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USER GUIDE FOR 5055 & 5055SC

Q-SWITCHING SYSTEMS



SERIAL No.

1.0 INTRODUCTION

5055 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 up to 750 Megawatts/cm², depending on the laser 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 self-contained, requiring only a low voltage DC power input and a trigger signal to activate operation.

The electronics portion of the system consists of a 5055 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 a 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 (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 but high intensity optical pulse.



IMPORTANT NOTE



HIGH VOLTAGE OUTPUT

There are several versions of the 5055 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 EOQS or quarter wave or half wave operation of a lithium niobate EOQS where voltage is switched from the high voltage level to ground when a Q-switched pulse is generated.

Under static conditions, when the 5055 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 EOQS 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 5055 System is not in active use. Refer to the Users Guide for KD*P 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 operation. This voltage can have an amplitude of between $\approx +2$ to $+5$ volts. Trigger pulse widths between 10 nsec to 100 μ sec 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 5055 is not in active use. Long term, static operation can effect component lifetime when subjected to continuous high voltage.

2.0 MODEL 5055 & 5055SC HIGH VOLTAGE PULSE GENERATOR

Specifications and Data Sheet

SERIAL No.

DC VOLTAGE REQUIRED

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

TRIGGER INPUT

Voltage	Min. +2 volts to Max. +5.0 volts
Pulse Width	Min. 10 nsec, Max. 100 μ sec (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)	1000 to \geq 4800 Volts
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POCKELS CELL MODEL

Halfwave Voltage @ 633nm	Q1059PSGV-1064 3.8 kV DC
Capacitance	5 pf

5055SC STANDARD OPERATIONAL AND CONTROL FUNCTIONS

Power ON LED	Indicates DC voltage is applied to the Pulse Module (Available on Special Order only - extra cost option)
Trigger Input jack (BNC)	Provides interconnection to positive signal sources.
+ 24 VDC jack (BNC)	Provides interconnection to + 24 VDC supply.
HV Adjust Potentiometer	Adjusts output pulse amplitude

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

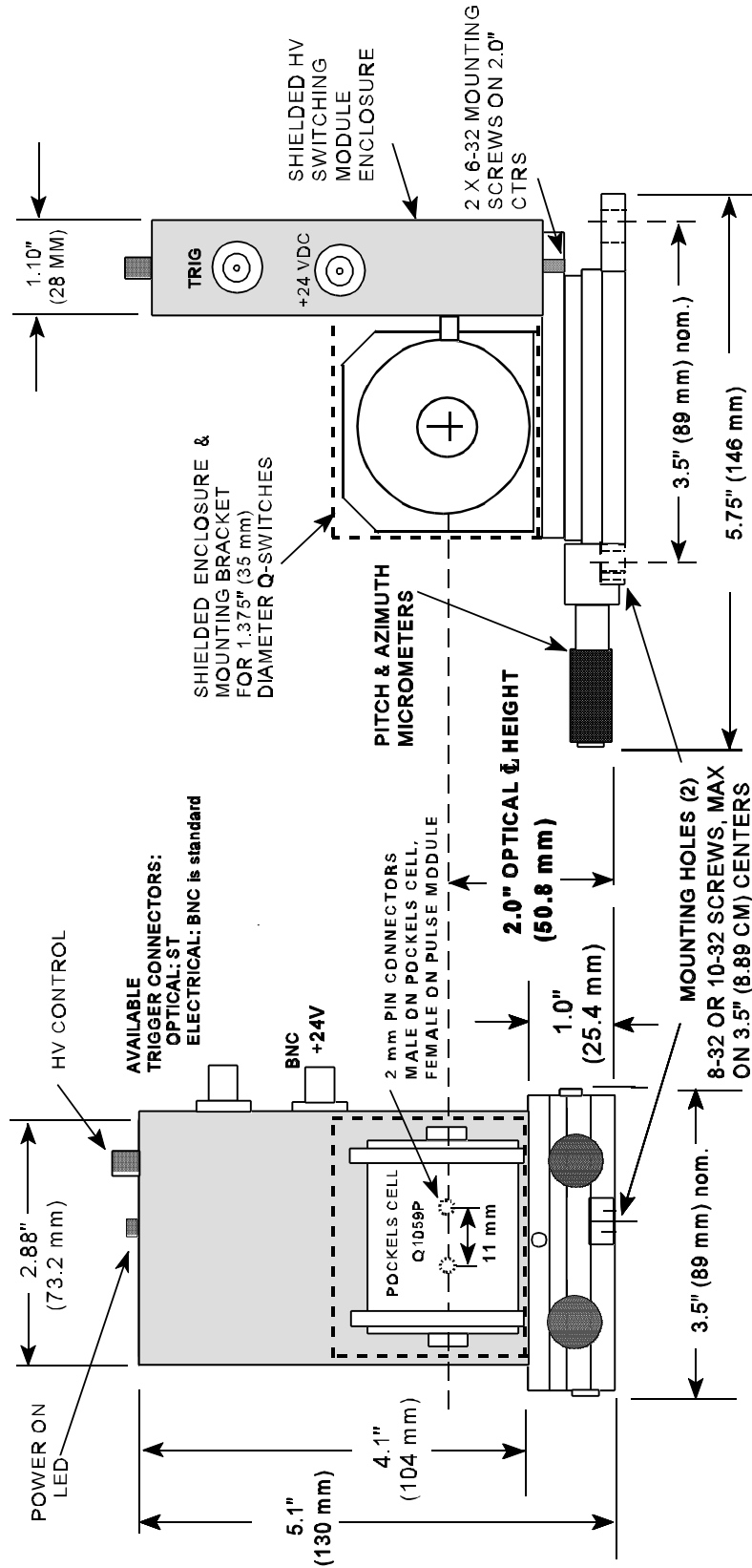


Figure 1: 5055SC System - Standard Configuration

5055SC INTEGRATED DRIVER / POKKELS CELL Q-SWITCHING SYSTEM

3.0 SYSTEM CONNECTION

NOTE: Before proceeding with system connection, insure that the AC Power Switch on the DC Power Supply (provided by user) is in the "OFF" position and that the DCV Control knobs are turned full counterclockwise.

3.01 Connect an appropriate trigger source to the TRIGGER input of the 5055 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 5055. The supply voltage must not exceed +24 volts DC. The mating connector to the one on the 5055 is Kings Model KM-51-07.

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 sec. Do not exceed 1.0 kHz trigger repetition rates.

4.0 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 (EOQS), 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 the pump energy. Typical values range from 100 μ sec to 500 μ sec. 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 sec (assuming that the flash lamp pulse is at least 500 μ sec 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 5055 Q-SWITCHING SYSTEM

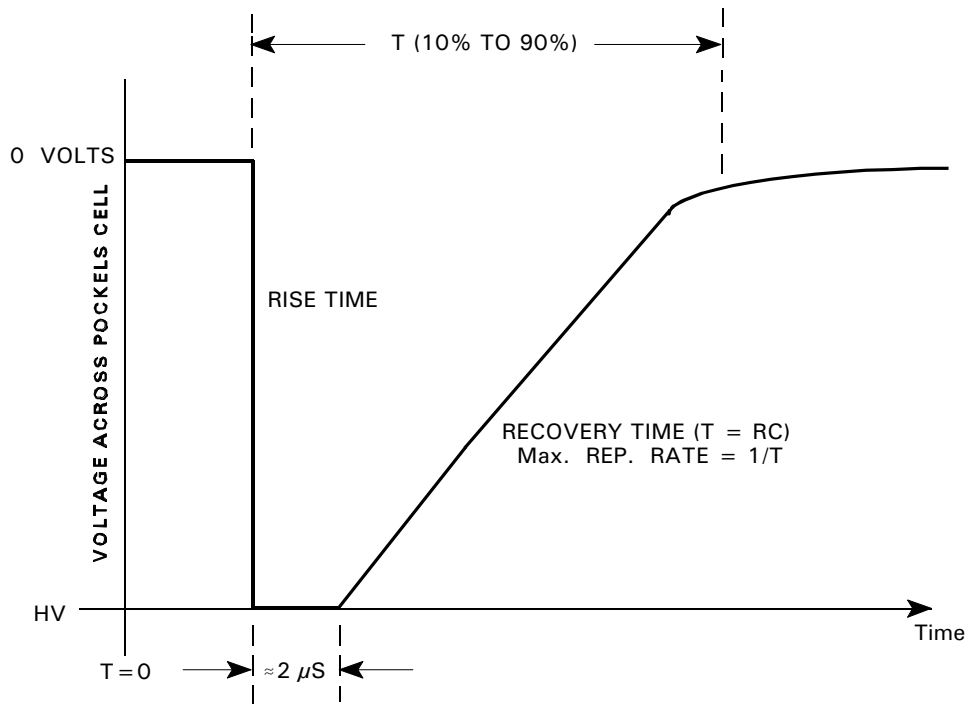
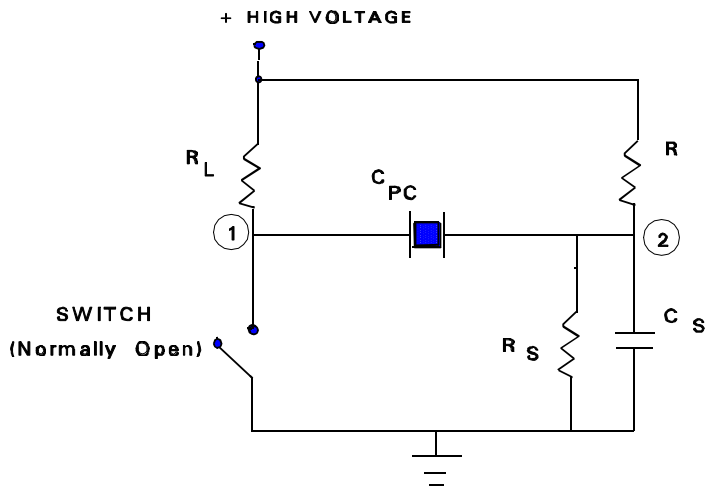
5.0 GENERAL

The Model 5055 is designed to operate with capacitive type Pockels cell Q-switches (EOQS) such as the Lasermetrics® Series 1040, 1050, 1060, 1090, 3900 and LMA-4 Pockels cell 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 mode of operation as detailed below is preset and cannot be changed.

Figure 2 indicates the equivalent output circuit of 5055 HV Pulse Module with balanced HV output which shows that under static, unswitched conditions, the voltage across the EOQS 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 has the form shown below the circuit. 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.

Figure 2A indicates a version of the 5055 PM where HV is applied continuously to the EOQS (output not balanced). Typically this voltage is the quarter wave retardation voltage. Upon triggering the PM, the 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 PM should be turned off when the unit is not in active use.

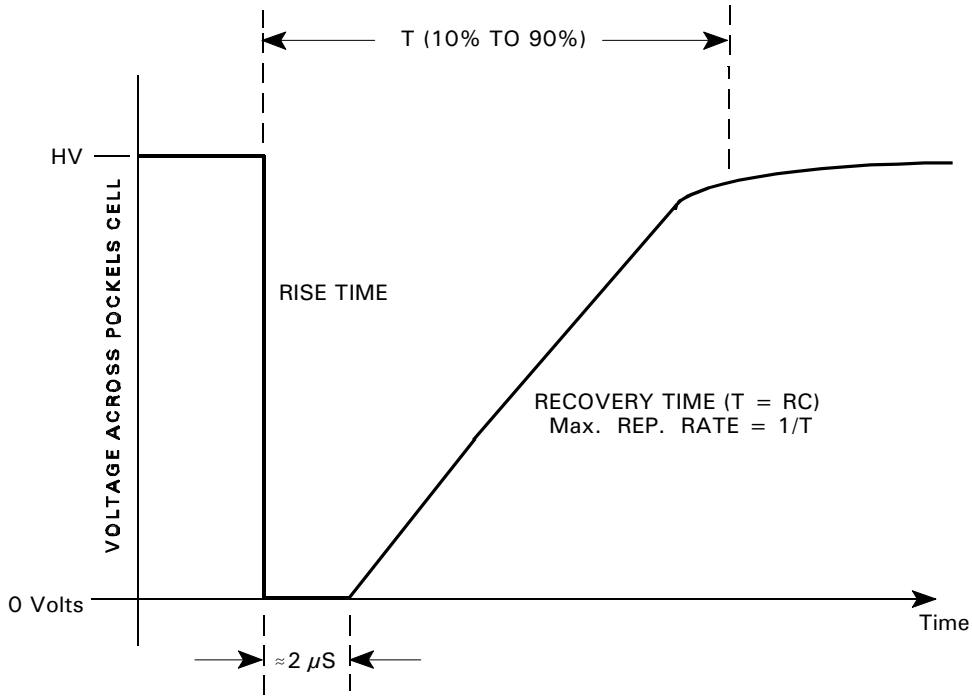
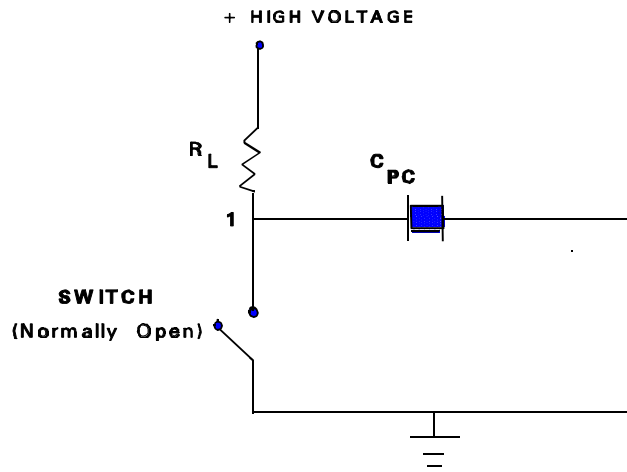
The mode of operation, corresponding to either Figure 2 or Figure 2A is preset at the factory and cannot be changed.



Balanced Output: Static voltage across Pockels cell is zero volts when output is not triggered ($T=0$). When output is triggered, voltage across cell switches to the high voltage level set by the front panel potentiometer. The ON time of $\approx 2 \mu\text{S}$ 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.

\baloutput.wpg

Figure 2: Typical Output of the 5055 - Balanced Output Version, indicating zero static voltage across the Pockels cell



Single Ended Output: High Voltage appears at output connector when +24 VDC is applied. When 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 2A: Single Ended Version - static HV is applied to Pockels cell

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 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 better 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 EOQS 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 EOQS 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.

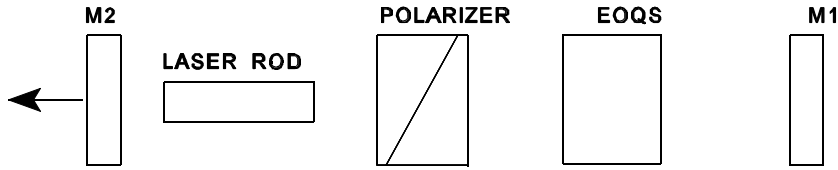
To establish the proper conditions for Q-Switching, the EOQS crystal must be aligned so that either its X or Y crystallographic axis is parallel to the polarization direction of the laser (some materials such as ruby have a defined polarization axis and some rods of ruby or other materials will have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

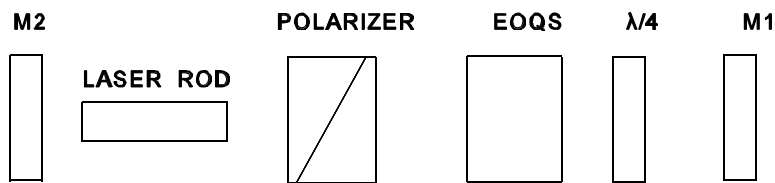
CAUTION

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.

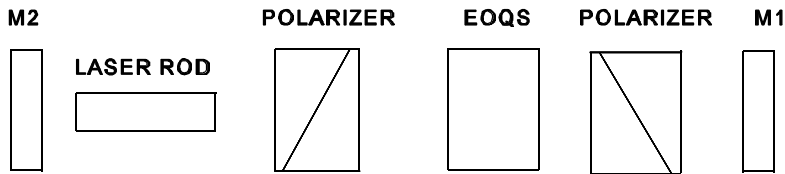
FIGURE 3: Q-Switching Configurations



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)

EOQS = Electro-Optic Q-Switch or Modulator

M1 = 100% Reflective Mirror

$\lambda/4$ = Quarterwave Plate

Polarizer = Glan-Laser Air Spaced Calcite Polarizer with 2 side escape windows.

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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 or device 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 no charge, but 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'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.

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.