV module incorporates a low voltage to high voltage DC to DC converter and the HV pulse generation output circuit. The only external power supply voltage needed is a voltage regulated +24 Volts DC supply with a current capacity of at least 1.0 amperes. A Model MW4024F AC-DC Power Supply is optionally available from FastPulse. This device will operate at input voltages of 100 to 240 VAC, 50/60 Hz and produce a regulated +24 VDC at up to 1.67 Amp. Output pulses are generated by application of TTL level trigger signals. Output pulse characteristics are independent of the trigger waveform when the trigger signals are within defined limits.

SC models: output pulse amplitude is adjusted by means of a miniature potentiometer knob on the front panel.

VC models: output pulse amplitude is adjusted by applying a DC control voltage to a BNC connector on the front panel. The Input/Output voltage ratio is approximately per 1 Volt of input per 1 kV of output.

In typical applications, HV output pulses are applied to a Pockels cell Electro-optic Q-switch (EOQS) which provides the optical 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 ≈ +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 10 ns to 1 μs are acceptable.

HEAT SINKING

For continuous operation at room temperature ambients and repetition rates less than 50 Hz, heat sinking the 5056 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 $<30^0C$ is required. A suitable thermal transfer compound must be used between the 5056 mounting surface and the sink to maximize heat transfer.

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.

2.0 MODEL 5056SC HIGH VOLTAGE PULSE MODULE

NOMINAL SPECIFICATIONS

SERIAL No. SAMPLE

MODELS – VOLTAGE RANGES

❐ 5056SC-5 ....*1.0 to 5.0 kV @5 kHz   ❐ 5056SC-5M2 ...*1.0 to 5.0 kV @<100 Hz

❐ 5056SC-8 ...*1.0 to 8.0 kV @5 kHz   ❐ 5056VC-5M2 ...*1.0 to 5.0 kV @<100 Hz

❐ 5056SC-11 .. *1.0 to 11 kV @1 kHz   ❐ 5056SC-8.5 ......*1.0 to 8.5 kV @5 kHz

❐ 5056SC-5 VC .*1.0 to 5.0 kV @ 1 kHz   ❐ 5056SC-8 VC .. *1.0 to 8.0 kV @ 1 kHz

DC VOLTAGE REQUIRED	
Voltage	+24 VDC, ±1 Volt (±0.2 Volt preferred)
Power	20 watts, typical at max. Rep. Rate
TRIGGER INPUT	
Voltage	Min. +2 Volts to Max. +5.0 Volts
Pulse Width	Min. 10 ns, Max. 1 µs
REPETITION RATE*	Single Shot to .... See Above, Maximum.
OUTPUT TRANSITION TIME, 20-80%	≤ 5 ns
OUTPUT PULSE WIDTH, 50% POINTS	13 µs
OUTPUT PULSE RECOVERY TIME	56 µs
PROPAGATION DELAY TIME	37 ns

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5056SC-VC MODELS	5056SC-5VC	5056SC-8VC
DC INPUT CONTROL RANGE	❐ 1.0 to 5.0 Volts	❐ 1.0 to 8.0 Volts
DC or PULSED HV OUTPUT	❐ 1.0 to 5.0 kV	❐ 1.0 to 8.0 kV
INPUT / OUTPUT VOLTAGE RATIO	1 Volt / 1 kV	

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POCKELS CELL MODEL
Halfwave Voltage @ 633 nm
Capacitance

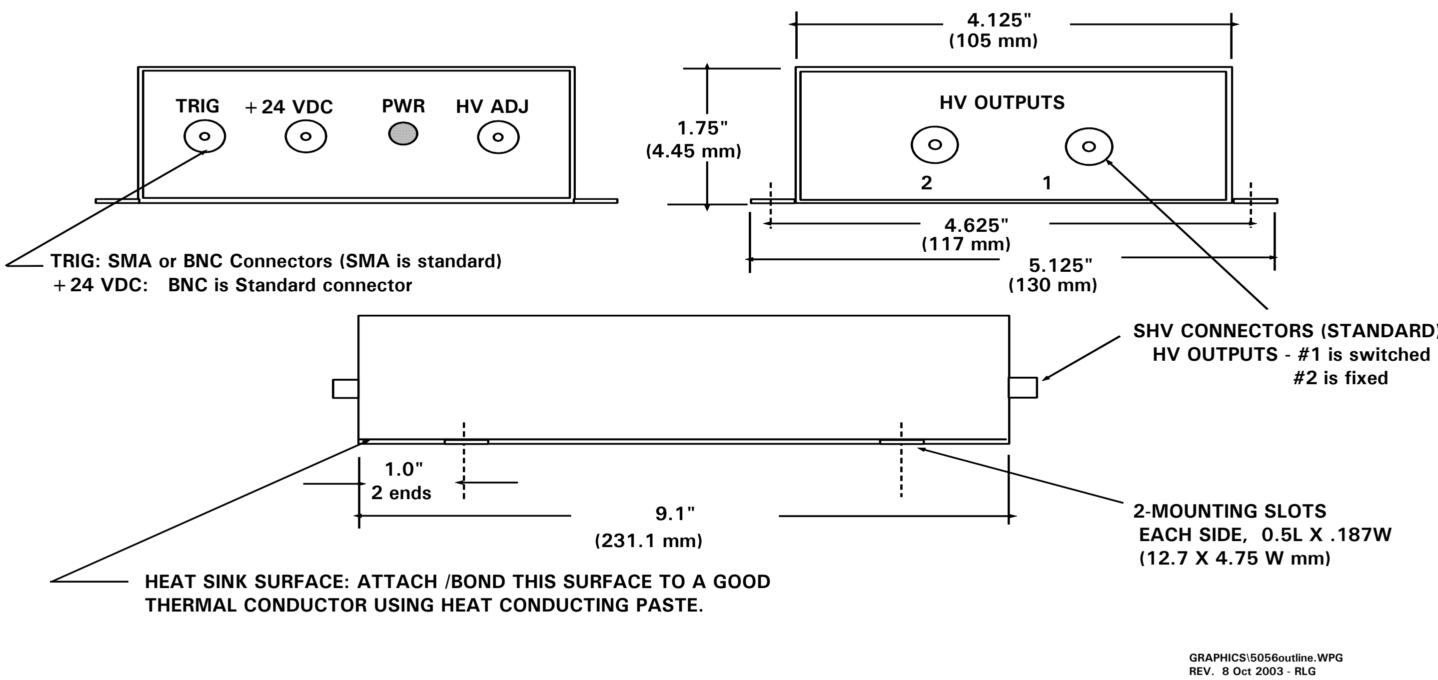
If a cell was ordered, See Page 4A (next page)

5056 OPERATIONAL AND CONTROL FUNCTIONS

PWR - Power Applied Lamp	Indicates DC Voltage is applied to the Pulse Module
TRIG - Trigger Input Connector*	Provides interconnection to positive signal sources.
+24 VDC - (BNC)	Provides interconnection to +24 Volt DC supply
HV ADJ - 5056SC - (Knob)	Manual HV Output control knob
- 5056VC - (BNC)	Connection for Input DC Voltage used to adjust HV Output
HV OUTPUTS 1 & 2 - (SHV)	Connect to RG59/u type cables for attachment to the Pockels cell Q-switch

*SMA or BNC -- SMA is standard. If specified at time of order, BNC Connector is supplied at no additional cost.

CAUTION: TURN OFF AC POWER AND/OR DISCONNECT THE DC POWER SUPPLY FROM THE 5056 BEFORE CONNECTING OR DISCONNECTING ANY ELECTRICAL LEADS.



MODEL 5056SC SHIELDED Q-SWITCH DRIVER MODULE

3.0 SYSTEM CONNECTIONS

Decide which output configuration is needed. Review Figures 1, 1a, 1b. to determine desired connections.

NOTE: 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 5056 Pulse Module. Use a 50 ohm cable (RG-58/U or RG-188A) with SMA connectors.

3.02 Connect the DC Voltage output on the power supply to the +24 VDC connector on the 5056. The supply Voltage must not exceed +25 Volts DC.

3.03 SC MODEL: The HV Output is manually controlled by a potentiometer. The miniature potentiometer knob for the HV ADJUST controls the output pulse amplitude. Minimum and Maximum voltages available are given on page 4 for each model in the product line.

VC MODEL: HV Output is controlled by an externally supplied analog (DC) voltage. No manual control knob is provided. Connect an external DC control Voltage, adjustable between 1 and 5 Volts, via the HV ADJUST BNC connector. Control Voltage must not exceed 5 VDC for the 5 kV model and 8 VDC for the 8 kV model.
Input / Output ratio is approximately 1V / 1kV.

3.04 Connect cable 1 connector (SHV) to HV Output 1 panel connector. The voltage present on the center pin of this connector switches from the +HV set point (controlled as in 3.03 above) towards zero volts. The center conductor at other end of cable 1 is connected to one terminal of the Pockels cell Q-switch. Depending on the output configuration desired, the braided shield of this cable may be connected to the other terminal of the Q-switch or it may be taped over (to prevent arcing or short circuits) and not used. Refer to Figures 1, 1A and 1B. The preferred configuration is shown in Figure 1 and set up as indicated in para. 3.05 below.

3.05 Connect cable 2 connector (SHV) to HV Output 2 panel connector. The center conductor at the other end of this cable is connected to the second terminal on the Pockels cell Q-switch. The shield may be attached to the shield from cable 1 and both grounded or tied together and left floating (but kept away from the HV conductors) since they are grounded internally at the 5056 Module. The center pin of this connector is fixed at the same voltage present on the connector for HV Output 1. However, the voltage on HV Output 2 is not switched to ground during output pulse generation; it remains at the high set point. The difference in voltage between the two outputs during the time HV Output 1 is switched is the amplitude of the output pulse applied to the Q-switch.

3.1 INPUT FUNCTIONS

The Input Trigger jack (BNC or SMA connector) will accommodate positive pulse sources. Do not exceed 5.0 Volts pulse amplitude or pulse widths of more than 1 μs. Do not exceed 5 kHz trigger repetition rates.

4.0 OPERATION

NOTE: To initially align the Pockels cell it may be necessary to employ a photodetector or power meter with a DC response. It is recommended that alignment be performed with a low power (<5 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 (EOQS), adjust the HV being applied to the Q-switch by adjusting the **HV ADJUST Control knob in SC models** or applying up to 5 Volts DC to **HV ADJUST BNC connector on VC models**; 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 µs to 500 µs. 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 Module Trigger Input. If no Q-switched pulse is present, set the delay to approximately 400 µs (assuming that the flash lamp pulse is at least 500 µs wide) and then vary the **HV ADJUST** voltage 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 the switched HV OUTPUT at SHV Connector **1** will generally be either the quarter or half-wave voltage of the Pockels cell (depending on the cavity configuration and the Q-switch type used).

The 5056SC-5 & 5056VC-5 output voltage is in the range of 1 kV to 5 kV which corresponds to the range of ¼ wave retardation voltages for typical KD*P, RTP and $LiNbO_3$ Pockels cell Q-switches operating in the 1000 nm wavelength range.

The 5056SC-8 & 5056VC-8-output voltage is in the range of 1.5 kV to 8 kV which corresponds to the range of ½ wave retardation voltages for typical KD*P, and $LiNbO_3$ and 1/4 wave retardation voltages for BBO Pockels cell Q-switches operating in the 1000 nm wavelength range.

The Pockels cell Q-switch data sheet indicates the DC ½ wave retardation voltage measured at 633 nanometers. The voltage required to attain this retardation with a voltage pulse will be approximately 15 to 20% higher than the DC test voltage due to the lower AC (clamped) 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

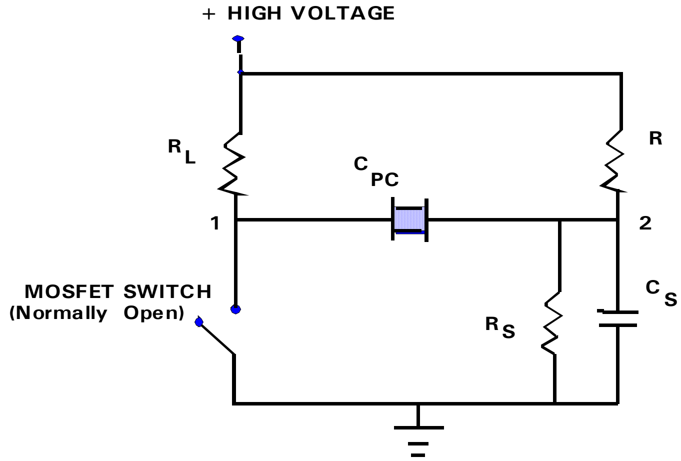
The Model 5056 HV Pulse Module is designed to operate with capacitive type Pockels cell Electro-Optic Q-switches (EOQS) such as the Lasermetrics 1040, 1050, 1145, 1147 and 1150 Pockels cells. The operating voltage range is preset at the factory. The three configuration types are described below:

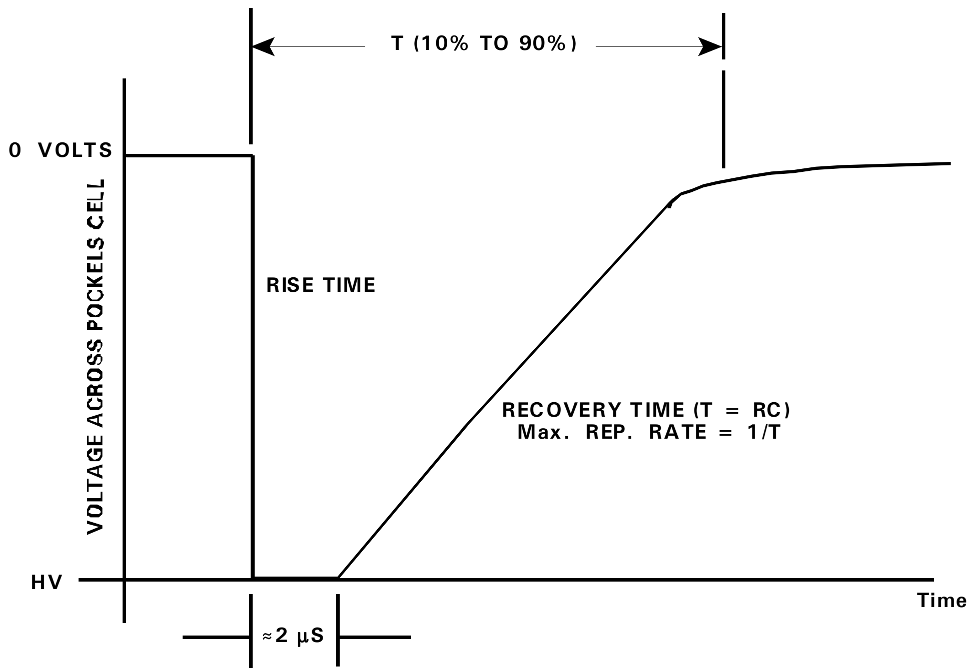
Figure 1 **(Type 1)** indicates the equivalent output circuit of the 5056 HV Module with balanced output - which shows that under static, unswitched conditions, the net voltage across the EOQS terminals is zero. Upon triggering the unit, the voltage across the EOQS is switched from zero voltage to the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

Figure 1A **(Type 2)** indicates a version of the 5056 where HV is applied continuously to the EOQS (output not balanced). Typically this voltage is the quarter wave retardation voltage. Upon triggering the 5056, HV at the center conductor of Output Connector 1 is switched to ground which permits the laser 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 5056 should be turned off when the unit is not in active use. In many 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 5056. High voltage appears across the EOQS terminals. High voltage is sustained until a trigger signal is applied to the 5056. The HV output circuits then switch the voltage across the EOQS 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. High voltage rises to its preset value in approximately 10 milliseconds and therefore maximum repetition rate for this type operation is <100 Hz. Practically, 10 to 25 Hz are more reasonable maximums.

A third configuration, **(Type 3)**, shown in Figure 1b, is common in low repetition rate lasers (<20 Hz). This arrangement uses a DC Voltage blocking capacitor to prevent DC Voltage from being applied to the EOQS. 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 capacitor are in the range of 250 to 500 pf at 6 to 10 kV.

Refer to "User's Guide to KD*P, RTP & Lithium Niobate Q-switches & Modulators ...." at the back of this manual or on FastPulse's web site 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 high voltage set point indicated on the front panel meter. The "ON" time of ≈2 µS 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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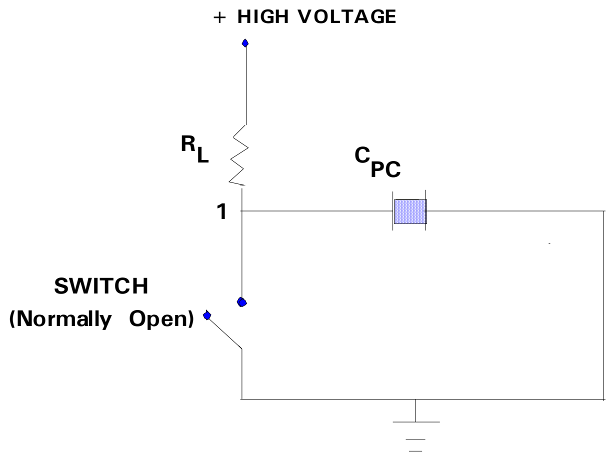
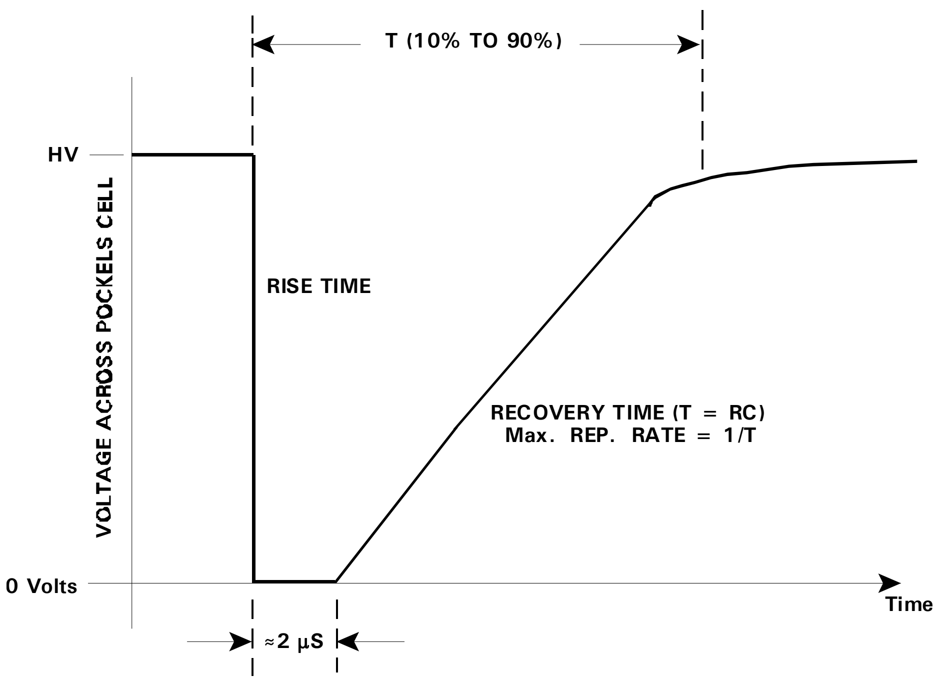
Figure 1: Typical Output of the 5056, Type 1 - Balanced Output Version, indicating zero static Voltage across the Pockels cell





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 ≈2 µS 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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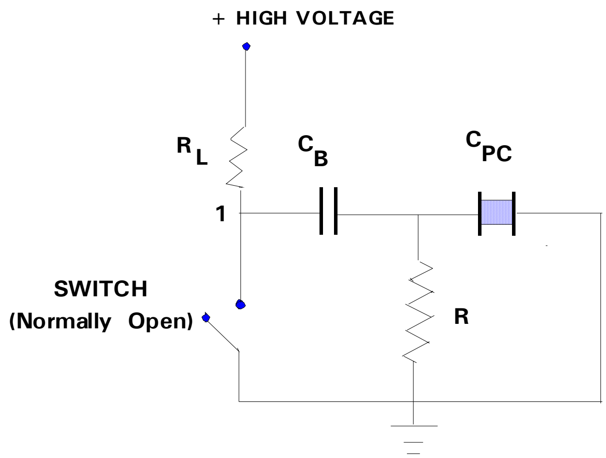
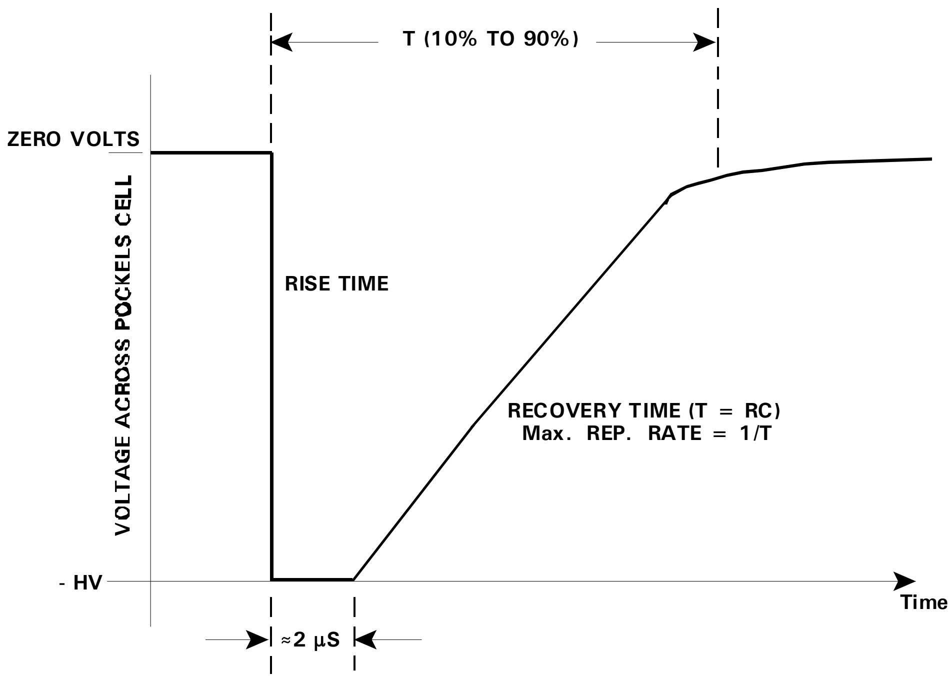
Figure 1A: Type 2, Single Ended Version - static HV is applied to Pockels cell





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 ≈2 µS is a function of the HV switching circuit elements. Recovery time is a function of RC time constants.

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Figure 1b: Type 3 Uses a capacitor to block HV from being applied continuously to the EOQS. The capacitor must have a voltage rating higher than the maximum Voltage available from the 5056 internal HV power supply. The capacitor is usually connected at the EOQS 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 (EOQS) which is also known as a Pockels cell light modulator. The technique involves controlling the laser beam polarization direction within the optical cavity thereby introducing 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 EOQS changes the polarization conditions within the optical cavity and the available stored energy is discharged in a single high peak power pulse.

Typically, the pulse may have a duration 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/cm^2 to more than 1 Gigawatt/cm^2.

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 "quarter wave" (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 EOQS crystal. Quarter wave configurations are generally less expensive to implement since only one polarizer is necessary. Halfwave operation may be 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 EOQS 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 EOQS 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 EOQS crystal X or Y axis must be parallel to the defined direction. In many 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.

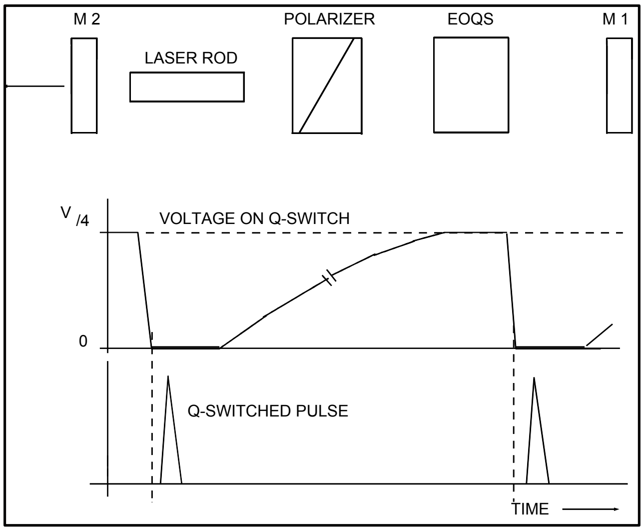

Figure 3. Quarter wave Configuration: DC Quarter wave Voltage is applied to prevent lasing. Voltage is then switched to zero Volts to generate the Q-switched output pulse.

The quarter wave 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. Quarter wave 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.

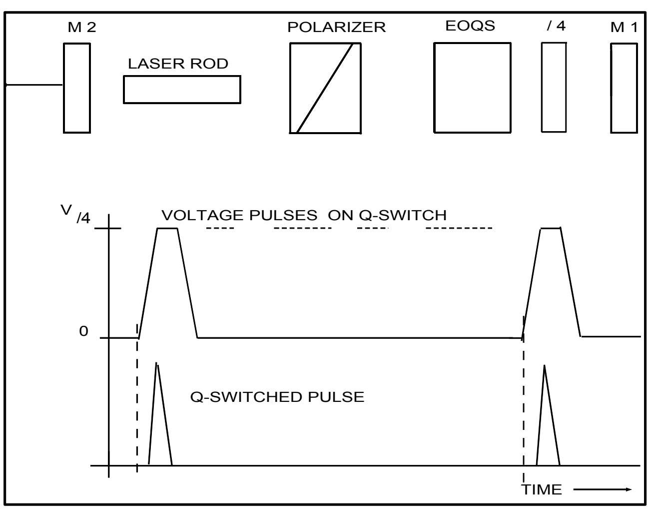

Figure 4. Pulsed Quarter wave Configuration: DC Voltage is not required to prevent lasing. Voltage pulses switching from to zero to quarter wave voltage generates the Q-switched optical pulse. Pulse amplitude must be (≈1.25) X (DC Quarter wave Voltage)

The Figure 4 configuration of elements combines the best features of the half and quarter wave modes. This arrangement requires a polarizer and quarter wave plate in addition to the Q-switch. Use of a quarter wave plate is equivalent to applying static quarter wave 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 suppliers.

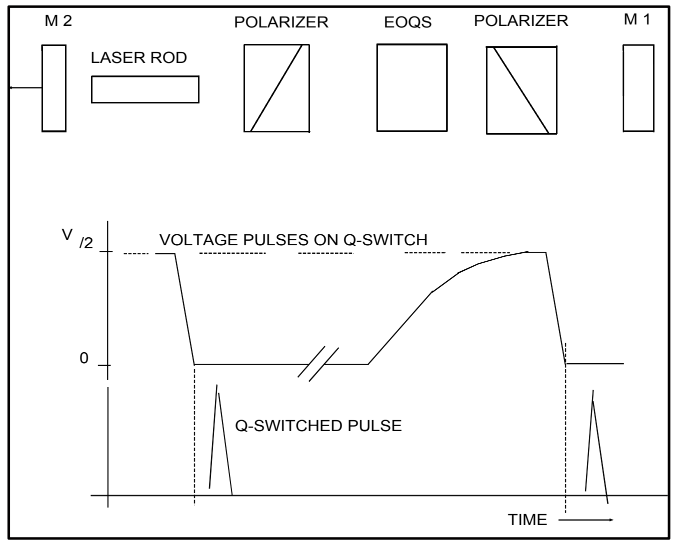

Figure 5. Halfwave Configuration: DC voltage is required to prevent lasing. Halfwave Voltage is switched to zero to generate the Q-switched pulse This mode requires a Q-switch and two polarizers and thus is more expensive to implement than the quarter wave mode. Another disadvantage is that a voltage pulse equal to the halfwave voltage (twice the amplitude of the quarter wave 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.

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COMPONENT DESCRIPTIONS

M1 = 100% Reflective Mirror
M2 = Output Mirror (partially reflective)
EOQS = Electro-Optic Q-Switch (Pockels cell)
λ/4 = Quarter wave Plate
Polarizer = Linear 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 that effects the indices of refraction. In the case of quarter wave 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 appears 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 lower amplitude conventional mode pulses 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, appears 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, RTP & Lithium Niobate Q-Switches and Modulators, For Q-switching, Chopping & Pulse Extraction”.

FastPulse Technology, Inc.

LASERMETRICS® **Division**

220 MIDLAND AVENUE
SADDLE BROOK, NEW JERSEY 07663
TEL (973) 478-5757
FAX (973)-478-6115

WARRANTY

Each standard component and instrument manufactured by FastPulse Technology 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 is 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. 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 external to the laser cavity, expendable items such as flash lamps and water filters and the like are specifically excluded from any liability. FastPulse Technology does not assume liability for installation, patent violation claims, labor, injuries, or consequential damages.

Major parts and subsystems manufactured by other companies which are integrated in FastPulse Technology equipment are covered by the original manufacturers' warranty.

Equipment must be returned to the factory with transportation charges prepaid and with advance notice to FastPulse Technology. Repaired equipment 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 service will be provided at the then current rate, and whose travel and living expenses will be charged to the purchaser.

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.

In many instances, equipment problems can, with the user's assistance, be resolved through brief communications with a factory engineer either by telephone or FAX. Should, in FastPulse Technology' 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.

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.

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