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USER GUIDE FOR 5055SC

Q-SWITCHING SYSTEMS

SERIAL No.

©\MANUALS\5055SC-Manual
Rev. 26 April 2012 / RLG

1.0 INTRODUCTION

5055SC 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 mote than 10 GW/cm^2, depending on the laser material 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 systems are **S**elf-**C**ontained, requiring only a low voltage DC power input and a trigger signal to activate operation.

The electronics portion of the system consists of a 5055SC 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 1.0 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 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 (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.

? **IMPORTANT NOTE** ?

HIGH VOLTAGE OUTPUT

There are several OEM versions of the 5055SC Pulse Module (PM). The following 2 paragraphs apply to those units which were specified to have a static DC HV applied to the Pockels cell - which is typical for quarter wave operation of a KD*P crystal QS and quarter wave or half wave operation of a lithium niobate QS where voltage is switched from the high voltage level to ground to generate a Q-switched pulse.

Under static conditions, when the 5055SC PM is not triggered, a DC voltage equal to the quarter wave or half wave voltage setting, controlled by the integral potentiometer, is applied across the QS terminals. When the PM is triggered, this voltage is switched to ground level thereby initiating the generation of the optical Q-switched pulse.

We strongly recommend that the DC supply voltage be turned off when the 5055SC System is not in active use. Refer to the Users Guide for BBO, KD*P, RTP and Lithium Niobate Q-switches which is an addendum to this manual for further details on alignment and use of these devices.

TRIGGER SIGNALS

Only one positive going trigger signal is needed to initiate an output pulse. This voltage can have an amplitude of between ? +4 to +10 volts into 50 Ohms. Trigger pulse widths between 100 nanosec to 10 microsec are acceptable. Avoid longer trigger pulse widths.

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 AC line power is turned off and the power switch or AC line cord is disconnected.

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 5055SC is not in active use. Long term, static operation can effect component lifetime when subjected to continuous high voltage.

2.0 MODEL 5055SC HIGH VOLTAGE PULSE MODULE

Nominal Specifications and Data Sheet

SERIAL No.

DC VOLTAGE REQUIRED

Voltage	+24 VDC
Power	7 Watts, typical maximum at max. Rep. Rate; (Depends on capacitive load, operating voltage and repetition rate)

TRIGGER INPUT

Voltage	Min. +4 Volts to Max. +10.0 Volts into 50 Ohm Input
Pulse Width	Min. 100 nanosec, Max. 10 microsec *(Input circuit is capacitor coupled to block DC voltage)*

REPETITION RATE	Single Shot to 1.0 kHz Max. **Do Not Exceed 1.0 kHz**
DC or Pulsed HV OUTPUT (Adjustable)	900 Volts to ~5.0 kV

5055SC 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 VDC supply.
HV Adjust Potentiometer	Controls/Adjusts output pulse amplitude

POCKELS CELL MODEL	Refer to following page if Pockels cell is included

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

POCKELS CELL OPERATIONAL CHARACTERISTICS

Model Number: Serial No.:

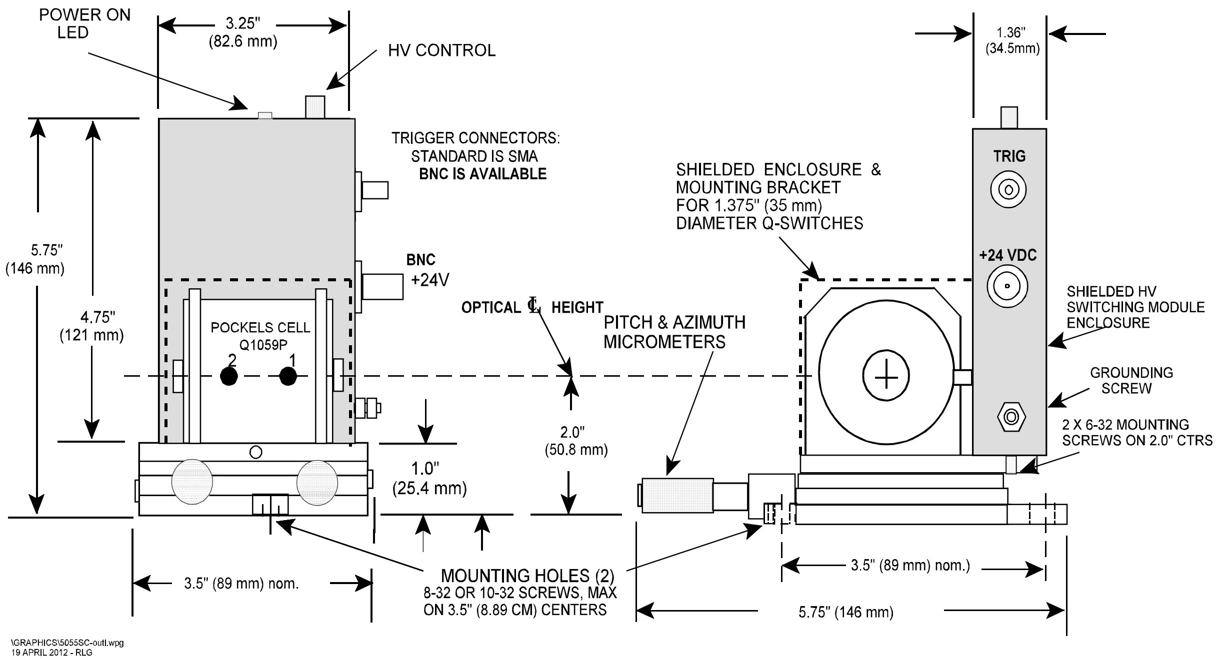
Crystal Material:
Crystal Coatings: AR @ nm
Window Material: Fused Silica
Window Coatings: AR/AR @ nm
Linear Aperture: mm Diameter
Index Matching Fluid: N/A

Polarizer: N/A
Analyzer: N/A

Contrast Ratio:
Intrinsic (between crossed polarizers, no voltage): >
At 1/2 wave Retardation Voltage: >
1/2 Wave Retardation Voltage: ~ kVDC @ 663 nm
1/2 Wave Retardation Voltage: ~ kVDC @ nm (calculated)
Quarter Wave Retardation Voltage: ~ kVDC @ nm (calculated)
Capacitance: pf

Tested By: Date:

When requesting information on this unit, please provide the MODEL and SERIAL NUMBER



5055SC INTEGRATED DRIVER / POCKELS CELL Q-SWITCHING SYSTEM

Figure 1: 5055SC System - Standard Configuration

MODEL 5055SC HV PULSE MODULE

3.0 GENERAL

The Model 5055SC HV Pulse Module is designed to operate with capacitive type Pockels cell, Electro-Optic Q-switches such as the Lasermetrics® Series 1040, 1050, 1145, 1147, 1150 and 3900 light modulators. When the Pockels cell is plugged or wired directly into the 5055SC module terminals, the mode of operation is MODE 1, "balanced output ", i.e., under static conditions (no triggering) there is zero net voltage applied across the Pockels cell terminals.

If the Pockels cell is not plugged or wired directly into the 5055SC module terminals there are two additional modes (Mode 2 and Mode 3) of operation possible, as detailed below.

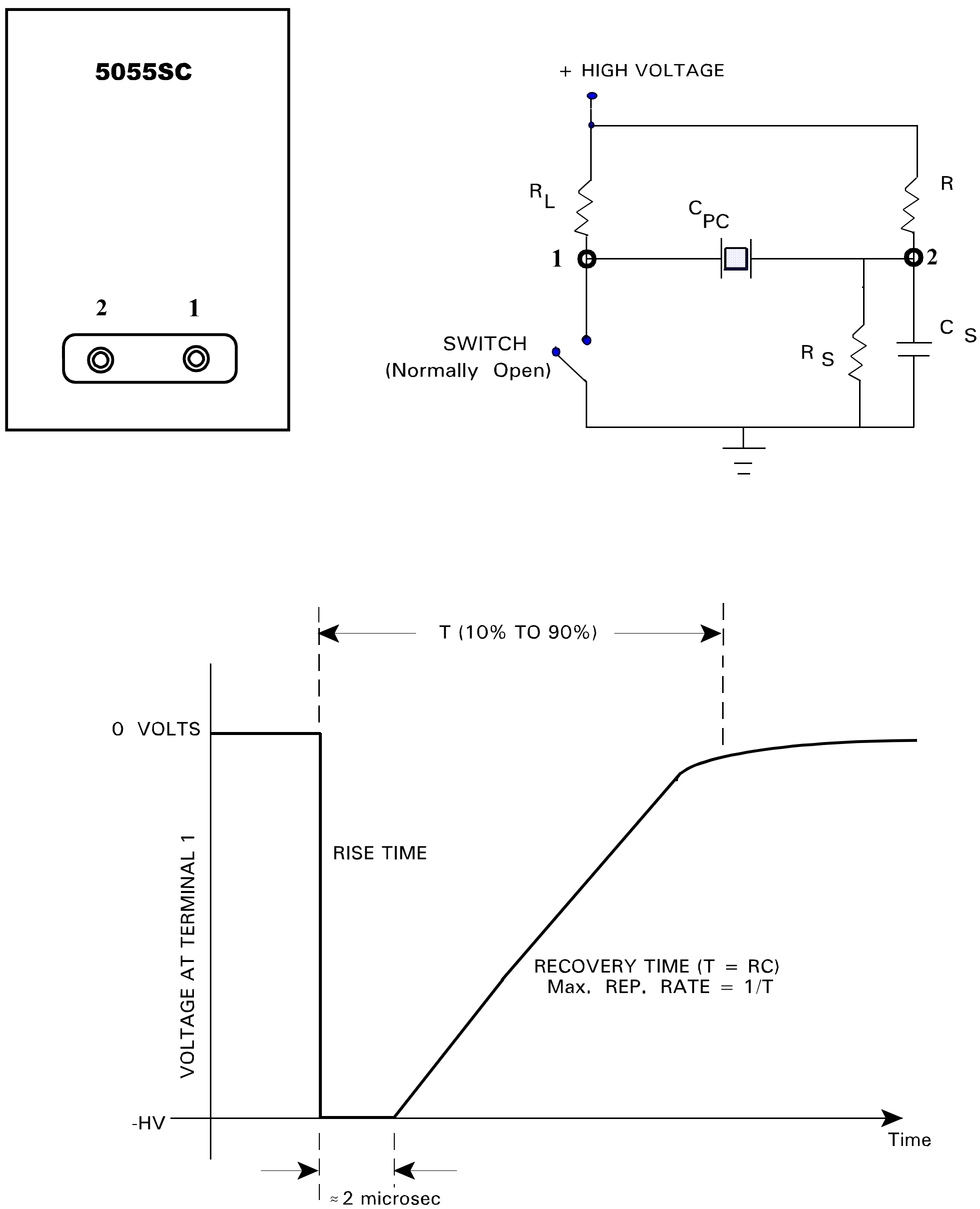
Figure 2a indicates **<u>MODE 1</u>** - the equivalent output circuit of 5055SC HV Pulse Module with balanced HV output which shows that under static, unswitched conditions, the voltage across the Pockels cell is zero. Upon triggering the unit, the voltage across the cell is switched from zero voltage to the high voltage set point.. The resulting output pulse has the form shown below the circuit in Figure 2a. The advantage of this circuit is the absence of a net DC voltage across the Pockels cell crystal. Continued long term application of DC voltage may cause ion migration within certain crystals such as KD*P, resulting in fogged optical surfaces and ultimate degradation of the device.

Figure 2b for **<u>MODE 2</u>** operation indicates how the Pockels cell can be connected so that voltage is applied directly to to the cell from terminal **1**. This configuration requires that the cell be connected by a single HV wire or cable to terminal 1, the side which is actively switched to ground. The other terminal (2) on the 5055SC is not used and must be insulated from its surroundings by means of electrical tape or RTV as there is DC high voltage remaining on the terminal. The second terminal on the Pockels cell is wired to ground.

Figure 2c for **<u>MODE 3</u>** operation indicates how a capacitor - resistor combination is used to block the DC high voltage from the terminal on the Pockels cell. Only terminal **1** on the 5055SC is used to connect to the capacitor. As in MODE 2 above, terminal **2** is not used and must be insulated. The second terminal on the Pockels cell is connected to ground. A blocking capacitor, in the range of 100 pf, rated for 6 to 10 kV, may reduce the maximum attainable pulse repetition rate due to increased RC time constants.

NOTE:

All <u>standard</u> 5055SC 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 System, or special output connections are ordered, the end user is responsible for correctly attaching the Pockels cell to the appropriate 5055SC terminals for use in Modes 1, 2 and 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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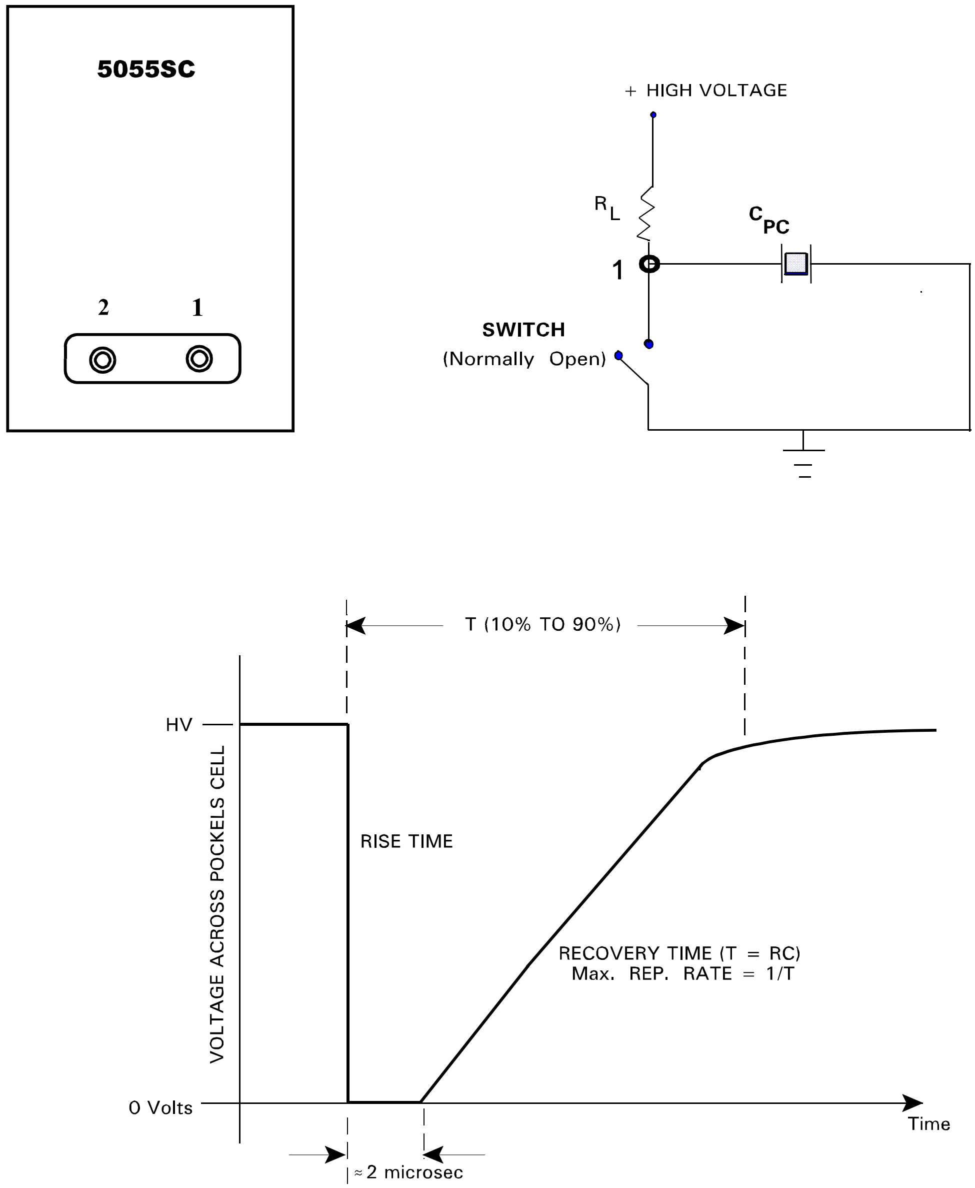
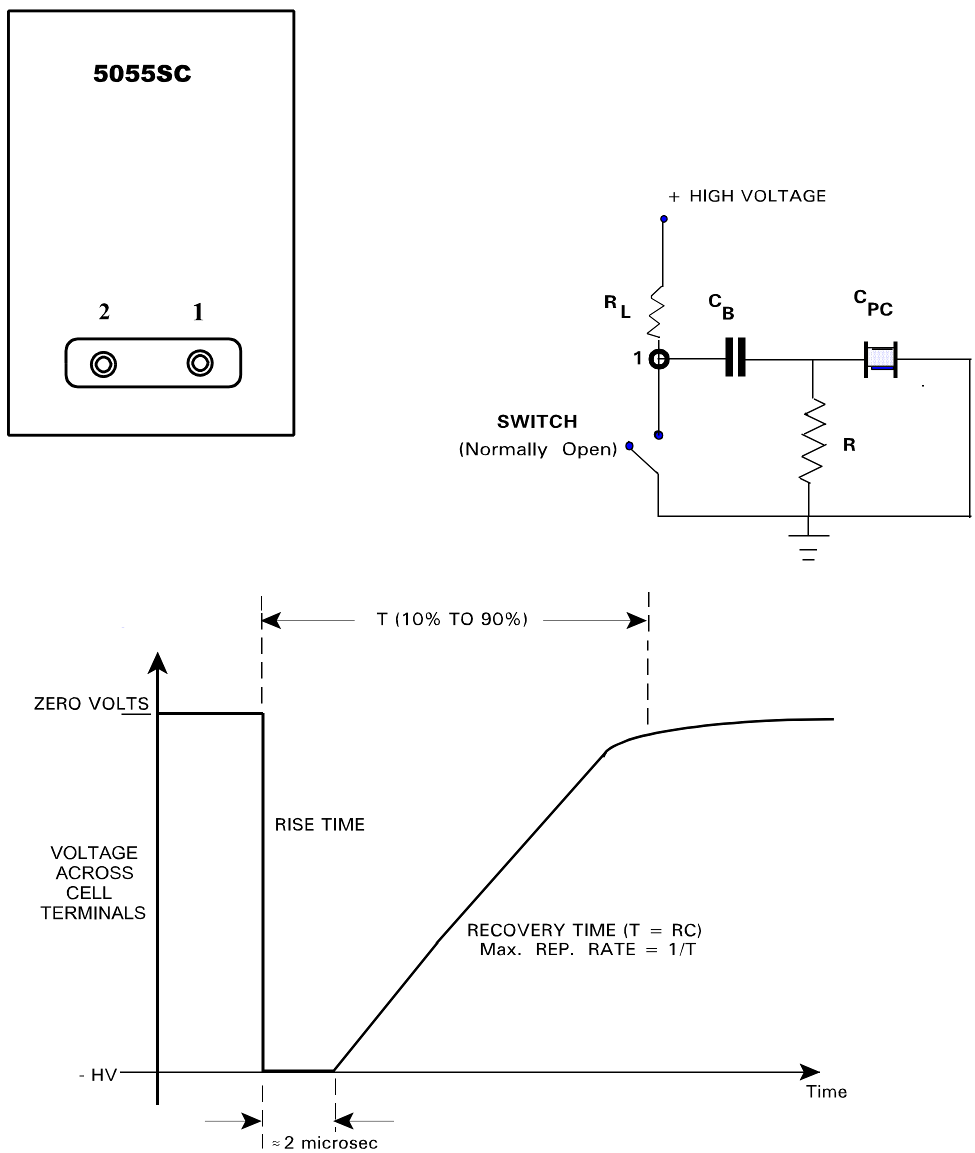
Figure 2a: MODE 1 - Balanced Output Version of the 5055SC - indicating zero static voltage across the Pockels cell terminals



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** 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. <u>Terminal **2** or any wire coming from terminal **2** is not used and must be insulated for safety.</u> 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 capacitance.

Figure 2b. MODE 2: Single Ended Operation - static HV is applied to Pockels cell



Zero Voltage Single Ended Output: An external blocking capacitor and bleed resistor can be connected to output terminal 1 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. <u>Output terminal 2 on the 5055SC is not used in this configuration and must be insulated since it is connected to HV (as shown in Mode 1, Figure 2a.</u>

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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 5056 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 attainable.

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) 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 Pulse Module.

4.2 Connect the +24 VDC voltage output from the external power supply to the +24 VDC connector on the 5055SC. 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 ?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 (<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 (QS), adjust the HV potentiometer on the 5055SC 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 HV 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.

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/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 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.

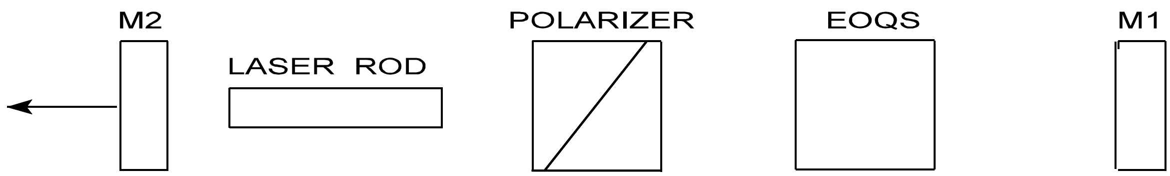
To establish the proper conditions for Q-Switching, the QS crystal must be aligned so that either its X or Y crystallographic axis is parallel to the polarization direction of the laser (some materials such as ruby have a defined polarization axis and some rods of ruby or other materials will have Brewster 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.

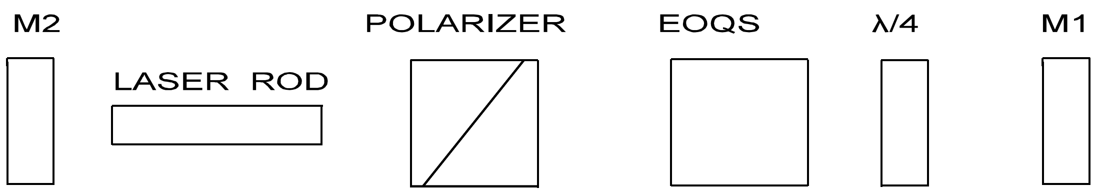
CAUTION

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.

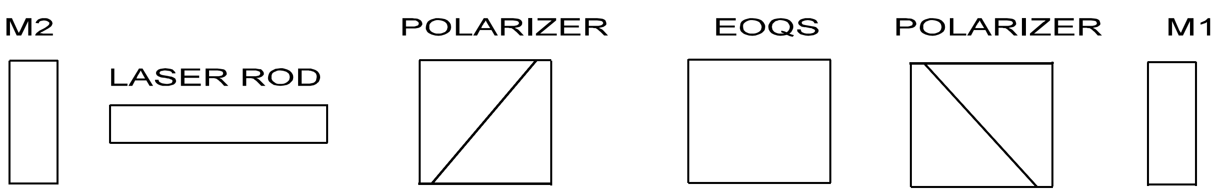
FIGURE 3: Q-Switching Configurations



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.

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M2 = Output Mirror (partially reflective)

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

M1 = 100% Reflective Mirror

?/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.

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