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**USER GUIDE FOR 5055SC-A
HIGH VOLTAGE PULSE MODULE
Q-SWITCH DRIVER**



RoHS2

**SERIAL No. 59xx
March 2018, PO 1234**

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15December1995

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MODELS: 5055SC-A

This instrument complies with EU Directive 2002/96/EG (RoHS Compliant) and conforms to the protection requirements of EMC Directive 89/336/EEC, specifically, EN 55011 Radiated and Conductive Emissions, EN 50082-1 Immunity (IEC 801-2, -3, -4) and safety requirements of EN 60601-2-22 (IEC 601-2-22:1995-11).

It is essential that the instrument be correctly connected, that the AC mains ground have a low impedance and that following precautions are observed:

1. Replacement Cables: Interconnecting coaxial cables must be matched to the impedance of the connectors used on the instrument, its input signal source and where possible, the output circuit load . Thus, 50 Ohm BNC cable connectors must be attached to 50 Ohm cable (RG58A/U OR RG55/U) and 75 Ohm MHV cable connectors to 75 Ohm cable (RG59/U). Impedance mismatches will cause ringing and radiated emissions. To reduce residual emissions due to impedance mismatch, aluminum foil may be wrapped around the cables or the cables may be enclosed in flexible braided copper tubing which is made for this purpose. In either case, the shielding must be well grounded.
2. Pockels cells which may be supplied as accessories to this instrument are passive components which are intended to be operated in the end-user's shielded enclosure. Failure to properly enclose the cell may result in electrically radiated noise.
3. As supplied, the Pockels cell light modulator and HV Pulse Modules are enclosed in a EMI shielded enclosure. This metal enclosure must be connected electrically to house ground. Because the modulator enclosure must have apertures to permit passage of the laser beam, these openings may be a source of low level RFI/EMI. If sensitive detectors or instruments are located in the immediate vicinity of the enclosure apertures, it may be necessary to provide additional shielding around the apertures in the form of a second grounded metal enclosure or a small cardboard carton covered with aluminum foil. The foil is grounded and two apertures are cut into the foil and cardboard. If the distance between the apertures in the modulator enclosures or cardboard box is 1 to 2 inches (25 to 50 mm) the residual radiation, if any, will be significantly attenuated .
4. This instrument generates internal voltages which can be hazardous. It is important to read and understand the operations manual provided with the instrument prior to connecting and applying AC line power or DC voltages. All cables must be connected to their mating connectors before application of any electrical power and turn-on of the power switches.

1.0 INTRODUCTION

5055SC-A HV Pulse Modules and Systems are designed for operation with pulsed or CW pumped lasers. With the appropriate Pockels cell and polarizer(s), the systems will produce Q-switched laser pulses exhibiting pulse widths as short as 5 nanoseconds and peak power densities of more than 10 GW/cm², depending on the laser material, Q-switch and cavity configuration. These systems can also be utilized as optical gates (intensity or polarization modulation) when the Pockels cell is located extra-cavity. The **5055SC-A** is **Self-Contained**, requiring only a low voltage DC power input and a trigger signal to activate operation.

The electronics portion of a system consists of a 5055SC-A High Voltage Pulse Module (PM) which incorporates low voltage to high voltage DC to DC converters and the HV pulse generation output circuit. The only power supply voltage necessary is +24 VDC with a current capacity of up to 1.5 amperes. 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. Output pulse amplitude is adjusted by means of a KNOB on front panel. (potentiometer Adjustment)

HV output pulses are applied to a Pockels cell, EOM Electro-optic modulator, Q-switch (QS) 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 but high intensity (Q-switched) optical pulse.

HIGH VOLTAGE OUTPUT

There are several OEM versions of the 5055SC-A Pulse Module (PM) possible. See page 7 for terminology. The standard model is MODE 1. Details are found on page 7 and page 8 figure 2A. The standard model can also be used in Mode 2 and Mode 3 configurations as described on pages 9 and 10 however factory configured versions are available.

INPUT VOLTAGE

The driver is robust and can be used 24/7 but when not in active use we recommend that the +24V DC supply voltage be turned off for safety considerations and to increase cell and driver lifetime.

POCKELS CELL

Refer to the Users Guide for BBO, KD*P, RTP and Lithium Niobate Q-switches, an addendum to this manual for further details on alignment and use of these devices. A Pockels cell is a capacitive load you can connect either HV lead to either cell terminal. At QWV switching leads to cell terminals will change handedness CW or CCW of circular polarized light. The long HV "ON" time will result in piezo ringing of DKDP starting about 2.5-3us after the leading edge this dampens over ~400us.

TRIGGER SIGNALS

Only one positive going trigger signal is needed to initiate an output pulse. This voltage can have an amplitude of between $\approx +4$ to +10 volts into 50 Ohms. Trigger pulse widths between 50 nanosec to 10 microsec are acceptable. Avoid longer trigger pulse widths. Trigger pulse width is unrelated to HV pulse width.

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 to prevent accidental voltage exposure.

DO NOT attempt to defeat the protection provided.

Maintenance:

This equipment should be maintained only by qualified personnel who are familiar with high voltage components, circuits and measurement techniques.

Do NOT operate if there are any signs of damage or degraded wires or connections.

Do NOT open the casing or remove parts.

Do NOT add components to or alter the HV wire leads. Discuss with factory.

Power Down:

Power must be removed and high voltage capacitors should be discharged prior to any maintenance work. Connect and disconnect all connectors only when AC line power is turned off and the AC line cord is disconnected.

Repairs/Service:

We suggest that you contact the factory before attempting any service. In many instances our engineers can provide information to help trouble shoot and diagnose the operating problem and advise appropriate operating and set up corrections.

In all cases if a device is not working properly **consult with factory** for operating discussion to verify type of problem. Once a defect is verified the equipment should be returned to FastPulse Technology for inspection, repair and service. Please contact factory for a RMA# prior to returning any device.

Safety & Lifetime:

HV should be turned off by removing the DC Supply voltage when the 5055SC-A is not in active use. Long term, static operation can effect component lifetime when subjected to continuous high voltage.

Do NOT exceed operating limits per specifications.

2.0 MODEL 5055SC-A Q-SWITCH DRIVER (HIGH VOLTAGE PULSE MODULE)

Nominal Specifications and Data Sheet

SERIAL No. 59xx

DC VOLTAGE REQUIRED

Voltage +24 VDC (+24 to +28V)
Power <20 Watts typical maximum at max. Rep. Rate;
(Depends on capacitive load, operating voltage
Repetition rate)

TRIGGER INPUT

Voltage Min. +4 Volts to Max. +10.0 Volts into 50 Ohm Input
Pulse Width Min. 50 ns, Max. 10 μ s
(*Input circuit is capacitor coupled to block DC voltage*)

REPETITION RATE

Single Shot to 1.0 kHz Maximum.

DC or Pulsed HV OUTPUT (Adjustable) 500 Volts to ~5.0 kV @ 1000 Hz Maximum
DC HV OUTPUT not triggered (Adjustable) 0V to 5 KV (Optimal switching starts ~500V and above)
Rise Time, 10 to 90% < 2.5 ns
Input to Output Delay Time ~45 ns (Trigger to HV pulse propagation delay)
Output Pulse Width, FWHM ~19 μ s (Full voltage ~2 μ s, recovery to OFF 50-100 μ s)

5055SC-A STANDARD OPERATIONAL AND CONTROL FUNCTIONS

Power ON LED Indicates DC voltage is applied to the Pulse Module

Trigger Input jack (SMA) Provides interconnection to positive trigger signal sources.

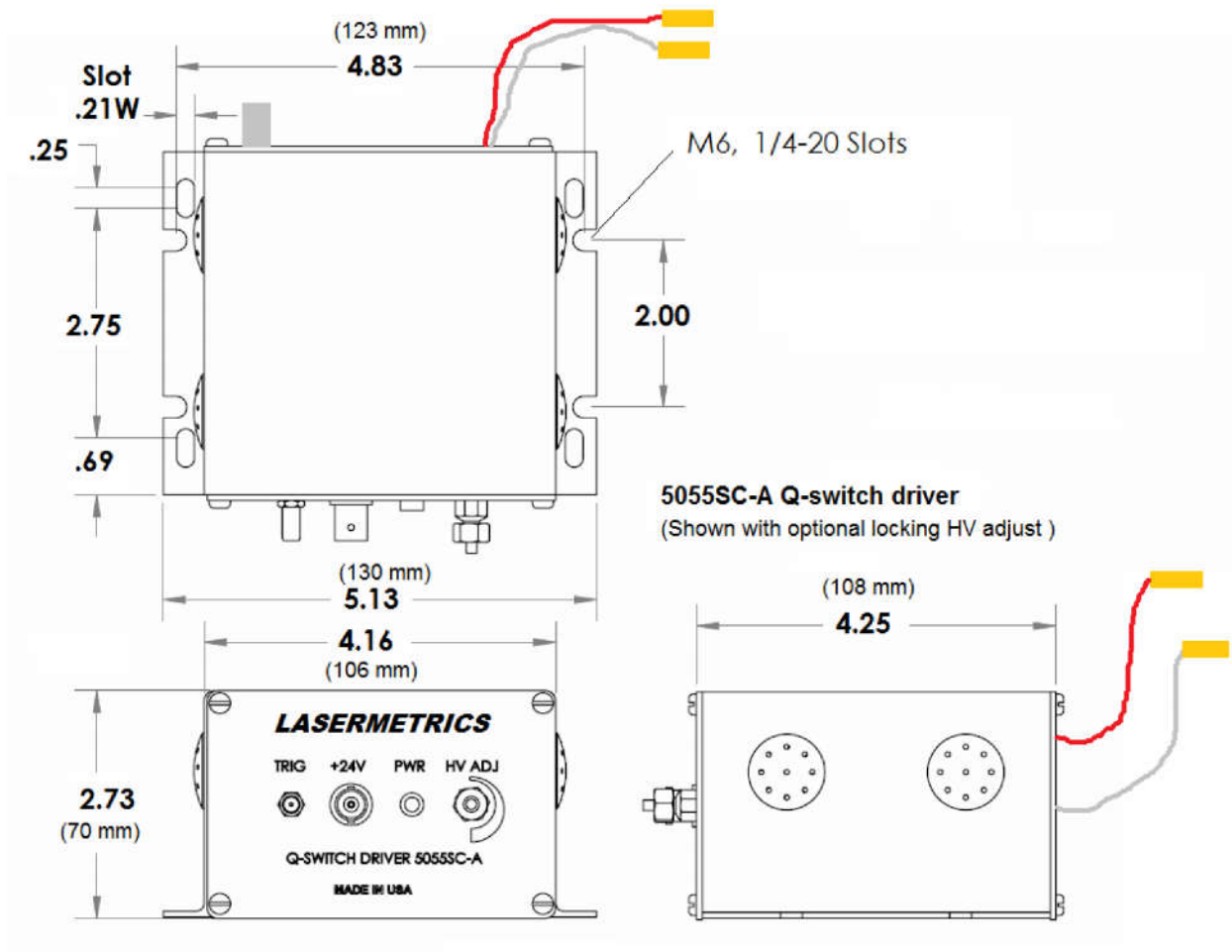
+24 VDC jack (BNC) Provides interconnection to external +24-28 VDC supply.

HV Adjust Potentiometer Controls/Adjusts output pulse amplitude

HV Output Wires Red Wire: Fixed, does not switch HV (Set high voltage)
White Wire: Switching HV lead (HV setting, switches to ground)

POCKELS CELL MODEL Optional item:
GIMBAL: Optional Item:

CAUTION: TURN OFF AC POWER AND/OR DISCONNECT THE DC POWER SUPPLY FROM THE 5055SC-A BEFORE CONNECTING OR DISCONNECTING ANY ELECTRICAL LEADS.



MODEL 5055SC-A HV PULSE MODULE Q-SWITCH DRIVER (Dimensions are in inches)

HV Output Wires:

RED wire has constant, FIXED HV as set by Adjustment KNOB.

WHITE wire is the switching lead connected to cell (HV equal to RED wire when not switched) – switches from the HV setting to ground when driver is triggered.

Model 5055SC-A HV Pulse Modules are designed to operate with capacitive type Pockels cells. **LASERMETRICS®** Electro-Optic Q-switches “Pockels cells” such as the Series CF1041, CF1042, Q1059, 1145, 1148, DKDP cells and 1150 series BBO and 1147 series RTP light modulators are well matched to the 5055SC-A. The driver will also operate with other 3rd party similar capacitive Pockels cells.

MODEL 5055SC-A Q-SWITCHING SYSTEM

3.0 GENERAL

The Model 5055SC-A is designed to operate with capacitive type Pockels cell, Electro-Optic Q-switches (QS) such as the Lasermetrics® Series Q1059, CF1042, 1145, 1148 DKDP cells as well as 1147 RTP, and 1150 BBO Pockels cell, light modulators. The operating voltage range can be preset (on request) at the factory to correspond to the type of Q-Switch (Pockels cell) being used and the wavelength of operation. The standard mode 5055SC-A has operation MODE 1 as below, “balanced output”, i.e., under static conditions (no triggering) there is ~zero net voltage applied across the QS cell terminals. **MODE 1 is standard and most common configuration.** There are three modes of operation available, as detailed below.

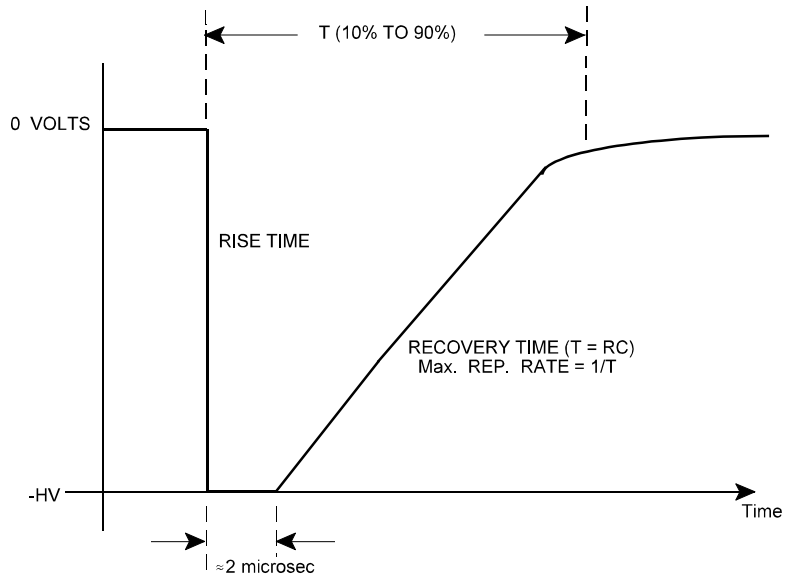
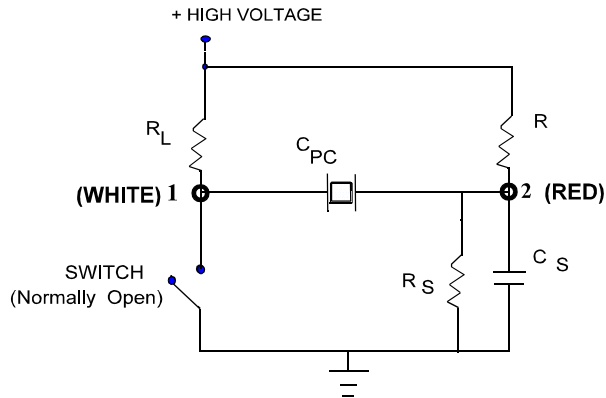
Figure 2a indicates **MODE 1** - the equivalent output circuit of 5055SC-A HV Pulse Module with balanced HV output which shows that under static, unswitched conditions, the voltage potential across the QS is zero. Upon triggering the unit, the voltage across the QS is switched from zero voltage to the 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 QS. Continued long term application of DC voltage may cause ion migration within the crystal resulting in fogged optical surfaces and, ultimately, degradation of the device. The leads can be connected to either cell terminal.

Figure 2b for **MODE 2** operation indicates how the QS can be connected so that voltage is applied directly to terminal 1. This configuration requires that the cell be connected by a single HV wire to terminal 1, the side WHITE WIRE which is actively switched to ground. The other HV lead RED WIRE on the 5055SC-A is not used and must be insulated from its surroundings by means of multilayer of electrical tape, Kapton tape, or RTV as there is DC high voltage remaining on that terminal. The second terminal of the QS must be connected to a grounding wire which should be connected to a screw or GND on the 5055SC-A.

Figure 2c for **MODE 3** operation indicates how a capacitor is used to block the DC high voltage from the terminal on the QS. Only terminal 1 on the 5055SC-A is used to connect to the capacitor. As in MODE 2 above, terminal 2 (Red Wire) is insulated and not used. Use of a blocking capacitor will limit on the maximum repetition rate ~50Hz nominal available due to the increased RC charge time required.

NOTE:

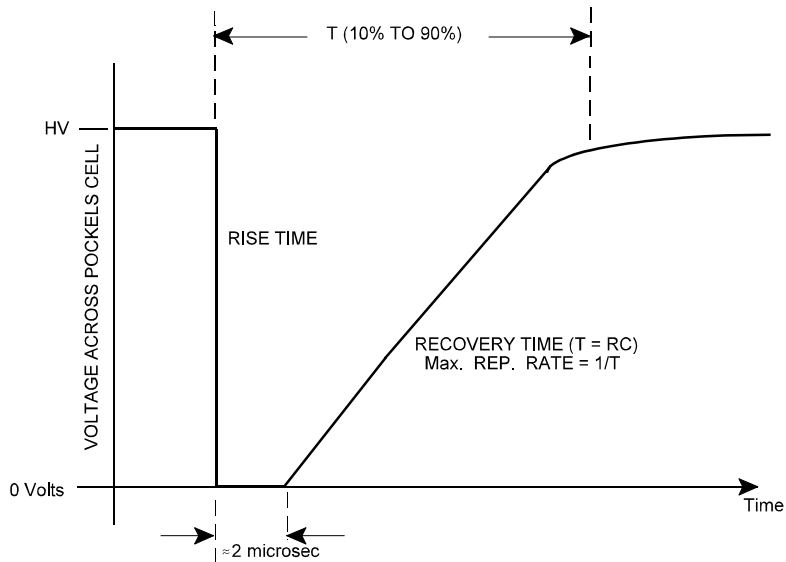
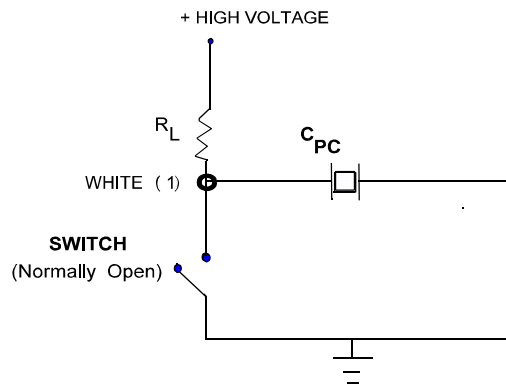
All standard 5055SC-A HV Pulse Modules are assembled as in Figure 2a, Mode 1; whether or not a Pockels cell is supplied with the module. Other, special configurations are available. Unless a Pockels cell is ordered as an integrated component of the 5055SC-A System, or special output connections are ordered, the end user is responsible for correctly attaching the Pockels cell to the appropriate 5055SC-A terminals (wires) for use in Modes 1, 2 or 3.



Balanced Output: When both terminals of the Pockels cell are connected to the terminals on the 5055SC, static voltage across Pockels cell is zero volts if output is not triggered. When a trigger signal is applied, output voltage across cell switches to the preset high voltage set by the front panel potentiometer. The "ON" time of ≈ 2 microsec 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.

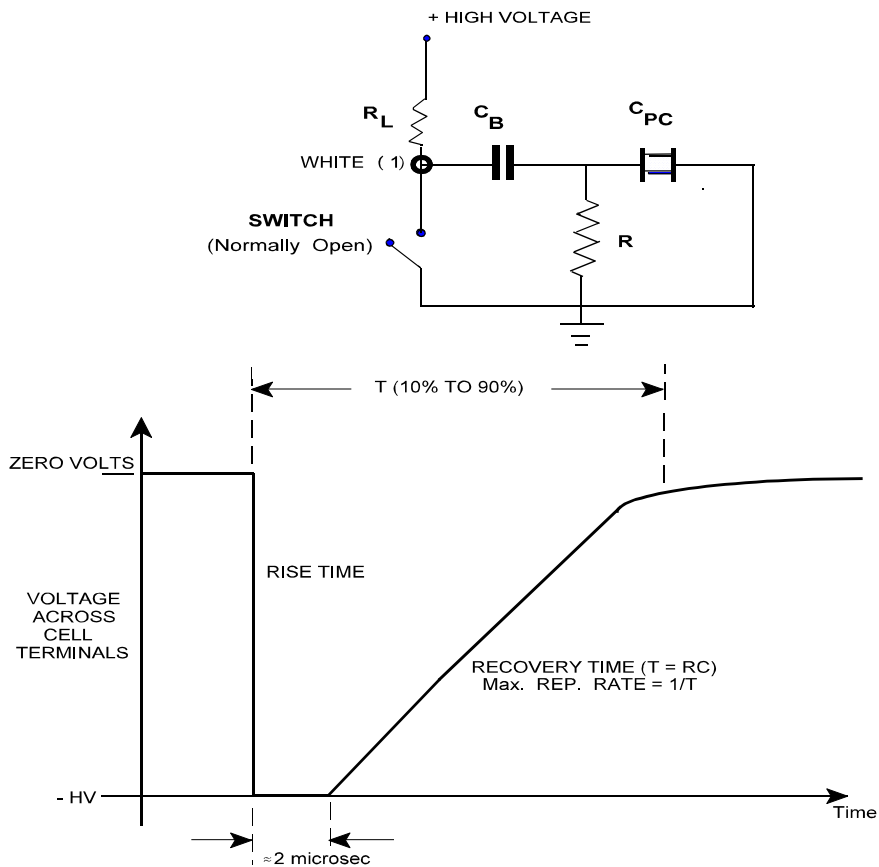
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Figure 2a: **MODE 1** - Balanced Output Version of the 5055SC-A - indicating zero static voltage across the Pockels cell terminals. Terminal 1 corresponds to the WHITE wire



Single Ended Output: This mode of operation may be set up by the user when static high voltage (usually the 1/4 wave retardation voltage) is to be applied to the Pockels cell. The output voltage at terminal 1 (White Wire) is connectec to one terminal on the Pockels cell. The other connection on the Pockels cell is wired to common ground or the ground lug on the 5055SC. RED wire is not used and must be insulated for safety. The aluminum box enclosure can be grounded. When the output circuit is triggered, voltage across cell switches toward zero volts. The "ON" time of ≈ 2 microsec 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/wire capacitance.

Figure 2b. **MODE 2: Single Ended Operation - static HV is applied to Pockels cell.**
Terminal 1 corresponds to the WHITE wire.



Zero Voltage Single Ended Output: An external blocking capacitor and bleed resistor can be connected from output terminal 1 (White Wire) to the Pockels cell to provide zero DC voltage across the Pockels cell. The other Pockels cell terminal is connected to ground. When the output circuit is triggered, voltage at terminal 1 is switched toward ground. This produces a negative going pulsed voltage across the Pockels cell terminals. The Red Wire) on the 5055SC-A is not used in this configuration and must be well insulated since it is connected to HV (as shown in Mode 1, Figure 2a.

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Figure 2c: **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 5055SC-A internal HV power supply. The blocking capacitor/resistor combination is usually connected at the PC terminals. The increased RC time constant limits maximum repetition rate (< 50Hz typical) attainable. **Terminal 1 corresponds to the WHITE wire.**

4.0 SYSTEM CONNECTION

NOTE: Before proceeding with system connection, insure that the AC Power Switch on the +24 VDC Power Supply (provided by user or FastPulse Model MW4024F unplug) is in the "OFF" position and that the DCV Control knobs are turned full counterclockwise.

4.1 Connect an appropriate trigger source to the TRIGGER input of the 5055SC-A Pulse Module.

4.2 Connect the +24 VDC voltage output from the external power supply to the +24 VDC connector on the 5055SC-A. The supply voltage must not exceed +24 volts DC. The mating connector is a standard BNC type.

5.0 INPUT FUNCTIONS

The input Trigger will accommodate ONLY positive pulse sources. Do not exceed 10.0 volts pulse amplitude or pulse widths of more than 10 μ Sec Do not exceed 1.0 kHz trigger repetition rates. The standard connector is a SMA type.

6.0 OPERATION

NOTE: To initially align the Pockels cell it is necessary to employ a photodetector with a DC response. It is recommended that alignment be performed with a low power (<50 milliwatt Laser). Focusing optics may be needed to concentrate the beam if the detector does not have high sensitivity or to prevent energy spillover of the detector active area. In most case the photodetector requires a 50 Ohm terminator to scope. 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 (QS), adjust the HV potentiometer on the 5055SC-A Pulse Module (PM) to approx. 50% of the maximum 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 or diode 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 cavity, lasing material and the pump energy. Typical values range from 50 microsec to 500 microsec. 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 microsec (assuming that the pump pulse is at least 500 microsec wide) and then adjust the 5055SC-A driver HV KNOB (potentiometer) until a Q-switched pulse appears. To maximize the Q-switch pulse amplitude, adjust time delay and HV to achieve the desired Q-switched 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 to 20% 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. Example: $3.9KV@633nm \times (1064/633) = 6.6KVDC @1064nm$.

7.0 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 (QS) 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 QS 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 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 Figure 3. The basic configurations are known as "quarterwave" (3a. & 3b.) and "halfwave" (3c.). The terminology relates to the voltage levels applied to the QS and resulting retardation, i.e., halfwave voltage is the voltage required to produce halfwave retardation between the o and e waves of the beam propagating through the QS 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 it is difficult to prevent 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 QS 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 QS 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 QS 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.

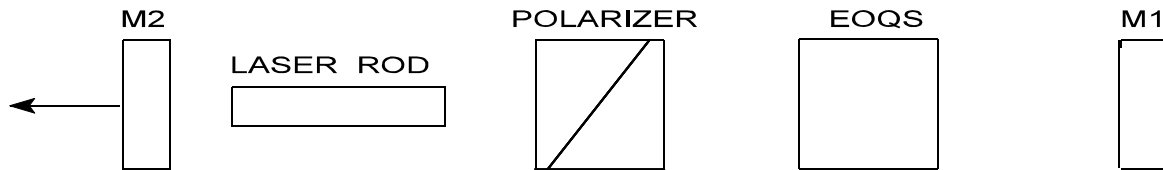
Inaccuracies in alignment and orientation of these optical elements result in degraded performance, i.e., inability to Q-Switch, inability to hold off lasing action, leakage of conventional mode laser energy, low Q-Switched power, optical pulse jitter and unusual or unstable pulse shapes. These degraded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

CAUTION

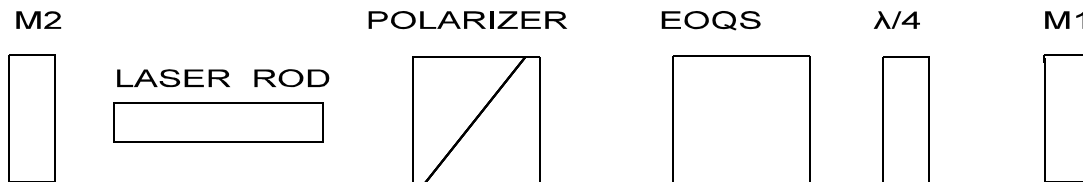
Laser energy deflected out of the cavity through polarizer side escape surfaces can be very intense. Safety glasses or goggles will not provide the attenuation necessary to prevent eye damage. Extreme care should be taken to either diffuse, absorb or block this energy.

FIGURE 3: Q-Switching Configurations

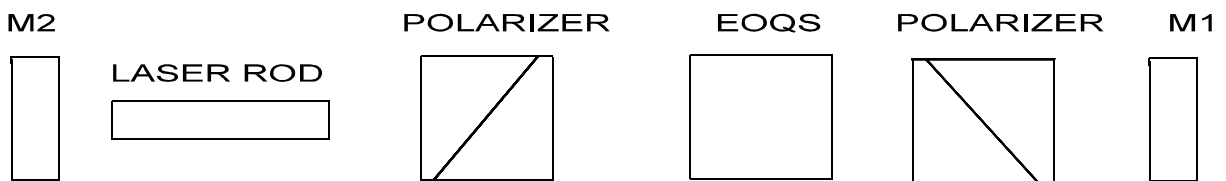
- A. Quarterwave Configuration: DC Quarterwave voltage is applied to prevent lasing. Voltage is then switched to zero volts to generate a Q-switched output pulse.



- B. Quarterwave Configuration: No DC voltage required to prevent lasing — Quarterwave plate provides optical bias. Quarterwave voltage is applied as a pulse to generate Q-switched output pulse.



- C. Halfwave Configuration: DC voltage is required to prevent lasing. DC Halfwave voltage is applied and is switched to zero volts (ground) to generate a Q-switched pulse.



M2 = Output Mirror (partially reflective)

QS = Electro-Optic Q-Switch (Pockels cell)

M1 = 100% Reflective Mirror

$\lambda/4$ = Quarterwave Plate

Polarizer = Glan-Laser Air Spaced Calcite Polarizer with 2 side escape windows, Brewster angle plates or other type linear polarizers.

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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.

For a rapid response include model number and serial number when referring to this equipment for any reason.

REV. 1 June 2011 /RLG