PIV

Pulsed Nd:YAG Laser for Particle Image Velocemetry

User's Manual

Spectra-Physics

Spectra-Physics Lasers, Inc.

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INTRODUCTION:

The Quanta-Ray PIV series Nd:YAG lasers are the first commercially available pulsed laser systems designed specifically for Particle Image Velocemetry (PIV) applications. The proven technique of polarization coupling the output beams from each cavity is used to generate a single collinear output beam. These independent oscillator cavities ensure almost infinitely variable pulse separation times, while maintaining constant output energy. A harmonic generator and a dichroic beam splitter are used to produce the coaxial second harmonic beams. There are several models to select from offering various energies, output polarizations and spatial modes.

This manual contains information you will need for day-to-day operation and maintenance of your Quanta-Ray PIV series Nd:YAG laser system. You will find instructions for installation, operation, preventive maintenance, a brief description of its circuitry, and repair guide. The system is comprised of four elements: the laser head, power supply, remote control, and delay generator.

While this manual contains a brief installation procedure, it is not intended as a guide to the initial installation and set-up of your laser. Please wait for the Spectra-Physics Lasers service engineer who has been assigned this task as part of your purchase agreement. Allow only those qualified and authorized by Spectra-Physics Lasers to install and set up your laser system.

The Service and Repair section is intended both as an aid to help you guide the field service engineer to the source of problems, and as a guide to repairs you my choose to do yourself. Do not attempt to repair the unit while it is under warranty.: instead, report all system failures to Spectra-Physics Lasers customer service for warranty repair.

The PIV series lasers emit laser radiation that can permanently damage eyes and skin, ignite fires, and vaporize substances. Moreover, focused back-reflections of even small percentage of its output energy can destroy expensive internal optical components. The Laser Safety section contains information and guidance about these hazards. To minimize the risk of injury, death, or expensive repairs, carefully follow these instructions.

UNPACKING YOUR LASER:

Your lasers were packed with great care and all containers were inspected prior to shipment. The laser left Spectra-Physics in good condition. Upon receipt of your laser, immediately inspect the outside of the shipping containers. If there is any major damage, such as holes in a box or cracked wooden frame members, or if any of the Shock Watch indicators show that the containers sustained undue impact, insist that a representative of the carrier be present when you unpack the contents.

Carefully inspect your laser as you unpack it. If you notice any damage, such as dents, scratches or broken knobs, immediately notify the carrier and your Spectra-Physics sales representative.

Keep the shipping containers. If you need to return the laser for upgrade or service, the specially designed shipping containers assure adequate protection of your equipment. Spectra-Physics Lasers will only ship Spectra-Physics equipment in original containers; you will be charged for replacement containers.

GENERAL DEFINITIONS:

PIV 200

The PIV 200 is a system consisting of two GCR 130 resonators. These are single rod oscillators which produce 450 mJ/p IR at 10 Hz. The output of the oscillators are combined through a beam combining optic at brewsters angle to produce two coaxial beams, which are doubled through a harmonic generator. The residual 1064 nm beam is separated by a dichroic mirror, and dumped into a beam dump. The result is two coaxial 532 nm beams specified at 200 mJ/p with their polarizations aligned in the standard configuration, or 140 mJ/p with orthogonal polarizations, in the cross polarized output option.

PIV 400

The PIV 400 is a system consisting of two GCR 170 resonators. These are dual rod oscillators which produce 750 mJ/p IR at 10 Hz. The 532 nm output of this system is specified at 350 mJ/p with their polarizations aligned in the standard configuration, or 280 mJ/p with orthogonal polarizations in the cross polarized output option.

STANDARD OUTPUT OPTION

The Standard output option for the PIV system is using one Type II KD*P crystal in the harmonic generator to produce the output 532 nm beams with the same polarization direction. This can be either vertical or horizontal, but in either case, both will be the same.

CROSSED POLARIZED (CPO) OUTPUT OPTION

The CPO output option for the PIV system uses two Type I KD*P crystals in the harmonic generator to produce the output 532 nm beams with orthogonal polarizations. One beam will be vertically polarized, while the other will be horizontally polarized.

INTERNAL TIMING

Internal timing allows the user to control the PIV system using basic internal timing controls to trigger the lamps and Marx Bank. The range of pulse timing separation using this method is limited to only a few milliseconds. This option is basically for alignment of the PIV system, as it allows easy access of the Long Pulse mode for both resonators.

EXTERNAL TIMING

The PIV system is designed to be externally triggered by a high quality delay generator, such as the Stanford Research Systems' DG 535. Four independent timing signals are required for the best performance and maximum flexibility. The DG 535 generates pulses with any time separation and almost no measurable time jitter with respect to each other, at any delay. Any high quality delay generator will work, but this manual covers only the DG 535.

SEEDED / UNSEEDED OPTIONS

The PIV is also offered in a seeded version. Both oscillators are seeded with the same temperature stabilized diode pumped Vanadate laser to produce a narrow linewidth (.003 cm-1) beam. Each GCR resonator is separately stabilized using piezoelectric positioning of the cavities' high reflector to lock onto a single axial mode.

PIV LASER OUTPUT CONFIGURATIONS:

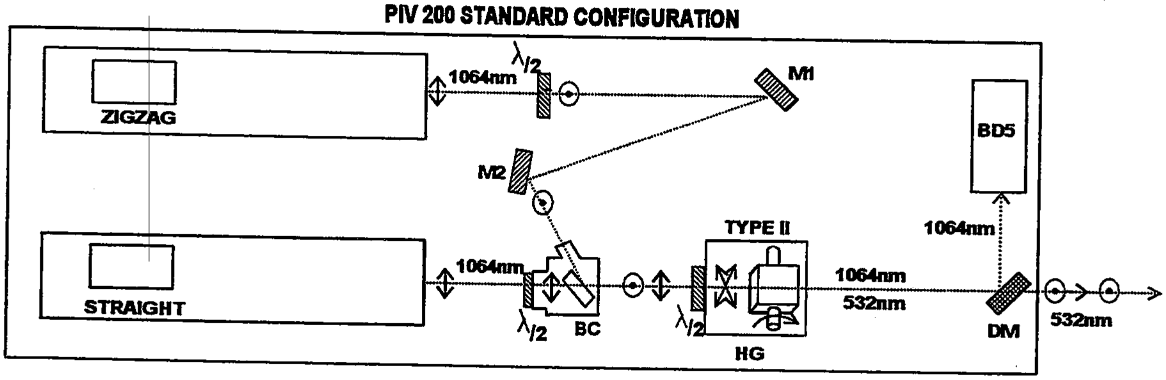
PIV 200

The PIV 200 series laser consists of two GCR 130 oscillators. The typical IR polarization output of the single rod resonator is horizontal (unless a λ/2 plate is inserted into the resonator to improve the mode.) If a λ/2 plate is inserted in the resonator, then the output polarization is oriented in some direction other than horizontal. In either case, an external λ/2 plate is used to orient the polarization to vertical before M1 on the Zig Zag path, and another λ/2 plate is used to orient the polarization to horizontal before the Beam Combiner on the Straight path. These λ/2 plates set the polarizations of the IR beams to the correct orientation to be combined coaxially through the Beam Combiner. If both resonator Q-switches are fired simultaneously, the Straight pulse will pass through the Beam Combiner ahead of the Zig Zag pulse due to the difference in distance the beams travel, as shown in the accompanying figures.

PIV 200 STANDARD CONFIGURATION:

The Standard configuration uses (1) Type II KD*P crystal to produce the second harmonics. Type II KD*P will accept a linear polarized IR beam oriented at 45° to produce a second harmonic with its polarization orthogonal to the crystal's axis of rotation. If the Harmonic Generator is set up so that the crystal rotates about a horizontal axis (as shown,) then both output pulses' polarizations will be vertical.

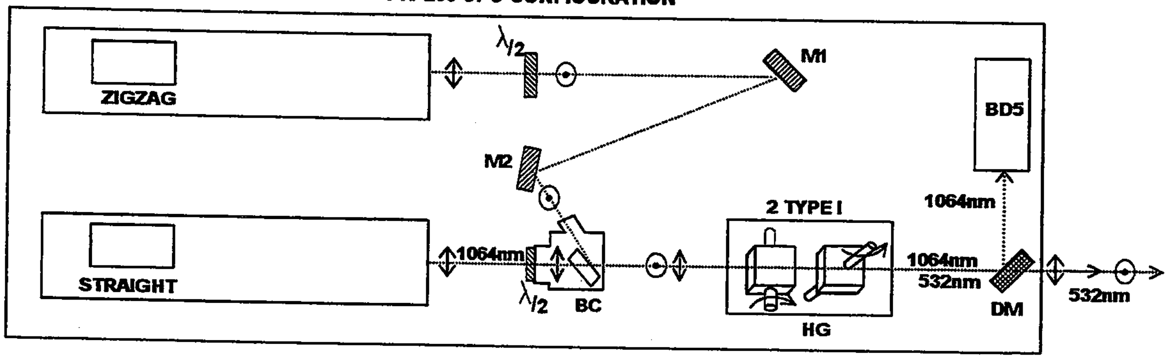
PIV 200 STANDARD CONFIGURATION



PIV 200 CPO CONFIGURATION:

The CPO configuration uses (2) Type I KD*P crystals to produce the second harmonics. Type I KD*P will accept an orthogonal linear polarized IR beam to produce second harmonics with their polarizations rotated 90° from the input IR. In this case, the output 532 nm polarizations will be orthogonal to one another as shown, providing the polarization of the IR beams is correct.

PIV 200 CPO CONFIGURATION



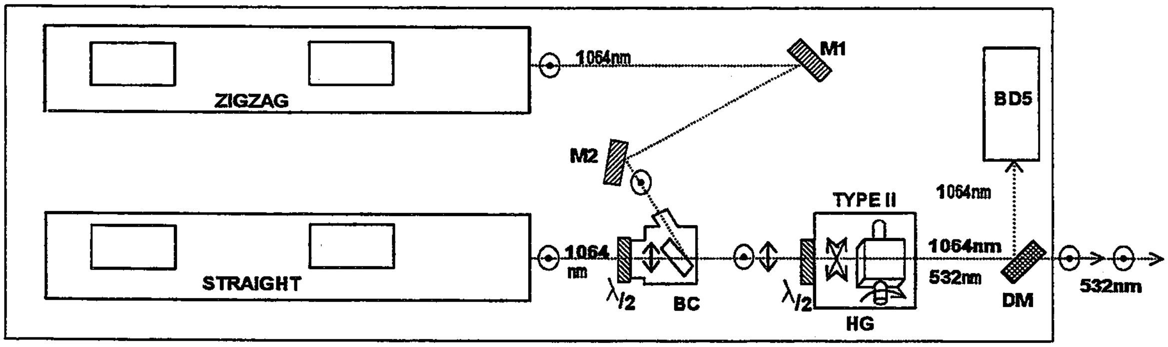
PIV 400

The PIV 400 series laser consists of two GCR 170 oscillators. The typical IR polarization output of the dual rod resonator is vertical (unless λ/4 plates are inserted into the resonator for seeding.) If λ/4 plates are inserted in the resonator, then the output polarization is oriented in some direction other than horizontal. In either case, an external λ/2 plate is used to orient the polarization to vertical before M1 on the Zig Zag path, and another λ/2 plate is used to orient the polarization to horizontal before the Beam Combiner on the Straight path. These λ/2 plates set the polarizations of the IR beams to the correct orientation to be combined coaxially through the Beam Combiner. If both resonator Q-switches are fired simultaneously, the Straight pulse will pass through the Beam Combiner ahead of the Zig Zag pulse due to the difference in distance the beams travel, as shown in the accompanying figures.

PIV 400 STANDARD CONFIGURATION:

The Standard configuration uses (1) Type II KD*P crystal to produce the second harmonics. Type II KD*P will accept a linear polarized IR beam oriented at 45° to produce a second harmonic with its polarization orthogonal to the crystal's axis of rotation. If the Harmonic Generator is set up so that the crystal rotates about a horizontal axis (as shown,) then both output pulses' polarizations will be vertical.

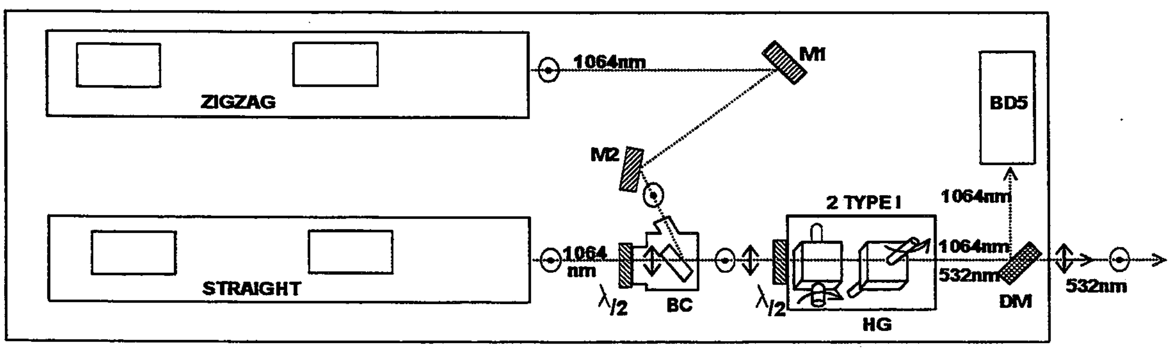
PIV 400 STANDARD CONFIGURATION



PIV 400 CPO CONFIGURATION:

The CPO configuration uses (2) Type I KD*P crystals to produce the second harmonics. Type I KD*P will accept an orthogonal linear polarized IR beam to produce second harmonics with their polarizations rotated 90° from the input IR. In this case, the output 532 nm polarizations will be orthogonal to one another as shown providing the polarization of the IR beams is correct.

PIV 400 CPO CONFIGURATION



PIV TIMING CONFIGURATIONS:

The SIS Quanta-Ray PIV consists of two independently triggered oscillators that are beam combined to give you collinear pulses with any desired time separation.

While it is possible to use the internal timing to set up both oscillators and adjust the timing to a small degree, the system is designed to be externally triggered by a high quality delay generator, such as Stanford Research Systems' DG 535. Four independent timing signals are required for the best performance and maximum flexibility. The DG 535 generates pulses with any time separation and almost no measurable time jitter with respect to each other, at any delay.

The easiest timing configuration to use is internal timing. Connect the LAMP SYNC OUTPUT to the LAMP TRIGGER DELAYED INPUT on the power supply front panel so both oscillators' lamps will fire simultaneously.

Interrupt the Q-switch signal coming from the laser umbilical to the back of the PIV head with the BNC "T" connector. (There is only one BNC connector—it's located on the back panel of the PIV head.) Connect the BNC to the delayed Q-switch input on the side of the PIV head. The delay between the two pulses will be determined by this cable length—10' to 20' is good. In this configuration, the long pulse Q-switch mode is enabled for both oscillators; therefore, for rough alignment and fine tuning the overlap, this is the easiest and most convenient set up. The upper LAMP ENERGY knob will control the delayed timing Straight oscillator; the lower LAMP ENERGY knob will control the fixed timing Zig-Zag oscillator.

If short delays of less than 1μ S are all that is required, remove the BNC "T" and trigger the DELAYED Q-SWITCH trigger input on the side of the PIV head from the Q-SWITCH ADV SYNC on the power supply's front panel. The delayed oscillator's "long pulse" is disabled.

When delays of less than 20 μ S are required, a single-channel delay generator will work.. The delayed Q-switch input wants a positive-going TTL pulse with 50 Ω impedance. The Q-SWITCH DELAY knob must be adjusted on the remote control to move the fixed pulse early in the lamp envelope, where its power is just starting to drop. Trigger the delay generator from the Q-SWITCH SYNC, Q-SWITCH ADV SYNC, or the PIV head back panel with the "T" connector.

External triggering is the recommended mode for both oscillators. Set all delay generator outputs to: TTL, 50 Ω, normal (positive edge). Set the trigger to INTERNAL and to the same repetition frequency set up at the factory.

Changing the repetition frequency requires a Spectra-Physics Lasers' service engineer.

If operating with a DG 535, use channels T_o, A, B, and C. Channel D is available for scope triggering.

CONNECTIONS:

T_o	LAMP TRIG INPUT on the power supply front panel
A	BNC connector at rear of PIV head. Abandon BNC cable coming from umbilical.
B	LAMP TRIG DELAYED INPUT on the power supply front panel.
C	Delay Q-switch trigger on the side of the PIV head.

DESCRIPTION:

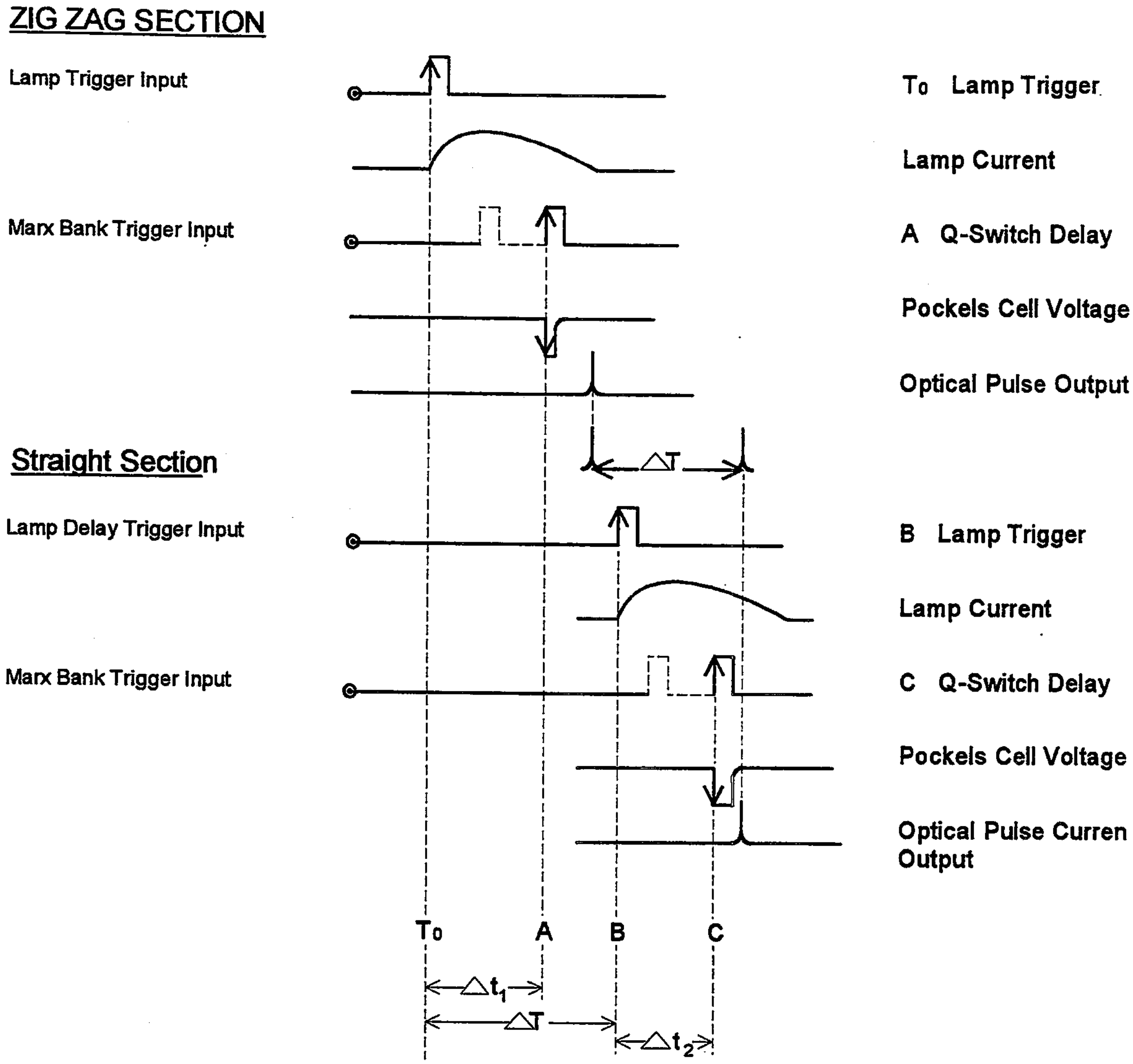
T_o	TIME ZERO—Fixed oscillator lamp trigger.
A	Fixed oscillator Q-switch delay.
B	Delayed oscillator lamp trigger. (Δ PIV)
C	Delayed oscillator Q-switch delay.

INSTRUCTIONS:

T_o	Fixed (Zig Zag) oscillator lamps trigger, typically 10 Hz.
A	Fixed Q-switch delay. Set to start at T_o + 160 μ S. Adjust the timing in 1 μ S steps and determine the optimal Q-switch delay for maximum power. There should be a 10 to 20 μ S window of maximum power.
B	Delayed lamp trigger. Initially, set at T_o + 0. Later, this is set at T_o + Δ PIV.
C	Delayed Q-switch trigger. Initially set at B + 160 μ S. Adjust timing as in "A." Since both oscillators are identical the Q-switch delays should be approximately the same. When the best performance is determined for both oscillators, maximum power from either oscillator can be obtained at the same Q-switch delay. (I.e., If this fixed oscillator has maximum power from T_o + 163 μ S to T_o + 178 μ S, and the delayed oscillator has maximum power from B + 158 μ S to B + 170 μ S, the fixed oscillator is set at 165 μ S, and the delayed oscillator at 165 μ S.) Using a photodiode and an oscilloscope, one can fine tune the timing delay of the delayed oscillator to be exactly 0 with respect to the fixed oscillator when the PIV delay is 0 (with A = T+ 165 μ S, B = T + 0, and C = B + 165 μ S, the delayed pulse is 4 n S behind the fixed pulse. Set A = T + 165.004 μ S to correct the timing)

Since C is tied to B, changing the timing of B will move the delayed pulse with respect to the fixed pulse, and not effect the relative powers of the two pulses. For example, for a PIV delay of 73 μ S, the timing would be as follows:

T_o		(time zero)
A	T_o+ 165 μ S	(fixed Q-switch delay)
B	T_o+ 73 μ S	(PIV delay)
C	B+ 165 μ S	(delayed Q-switch delay)



$\triangle t_1$:	Zig Zag Section Q-Switch Delay	150 μs < $\triangle t_1$ < 200 μs
$\triangle T$:	Pulse Seperation Time	1 ns < $\triangle T$ < 1/Laser Rep Rate
$\triangle t_2$:	Straight Section Q-SwitchDelay	150 μs < $\triangle t_2$ < 200 μs

REMOTE CONTROL Operation:

OSC LAMP ENERGY control knob sets the Zig Zag oscillator flash lamp energy.

AMP LAMP ENERGY control knob sets the Straight oscillator flash lamp energy.

SIMMER indicator LEDs glow when the simmer current is on.

REP RATE: ERROR indicator LED is used only for computer controlled systems.

Q-SWITCH: ERROR indicator LED is used only for computer controlled systems.

REP RATE: VARIABLE control sets the variable lamp firing rate. The range is $\pm$ 5% Hz from the optimized frequency setting for your laser.

REP RATE: MODE selector selects the source of the lamp firing pulse: FIXED repetition rate, VARIABLE repetition rate, and EXTernal repetition rate. EXTernal control requires a firing pulse at the LAMP TRIG input.

Q-SWITCH: MODE selector determines source and timing of control signals for the Pockels cell.
In Q-SWitch mode, the Pockels cell firing follows the firing of the flash lamps by about 170 μ S.
In LONG PULSE mode, the Pockels cell and flash lamp firing are synchronous.
In EXTernal mode, a signal at the Q-SW TRIG input fires the Pockels cell.

INTernal / COMPUTER toggle switch selects either the remote control module or a computer for control.

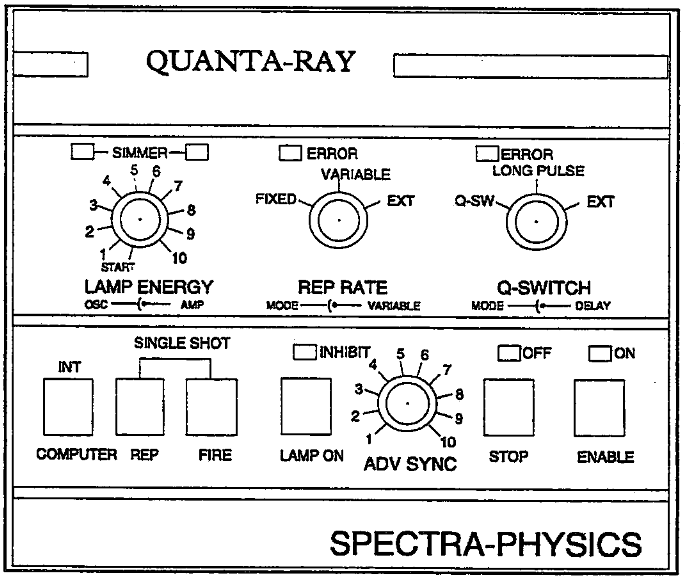
SINGLE SHOT switches determine whether the laser fires repetitively, or one shot at a time, on command. When the REP switch is in the SINGLE SHOT (up) position, the FIRE button is enabled.

LAMP ON switch turns on the switching mode power supply. If the switch is in the INHIBIT position, the lamp can not flash, and the INHIBIT indicator glows.

ADVanced SYNC control adjusts the timing of a signal used to synchronize auxiliary equipment with the Q-switch signal. The signal is available at the Q-SW ADV SYNC output connector on the power supply. Its range is $\pm$ 500 ns.

STOP switch turns off the laser.

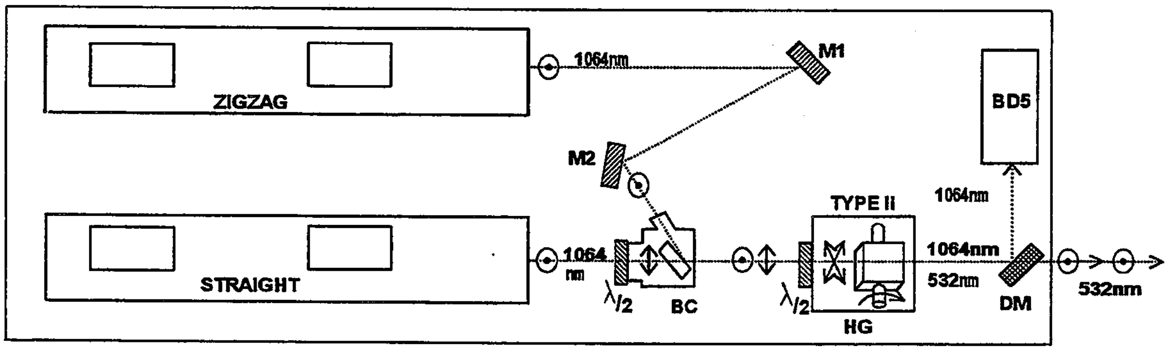
ENABLE switch starts the laser.



OVERLAP PROCEDURE FOR THE STANDARD OUTPUT OPTION

Overlap occurs when the beam from the Zig Zag oscillator is propagating coaxially with the beam from the Straight oscillator. This overlap is achieved using a beam combining optic (BC), a window at brewster's angle which combines the two beams of orthogonal polarizations. The beam combiner allows horizontal polarization to pass from the Straight oscillator, and vertical polarization to pass from the Zig Zag oscillator. The polarization orientations for each oscillator is achieved using 1/2 waveplates in their beam paths. In this manual we will assume that both oscillators have been separately optimized for IR mode and energy at full power in the Q-switched mode of operation.

PIV 400 STANDARD CONFIGURATION



INITIAL IR BEAM ALIGNMENT CHECK

1. Set up the PIV in the "Internal Timing" mode of operation.
2. Remove the output dichroic mirror (DM) from the beam path.
3. Slide the harmonic crystal out of the beam path.
4. Check that the external 1/2 waveplates are centered on the IR beams and adjusted correctly for each leg by measuring the energy before and after the beam combiner, (there should be no more than a few percent loss of energy through the beam combiner for each leg.) If a loss is measured, adjust the corresponding 1/2 waveplate to maximize the energy through the beam combiner.
5. Check the rough overlap of the IR beams by the following procedure:
    - Turn up the Straight oscillator in Long Pulse to the point where it lases. Mark its position with a target several meters from the laser. (The target can be an iris, an IR card, or a cross drawn on a business card, taped to the wall, viewed with an IR viewer.)
    - Turn up the Zig Zag oscillator and check that its beam is overlapped with the Straight oscillator both in the near-field and far-field using an IR card.
    - If the Zig Zag oscillator is not overlapped with the Straight oscillator, adjust M1 to overlap the beams in the near-field (right after the HG), and adjust M2 to overlap the beams in the far-field (several meters away).
    - Iterate this process until the beams are roughly colinearly aligned.

VERTICAL 532 nm BEAM ALIGNMENT

6. Reinstall the dichroic optic and adjust its mount to direct the IR into the beam dump. Slide the harmonic crystal back into position. Make sure that the harmonic generator is rotated so that the crystal arm is positioned vertical (meaning the 532 nm output will be vertical.)

7. Turn the Q-sw to Long Pulse and mark the low power 532 nm beams' position in the far field with a target. Turn up the Zig Zag oscillator in Long Pulse and check if its 532 nm beam is roughly overlapped with the Straight oscillator, If you did step 5 correctly, this should be correct..

8. Place a power meter in the beam path. Turn up the Straight oscillator to full energy Q-switched and peak up the harmonic generator's 1/2 waveplate and crystal angle to give the highest output energy. Once the output of this oscillator has stabilized at its maximum point,. Do not touch the crystal angle again because the optimized crystal will be used to peak the Zig Zag beam alignment.

9. Turn down the Straight oscillator, and turn the Zig Zag oscillator to full Q-switch energy. Adjust only the vertical of M2 to maximize the 532 output energy. Vertical is the tuning direction of the crystal. The crystal is extremely sensitive to vertical angle, and insensitive to horizontal angle. Adjusting the beam so that both beams are at maximum power with the crystal at a single angle, insures the beams are parallel in the vertical plane. Now go back to step 7, remove the power meter from the beam path, and check the near and far field overlap in the Long Pulse mode. If it looks off, peak M1 and M2 to overlap the beams, (adjust M1 for near-field and M2 for far-field.) and repeat steps 8 and 9.

10. Iterate steps 7, 8, and 9 until the Zig Zag beam is vertically overlapped with the Straight beam. This will complete the vertical alignment portion.

HORIZONTAL 532 nm BEAM ALIGNMENT

11. Rotate the harmonic generator so that the crystal arm is in the horizontal position. This will allow for the optimization and overlap in the horizontal plane.

12. In the Long Pulse, low power mode, mark the far field position of the Straight oscillator beam. (It will change a small amount from when the HG is in the vertical position, because the crystal is wedged.)

13. Place a power meter in the beam path. Turn up the Straight oscillator to full energy Q-switched and peak up the harmonic generator's 1/2 waveplate and crystal angle to give the highest output energy. Once the output of this oscillator has stabilized at its maximum point,. Do not touch the crystal angle again because the optimized crystal will be used to peak the Zig Zag beam alignment.

14. Turn down the Straight oscillator and turn the Zig Zag oscillator to full Q-switch energy mode. Adjust only the horizontal of M2 to maximize the 532 output energy. Horizontal is now the tuning direction of the crystal. The crystal is now extremely sensitive to horizontal angle, and insensitive to vertical angle. Adjusting the beam so that both beams are at maximum power with the crystal at a single angle, insures the beams are parallel in the horizontal plane. Now go back to step 12, remove the power meter from the beam path, and check the near and far field overlap in the Long Pulse mode. If it looks off, peak M1 and M2 to overlap the beams, (adjust M1 for near-field and M2 for far-field.) and repeat steps 13 and 14.

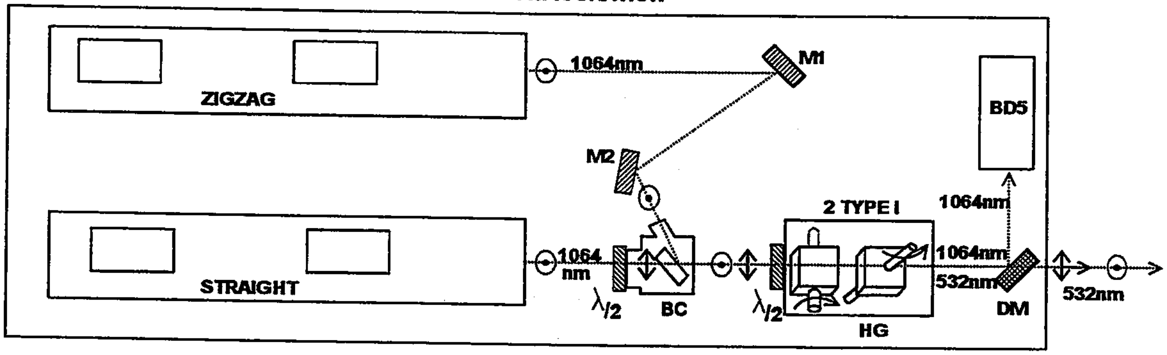
15. Iterate steps 12, 13, and 14 until the Zig Zag beam is horizontally overlapped with the Straight beam. This will complete the horizontal alignment portion

16. Once this procedure is complete, the overlap of the 532 nm beams can be checked by using a photo diode using the following technique:
    - Place a photo diode to pick up the 532 nm energy. Adjust the delay of the oscillators so that both beams can be seen on an oscilloscope side-by-side.
    - Adjust the harmonic crystal through its peak and look to see that both beams peak at the same time. This should be done in both vertical and horizontal orientations of the harmonic generator
    - If both oscillator's beam amplitudes don't move together in either HG orientation, the alignment is not correct

OVERLAP PROCEDURE FOR THE CROSSED POLARIZED (CPO) OUTPUT OPTION

The crossed polarized option uses two type I doubling crystals to double each beam independently in a crossed polarized fashion (one beam vertically polarized, one beam horizontally polarized.)

PIV 400 CPO CONFIGURATION



INITIAL IR BEAM ALIGNMENT CHECK

1. Set up the PIV in the "Internal Timing" mode of operation.
2. Remove the output dichroic optic from the beam path.
3. Slide both harmonic crystals out of the beam path.
4. Check that the external 1/2 waveplates are centered on the beams and adjusted correctly for each leg by measuring the energy before and after the beam combiner (BC). There should be no more than a few percent loss of energy through the beam combiner for each leg. If a loss is measured, adjust the corresponding 1/2 waveplate to maximize the energy through the beam combiner.
5. Check the overlap of the IR beams by the following procedure:
   - Turn up the Straight oscillator in Long Pulse to the point where it lases. Mark its position with a target several meters from the laser. (The target can be an iris, an IR card, or a cross drawn on a business card, taped to the wall, viewed with an IR viewer)
   - Turn up the Zig Zag oscillator and check that its beam is overlapped with the Straight oscillator both in the near-field and far-field using an IR card.
   - If the Zig Zag oscillator is not overlapped with the Straight oscillator, adjust M1 to overlap the beams in the near-field, and adjust M2 to overlap the beams in the far-field.
   - Iterate this process until the beams are colinearly aligned.

VERTICAL 532 nm BEAM ALIGNMENT

6. Reinstall the dichroic optic and adjust its mount to direct the IR into the beam dump. Slide the 1st harmonic crystal back into position. Make sure that the harmonic generator is rotated so that the 1st crystal arm is positioned vertical (meaning the 532 nm output will be vertical.) Place the second crystal in the parked position.
7. In Long Pulse mode, mark the low power 532 nm beams' position in the far field with a target Rotate the HG's waveplate to minimize the green light, and then turn down the Straight oscillator. Turn up the Zig Zag oscillator in Long Pulse and check if its 532 nm beam is roughly overlapped with the Straight oscillator, If you did step 5 correctly, this should be correct

8. Place a power meter in the beam path. Turn up the Straight oscillator to full energy Q-switched and peak up the harmonic generator's 1/2 waveplate and crystal angle to give the highest output energy. Once the output of this oscillator has stabilized at its maximum point,. Do not touch the crystal angle again since the optimized crystal will be used to peak the Zig Zag beam alignment. Rotate the harmonic generator 1/2 waveplate to minimize the 532 nm energy. This setting should be the maximum setting for the Zig Zag oscillator's polarization now. Turn down the Straight Through oscillator.

9. Turn the Zig Zag oscillator to full Q-switch energy mode. Adjust only the vertical of M2 to maximize the 532 output energy. Vertical is the tuning direction of the crystal. The crystal is extremely sensitive to vertical angle, and insensitive to horizontal angle. Adjusting the beam so that both beams are at maximum power with the crystal at a single angle, insures the beams are parallel in the vertical plane. Now go back to step 7, remove the power meter from the beam path, and check the near and far field overlap in the Long Pulse mode. If it looks off, peak M1 and M2 to overlap the beams, (adjust M1 for near-field and M2 for far-field.) and repeat steps 8 and 9 until you feel you have a good vertical overlap. In the CPO setup, you must rotate the HG's waveplate each time you change oscillators.

10. Iterate steps 7, 8, and 9 until the Zig Zag beam is vertically overlapped with the Straight beam. This will complete the vertical alignment portion.

HORIZONTAL 532 nm BEAM ALIGNMENT

11. Park the 1st crystal arm, and pull up the second crystal in the horizontal position. This will allow for the optimization and overlap in the horizontal plane.

12. In the Long Pulse low power mode, mark the far field position of the Straight oscillator beam. (It will change a small amount from the beam passing through the other crystal, because the crystals are wedged., and in orthogonal positions relative to each other. If both crystals were in the beam path, the near field beam position would not change, but this would complicate the alignment.)

13. Place a power meter in the beam path. Turn up the Straight oscillator to full energy Q-switched and peak up the harmonic generator's 1/2 waveplate and crystal angle to give the highest output energy. Once the output of this oscillator has stabilized at its maximum point,. Do not touch the crystal angle again because the optimized crystal will be used to peak the Zig Zag beam alignment. Rotate the harmonic generator 1/2 waveplate to minimize the 532 nm energy. This setting should be the maximum setting for the Zig Zag oscillator's polarization now. Turn down the Straight oscillator.

14. Turn the Zig Zag oscillator to full Q-switch energy mode. Adjust only the horizontal of M2 to maximize the 532 output energy. horizontal is the tuning direction of this crystal. The crystal is extremely sensitive to horizontal angle, and insensitive to vertical angle. Adjusting the beam so that both beams are at maximum power with the crystal at a single angle, insures the beams are parallel in the vertical plane. Now go back to step 12, remove the power meter from the beam path, and check the near and far field overlap in the Long Pulse mode. If it looks off, peak M1 and M2 to overlap the beams, (adjust M1 for near-field and M2 for far-field.) and repeat steps 13 and 14 until you feel you have a good vertical overlap. In the CPO setup, you must rotate the HG's waveplate each time you change oscillators.

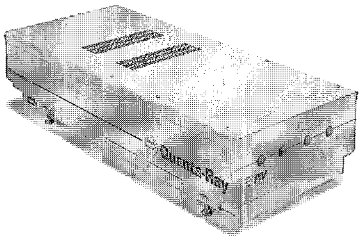
15. Iterate steps 12, 13, and 14 until the Zig Zag beam is horizontally overlapped with the Straight beam. This will complete the horizontal alignment portion.

16. This completes the beam alignment for the CPO option. Now the 1st crystal can be pulled back into position and both beams should still be coaxially aligned.

17. Once this procedure is complete, the overlap of the 532 nm beams can be checked by using a photo diode using the following technique:

- Place a photo diode to pick up the 532 nm energy.
- Adjust the delay of the oscillators so that both beams can be seen on an oscilloscope side-by-side.
- Turn up the Straight oscillator to full power and adjust the waveplate so that only the first crystal effects the 532 power of the Straight oscillator. Detune the crystal angle and adjust the 2nd crystals angle. It should have no effect.
- Turn down the straight through oscillator, and turn up the Zig Zag oscillator. It should be only effected by the 2nd crystals angle.
- Turn on both oscillators to full power. Crystal 1 should only effect the amplitude of the straight through oscillator, and crystal 2 should only effect the amplitude of the Zig Zag oscillator.
- If you are having trouble, remove the waveplate from the front of the HG, and the input polarizations will be correct. Check out how only one crystal can effect one oscillator. Replace the waveplate and duplicate the setup..
- You can adjust the HG waveplate so either crystal effects either oscillator.

IT IS POSSIBLE TO MISADJUST THE HG WAVEPLATE IN A WAY THAT EACH BEAM HAS SOME OF EACH POLARIZATION COMPONENT



PIV Series Pulsed Nd:YAG

Power Specifications											
Model[1]	**PIV-200-***			**PIV-300-**				**PIV-400-**			
Rep Rate (Hz)	7.5	10	15	7.5	10	15	30	7.5	10	15	30
Energy (mJ/p)[2]											
532 nm	200	200	170	300	300	250	200	400	400	350	300
355 nm[3]	70	70	60	110	110	95	75	150	150	130	110
266 nm[3]	50	50	35	60	60	50	35	80	80	70	60
CPO[4] 532 nm	135	135	100	200	200	175	150	250	250	225	200

** All PIV systems come standard with W/W heat exchangers except the unseeded PIV-200 7.5 and 10 Hz which come standard with A/W heat exchangers.*

Performance			
Wavelength 532 nm	Pulse Width[5] 5-10 ns	Short Term Energy Stability[6] ± 5 %	Long Term Power Drift[7] < 5 %
	Beam Divergence[8] < 0.5 mrad	Pointing Stability[9] < ± 100 μrad	Timing Jitter[10] < 0.5 ns

Mode			**Pulse**	
Spatial Mode Profile[11]	**Standard Fit**	**ESM Fit**[12]	**Line Width**[13]	
Near Field (1m)	> 60%	> 80%	Standard	< 1.4 cm^{-1}
Far Field (∞)	> 95%	> 95%	Injection Seeded	< 0.005 cm^{-1}
Modulation[14]	< 50%	< 25%	Coherence Length	> 2 m
Beam Diameter[15]	PIV-200, -300: 8 mm	PIV-400: 9 mm	Tunability[16]	> 30 GHz

Note: Additional nonstandard options are available such as dual harmonic generators and double pulse options. Contact factory for specialized systems.

1. *All specifications subject to change without notice. Unless otherwise stated, specifications are given for Q-switched operation at 532 nm.*
2. *Harmonic energies are specified after separation using dichroic mirrors and using type II second harmonic generation (SHG) crystal.*
3. *Requires additional IHS-XXX and external BD-5.*
4. *CPO = crossed polarized option. Consecutive output pulses are polarized orthogonal to one another. For other CPO Harmonics contact factory.*
5. *PIV-200 pulse widths are 8-10 ns, PIV-300, -400 pulse widths are 5-8 ns.*
6. *Pulse to pulse stability for >99% of pulses, measured over a 1 hour period.*
7. *Over an 8 hour period with temperature variations of <±3°C.*
8. *Full angle measured at FWHM points.*
9. *Long term average pointing drift on combined beams after warmup, over 8 hours ±3°C.*
10. *rms jitter from Q-switch sync pulse. Jitter is ≤1 ns rms when using the model 6350 injection seeder, at 10 Hz, ≤1.5 ns at 15 and 30 Hz.*
11. *Near field spatial profiles measured 1 m from laser using a commercially available beam diagnostic system. 60% refers to the correlation between the actual beam profile and the best least squares fit Gaussian profile. Far field profiles are measured at the focal plane of a 2 m focal length lens.*
12. *Enhanced spatial mode options can be tailored to meet your applications needs. To obtain >80% Gaussian fits, energy can be reduced by 30%.*
13. *Insertion losses for systems using the Model 6350 injection seeder are <15% at 532 nm, 355 nm, and 266 nm wavelengths.*
14. *Refers to the maximum deviation from the best-fit Gaussian profile measured in the near field (1 m) between the FWHM points.*
15. *Actual beam diameter will vary ± 1 mm depending on laser configuration.*
16. *Temperature tuning of seeder controllable via BNC voltage.*

Spectra-Physics
Spectra-Physics Lasers

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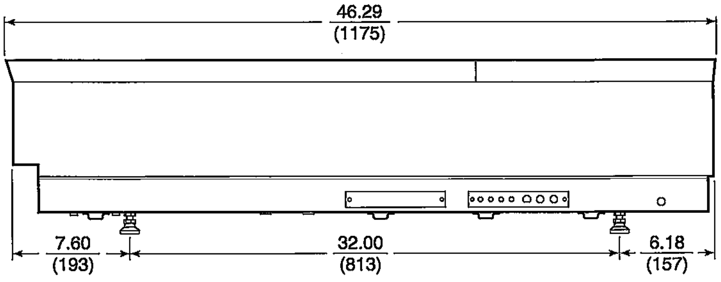
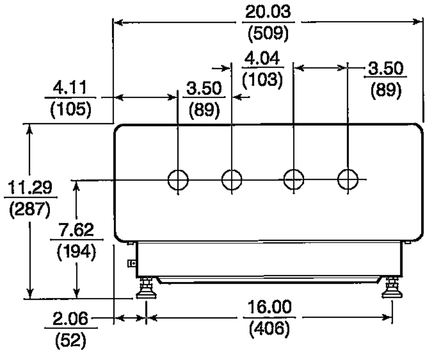
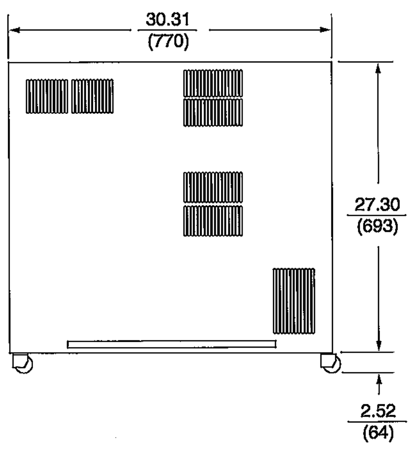
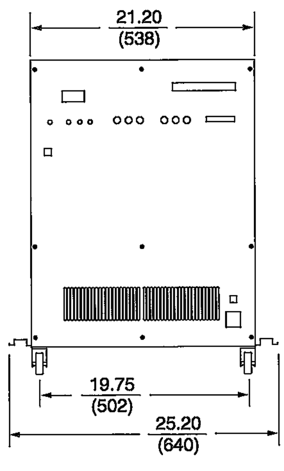
System Specifications	
Lamp Lifetimes[17]	> 30 million pulses
Water Service	10 / 15 / 30 Hz: 1.0 / 1.5 / 2.0 US gal/min @ 75°F
Electrical Service	10 / 15 / 30 Hz: < 25A / < 30A / < 40A
Voltage[18]	190 - 260 V, single phase, 50/60 Hz
Umbilical Length	3m (10 ft.)
Remote Cord Length	3m (10 ft.)
PIV Weight	Laser head: 185 lb., Power Supply: 250 lb.

17. Specified as < 10% energy loss in 1064 nm output.
18. Input transformer has taps at 190, 200, 210, 220, 230, 240, 250, and 260 V. Once tap is chosen, actual input voltage differing by more than ± 10% may affect operation of laser.









DANGER
VISIBLE & INVISIBLE*
LASER RADIATION
AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION
Nd:YAG/1.5J/8nS
* See Manual CLASS IV LASER PRODUCT

Spectra-Physics
Spectra-Physics Lasers

All dimensions in $\frac{\text{inches}}{\text{(mm)}}$

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