Pulstar series p100

OEM p100 operator's manual

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Pulstar OEM p100
Operator's Manual

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Trademark/copyright information

SYNRAD is a registered trademark of SYNRAD, Inc.

All other trademarks or registered trademarks are the property of their respective owners.

Warranty information

This is to certify that Pulstar p100 lasers are guaranteed by SYNRAD, Inc. to be free of all defects in materials and workmanship for a period of one year from the date of purchase. This warranty does not apply to any defect caused by negligence, misuse (including environmental factors), accident, alteration, or improper maintenance. We request that you examine each shipment within 10 days of receipt and inform SYNRAD, Inc. of any shortage or damage. If no discrepancies are reported, SYNRAD shall assume the shipment was delivered complete and defect-free.

If, within one year from the date of purchase, any part of the Pulstar p100 laser should fail to operate, contact the SYNRAD Customer Service department at 1.800.SYNRAD1 (outside the U.S. call 1.425.349.3500) and report the problem. When calling for support, please be prepared to provide the date of purchase, model number and serial number of the unit, and a brief description of the problem. When returning a unit for service, a Return Authorization (RA) number is required; this number must be clearly marked on the outside of the shipping container in order for the unit to be properly processed. If replacement parts are sent to you, then you are required to send the failed parts back to SYNRAD for evaluation unless otherwise instructed.

If your Pulstar p100 laser fails within the first 45 days after purchase, SYNRAD, Inc. will pay all shipping charges to and from SYNRAD when shipped as specified by SYNRAD Customer Service. After the first 45 days, SYNRAD will continue to pay for the costs of shipping the repaired unit or replacement parts back to the customer from SYNRAD. The customer, however, will be responsible for shipping charges incurred when sending the failed unit or parts back to SYNRAD or a SYNRAD Authorized Distributor. In order to maintain your product warranty and to ensure the safe and efficient operation of your Pulstar p100 laser, only authorized SYNRAD replacement parts can be used. This warranty is void if any parts other than those provided by SYNRAD, Inc. are used.

SYNRAD, Inc. and SYNRAD Authorized Distributors have the sole authority to make warranty statements regarding SYNRAD products. SYNRAD, Inc. and its Authorized Distributors neither assumes nor authorizes any representative or other person to assume for us any other warranties in connection with the sale, service, or shipment of our products. SYNRAD, Inc. reserves the right to make changes and improvements in the design of our products at any time without incurring any obligation to make equivalent changes in products previously manufactured or shipped. Buyer agrees to hold SYNRAD harmless from any and all damages, costs, and expenses relating to any claim arising from the design, manufacture, or use of the product, or arising from a claim that such product furnished Buyer by SYNRAD, or the use thereof, infringes upon any Patent, foreign or domestic.

Contact information

Worldwide headquarters

SYNRAD's worldwide headquarters are located north of Seattle in Mukilteo, Washington, U.S.A. Our mailing address is:

SYNRAD, Inc.
4600 Campus Place
Mukilteo, WA 98275
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Outside the U.S.:	+1.425.349.3500
Fax:	+1.425.349.3667
E-mail:	synrad@synrad.com

Sales and Applications

SYNRAD's Regional Sales Managers work with customers to identify and develop the best CO_2 laser solution for a given application. Because they are familiar with you and your laser application, use them as a first point of contact when questions arise. Regional Sales Managers also serve as the liaison between you and our Applications Lab in processing material samples per your specifications. To speak to the Regional Sales Manager in your area, call SYNRAD at 1.800.SYNRAD1.

Customer Service

For assistance with order or delivery status, service status, or to obtain a Return Authorization (RA) number, contact SYNRAD at 1.800.SYNRAD1 and ask to speak to a Customer Service representative.

Technical Support

SYNRAD's Regional Sales Managers are able to answer many technical questions regarding the installation, use, troubleshooting, and maintenance of our products. In some cases, they may transfer your call to a Laser, Marking Head, or Software Support Specialist. You may also e-mail questions to the Technical Support Group by sending your message to support@synrad.com or to support@winmark.com.

Reference materials

Your Regional Sales Manager can provide reference materials including Outline & Mounting drawings, Operator's Manuals, Technical Bulletins, and Application Newsletters. Most of these materials are also available directly from SYNRAD's web site at http://www.synrad.com.

European headquarters

For assistance in Europe, contact SYNRAD's European subsidiary, Synrad Europe, at:

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Münchener Straße 2A
D-82152 Planegg, Germany

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E-mail:	info@synrad-europe.com

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laser safety

Hazard information

Hazard information includes terms, symbols, and instructions used in this manual or on the equipment to alert both operating and service personnel to the recommended precautions in the care, use, and handling of Class 4 laser equipment.

Terms

Certain terms are used throughout this manual or on the equipment labels. Please familiarize yourself with their definitions and significance.

⚠ Danger: Imminent hazards which, if not avoided, will result in death or serious injury.

⚠ Warning: Potential hazards which, if not avoided, could result in death or serious injury.

⚠ Caution: Potential hazards or unsafe practices which, if not avoided, may result in minor or moderate injury.

Caution: Potential hazards or unsafe practices which, if not avoided, may result in product damage.

Important Note: Important information or recommendations concerning the subject under discussion.

Note: Points of particular interest for more efficient or convenient equipment operation; additional information or explanation concerning the subject under discussion.

General hazards

Following are descriptions of general hazards and unsafe practices that could result in death, severe injury, or product damage. Specific warnings and cautions not appearing in this section are found throughout the manual.

⚠ Danger
serious personal injury

This Class 4 laser product emits ***invisible*** infrared laser radiation in the 10.6 µm CO_2 wavelength band.

Do not allow laser radiation to enter the eye by viewing direct or reflected laser energy. CO_2 laser radiation can be reflected from metallic objects even though the surface is darkened. Direct or diffuse laser radiation can inflict severe corneal injuries leading to permanent eye damage or blindness. All personnel must wear eye protection suitable for 10.6 µm CO_2 radiation when in the same area as an exposed laser beam. Eyewear protects against scattered energy but is not intended to protect against direct viewing of the beam—never look directly into the laser output aperture or view scattered laser reflections from metallic surfaces.

Enclose the beam path whenever possible. Exposure to direct or diffuse CO_2 laser radiation can seriously burn human or animal tissue, which may cause permanent damage.

This product is not intended for use in explosive, or potentially explosive, atmospheres.

laser safety

Hazard information

⚠ Warning
serious personal injury

U.S. customers should refer to and follow the laser safety precautions described in the American National Standards Institute (ANSI) Z136.1-2007 document, *Safe Use of Lasers*. Procedures listed in this Standard include the appointment of a Laser Safety Officer (LSO), operation of the product in an area of limited access by trained personnel, servicing of equipment only by trained and authorized personnel, and posting of signs warning of the potential hazards.

European customers should appoint a Laser Safety Officer (LSO) who should refer to and follow the laser safety precautions described in EN 60825-1, 2007—*Safety of Laser Products*.

⚠ Warning
serious personal injury

Materials processing with a laser can generate air contaminants such as vapors, fumes, and/or particles that may be noxious, toxic, or even fatal. Material Safety Data Sheets (MSDS) for materials being processed should be thoroughly evaluated and the adequacy of provisions for fume extraction, filtering, and venting should be carefully considered. Review the following references for further information on exposure criteria:

ANSI Z136.1-2007, *Safe Use of Lasers*, section 7.3.

U.S. Government's *Code of Federal Regulations*: 29 CFR 1910, Subpart Z.

Threshold Limit Values (TLV's) published by the American Conference of Governmental Industrial Hygienists (ACGIH).

It may be necessary to consult with local governmental agencies regarding restrictions on the venting of processing vapors.

⚠ Warning
serious personal injury

The use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

⚠ Warning
serious personal injury

The use of aerosol dusters containing difloroethane causes "blooming", a condition that ***significantly*** expands and scatters the laser beam. This beam expansion can effect mode quality and/or cause laser energy to extend beyond the confines of optical elements in the system, possibly damaging acrylic safety shielding. Do not use air dusters containing difloroethane in any area adjacent to CO_2 laser systems because difloroethane persists for long time periods over wide areas.

laser safety

Hazard information

Pulstar p100 lasers should be installed and operated in manufacturing or laboratory facilities by trained personnel only. Due to the considerable risks and hazards associated with the installation and operational use of any equipment incorporating a laser, the operator must follow product warning labels and instructions to the user regarding laser safety. To prevent exposure to direct or scattered laser radiation, follow all safety precautions specified throughout this manual and exercise safe operating practices per ANSI Z136.1-2007 at all times when actively lasing.

Always wear safety glasses or protective goggles with side shields to reduce the risk of damage to the eyes when operating the laser.

A CO_2 laser is an intense heat source and will ignite most materials under the proper conditions. Never operate the laser in the presence of flammable or explosive materials, gases, liquids, or vapors.

The use of controls or adjustments or performance of procedures other than those specified herein may result in exposure to hazardous ***invisible*** laser radiation, damage to, or malfunction of the laser. Severe burns will result from exposure to the laser beam.

Safe operation of the laser requires the use of an external beam block to safely block the beam from traveling beyond the desired work area. Do not place your body or any combustible object in the path of the laser beam. Use a water-cooled beam dump or power meter, or similar non-scattering, noncombustible material as the beam block. Never use organic material or metals as the beam blocker; organic materials, in general, are apt to combust or melt and metals act as specular reflectors which may create a serious hazard outside the immediate work area.

Other hazards

The following hazards are typical for this product family when incorporated for intended use: (A) risk of injury when lifting or moving the unit; (B) risk of exposure to hazardous laser energy through unauthorized removal of access panels, doors, or protective barriers; (C) risk of exposure to hazardous laser energy and injury due to failure of personnel to use proper eye protection and/or failure to adhere to applicable laser safety procedures; (D) risk of exposure to hazardous or lethal voltages through unauthorized removal of covers, doors, or access panels; (E) generation of hazardous air contaminants that may be noxious, toxic, or even fatal.

Disposal

This product contains components that are considered hazardous industrial waste. If a situation occurs where the laser is rendered non-functional and cannot be repaired, it may be returned to SYNRAD, Inc. who, for a fee, will ensure adequate disassembly, recycling and/or disposal of the product.

Additional laser safety information

The SYNRAD web site (http://www.synrad.com/LaserFacts/lasersafety.html) contains an online laser safety handbook that provides information on (1) Laser Safety Standards for OEM's/System Integrators, (2) Laser Safety Standards for End Users, (3) References and Sources, and (4) Assistance with Requirements.

In addition, the Occupational Safety and Health Administration (OSHA) provides an online Technical Manual (located at http://www.osha.gov/dts/osta/otm/otm_iii/otm_iii_6.html). Section III, Chapter 6 and Appendix III are good resources for laser safety information.

Another excellent laser safety resource is the Laser Institute of America (LIA). Their comprehensive web site is located at http://www.laserinstitute.org.

laser safety

Pulstar p100 label locations

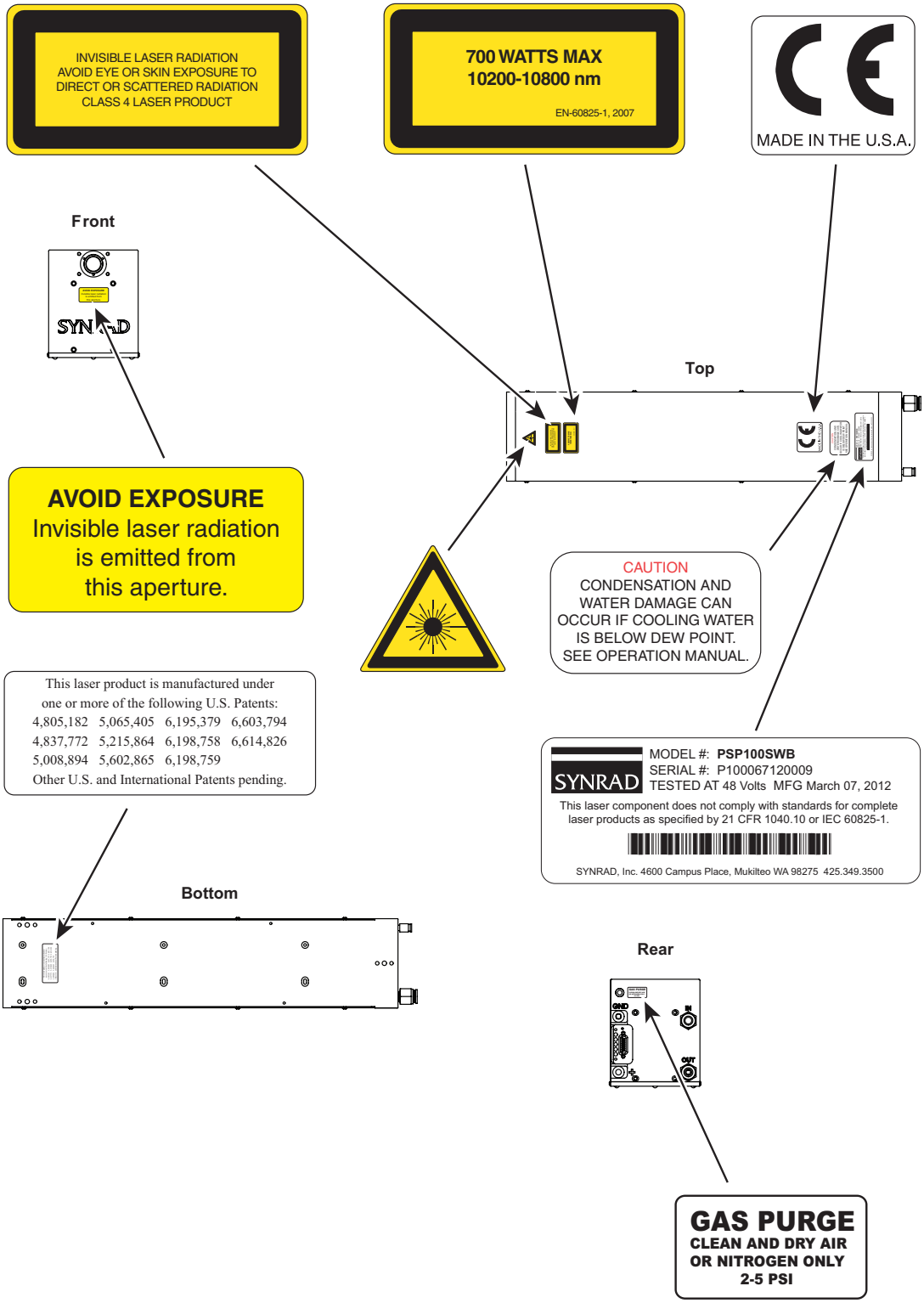

Figure 1 Pulstar p100 hazard label and CE label locations

laser safety

Agency compliance

The *Agency compliance* section includes subsections:

- Center for Devices and Radiological Health (CDRH) requirements
- Federal Communications Commission (FCC) requirements
- European Union (EU) requirements

SYNRAD lasers are designed, tested, and certified to comply with certain United States (U.S.) and European Union (EU) regulations. These regulations impose product performance requirements related to electromagnetic compatibility (EMC) and product safety characteristics for industrial, scientific, and medical (ISM) equipment. The specific provisions to which systems containing Pulstar OEM p100 lasers must comply are identified and described in the following paragraphs. Note that compliance to CDRH, FCC, and EU requirements depends in part on the laser version selected—Keyswitch or OEM.

In the U.S., laser safety requirements are governed by the Center for Devices and Radiological Health (CDRH) under the auspices of the U.S. Food and Drug Administration (FDA) while radiated emission standards fall under the jurisdiction of the U.S. Federal Communications Commission (FCC). Outside the U.S., laser safety and emissions are governed by European Union (EU) Directives and Standards.

In the matter of CE-compliant laser products, SYNRAD, Inc. assumes no responsibility for the compliance of the system into which the product is integrated, other than to supply and/or recommend laser components that are CE marked for compliance with applicable European Union Directives.

Because OEM laser products are intended for incorporation as components in a laser processing system, they do not meet all of the Standards for complete laser processing systems as specified by 21 CFR, Part 1040 or EN 60825-1. SYNRAD, Inc. assumes no responsibility for the compliance of the system into which OEM laser products are integrated.

Center for Devices and Radiological Health (CDRH) requirements

Product features incorporated into the design of Pulstar OEM p100 lasers to comply with CDRH requirements are integrated as panel controls or indicators, internal circuit elements, or input/output signal interfaces. Specifically, these features include a *Keyswitch* (Keyswitch versions), lase and laser ready indicators, remote interlock for power on/off, a laser aperture shutter switch, and a five-second delay between power on and lasing. Incorporation of certain features is dependent on the laser version (Keyswitch or OEM).

Table 1, *Class 4 safety features*, indicates which features are available on OEM p100 lasers, the type and description of the feature, and if the feature is required by CDRH regulations.

OEM models

Pulstar OEM p100 lasers are OEM products intended for incorporation as components in laser processing systems. As supplied by SYNRAD, these lasers do not meet the requirements of 21 CFR, Subchapter J without additional safeguards. In the U.S., the Buyer of these OEM laser components is solely responsible for the assurance that the laser processing system sold to an end user complies with all laser safety requirements before the actual sale of the system. Under CDRH regulations, the Buyer must submit a report to the CDRH prior to shipping the system. In jurisdictions outside the U.S., it is the sole responsibility of the Buyer of these OEM components to ensure that they meet all applicable local laser safety requirements. In cases where the Buyer is also the end-user of the OEM laser product, the Buyer/end-user must integrate the laser so that it complies with all applicable laser safety standards as set forth above.

laser safety

Agency compliance

Federal Communications Commission (FCC) requirements

The United States Communication Act of 1934 vested the Federal Communications Commission (FCC) with the authority to regulate equipment that emits electromagnetic radiation in the radio frequency spectrum. The purpose of the Communication Act is to prevent harmful electromagnetic interference (EMI) from affecting authorized radio communication services. The FCC regulations that govern industrial, scientific, and medical (ISM) equipment are fully described in 47 CFR, Part 18, Subpart C.

SYNRAD's Pulstar OEM p100 lasers have been tested and found to comply by demonstrating performance characteristics that have met or exceeded the requirements of 47 CFR, Part 18, Radiated and Conducted Emissions.

FCC information to the user

NOTE: The following FCC information to the user is provided to comply with the requirements of 47 CFR, Part 18, Section 213.

Interference Potential

In our testing, SYNRAD, Inc. has not discovered any significant electrical interference traceable to Pulstar p100 lasers.

System Maintenance

Ensure that all exterior covers are properly fastened in position.

Measures to Correct Interference

If you suspect that your Pulstar laser interferes with other equipment, take the following steps to minimize this interference:

1. Use shielded cables to and from the equipment that is experiencing interference problems.
2. Ensure that the Pulstar laser is properly grounded to the same electrical potential as the equipment or system it is connected to.

FCC caution to the user

The Federal Communications Commission warns the user that changes or modifications of the unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

European Union (EU) requirements

RoHS compliance

SYNRAD Pulstar p100 lasers meet the requirements of the European Parliament and Council Directive 2011/65/EU on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment that establishes maximum concentration values for certain hazardous substances in electrical and electronic equipment.

laser safety

Agency compliance

Laser safety standards

Under the Low Voltage Directive, 2006/95/EC, the European Norm (EN) document EN 60825-1 was developed to protect persons from laser radiation by imposing requirements upon manufacturers of laser products to provide an indication of laser radiation; to classify laser products according to the degree of hazard; to require both user and manufacturer to establish procedures so that proper precautions are adopted; to ensure adequate warning of the hazards associated with accessible radiation through signs, labels, and instructions; to improve control of laser radiation through protective features; and to provide safe usage of laser products by specifying user control measures.

Table 1, *Class 4 safety features*, summarizes Pulstar OEM p100 product features, indicating the type and description of features and whether those features are required by European Union regulations.

OEM models

Pulstar OEM p100 lasers are OEM products intended for incorporation as components in laser processing systems. As supplied by SYNRAD, these lasers do not meet the requirements of EN 60825-1 without additional safeguards. European Union Directives state that "OEM laser products which are sold to other manufacturers for use as components of any system for subsequent sale are not subject to this Standard, since the final product will itself be subject to the Standard." This means that Buyers of OEM laser components are solely responsible for the assurance that the laser processing system sold to an end-user complies with all laser safety requirements before the actual sale of the system. Note that when an OEM laser component is incorporated into another device or system, the entire machinery installation may be required to conform to EN 60825-1; EN 60204-1:2006, *Safety of Machinery;* the Machinery Directive, EN 2006/42/EC; and/or any other applicable Standards. In cases where the Buyer is also the end-user of the OEM laser product, the Buyer/end-user must integrate the laser so that it complies with all applicable laser safety standards as set forth above.

Electromagnetic interference standards

The European Union's Electromagnetic Compatibility (EMC) Directive, 2004/108/EC, is the sole Directive developed to address electromagnetic interference (EMI) issues in electronic equipment. In particular, the Directive calls out European Norm (EN) documents that define the emission and immunity standards for specific product categories. For Pulstar p100 lasers, EN 61000-6-4 defines radiated and conducted RF emission limits while EN 61000-6-2 defines immunity requirements for industrial environments.

SYNRAD's Pulstar OEM p100 lasers have demonstrated performance characteristics that have met or exceeded the requirements of EMC Directive 2004/108/EC.

laser safety

Agency compliance

Table 1 Class 4 safety features

Feature	Location / Description	Required by: CDRH	EN60825-1
Keyswitch[1]	Rear panel control On/Off/Reset Keyswitch controls power to laser electronics. Key cannot be removed from switch in the "On" position.	Yes	Yes
Shutter function	Laser control Functions as a beam attenuator to disable RF driver/laser output when closed.	Yes	Yes
Shutter indicator	Rear panel indicator (Blue) Illuminates blue to indicate shutter is open.	No	No
Ready indicator	Rear panel indicator (Yellow) Indicates that laser has power applied and is capable of lasing.	Yes	Yes
Lase indicator	Rear panel indicator (Red) Indicates that Pulstar is actively lasing. Lase LED illuminates when the duty cycle of the Command signal is long enough to produce laser output.	Yes	Yes
Five-second delay[1]	Pulstar circuit element Disables RF driver/laser output for five seconds after Keyswitch is turned to "On" or remote reset/start pulse is applied when Keyswitch is in "On" position.	Yes	No
Power fail lockout[1]	Pulstar circuit element Disables RF driver/laser output if input power is removed then later reapplied (AC power failure or remote interlock actuation) while Keyswitch is in "On" position.	Yes	Yes
Remote Interlock	Rear panel connection Disables RF driver/laser output when a remote interlock switch on an equipment door or panel is opened.	Yes	Yes
Remote Interlock indicator	Rear panel indicator (Green/Red) Illuminates green when Remote Interlock circuitry is closed. Illuminates red when interlock circuitry is open.	No	No
Over temperature protection	Pulstar circuit element Temperature shutdown occurs if temperature of the laser tube rises above safe operating limits.	No	No
Temp indicator	Rear panel indicator (Green/Red) Illuminates green when laser temperature is within operating limits, changing to red when thermal limits are exceeded.	No	No
Warning labels	Pulstar exterior Labels attached to various external housing locations to warn personnel of potential laser hazards.	Yes	Yes

1 Not available on OEM p100 lasers

laser safety

Agency compliance

When integrating SYNRAD's Pulstar p100 OEM lasers, the Buyer and/or integrator of the end system is responsible for meeting all applicable Standards to obtain the CE mark. To aid this compliance process, SYNRAD's testing program has demonstrated that Pulstar p100 lasers comply with the relevant requirements of 2004/108/EC, the Electromagnetic Compatibility Directive, as summarized in Table 2 below.

Table 2 European Union Directives

Applicable Standards / Norms	
2004/108/EC	Electromagnetic Compatibility Directive
2006/95/EC	Low Voltage Directive
2011/65/EU	RoHS Directive
EN 61010-1:2001	Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use - Part 1: General Requirements
EN 61000-6-4:2007	Radiated Emissions Group 1, Class A
EN 61000-6-4:2007	Conducted Emissions Group 1, Class A
EN 61000-6-2:2005	Electrostatic Discharge Immunity
EN 61000-6-2:2005	RF Electromagnetic Field Immunity
EN 61000-6-2:2005	Electrical Fast Transient/Burst Immunity
EN 61000-6-2:2005	Conducted RF Disturbances Immunity

After a laser or laser processing system has met the requirements of all applicable EU Directives, the product can bear the official compliance mark of the European Union as shown in Figure 2 and a Declaration of Conformity is provided for the compliant component.

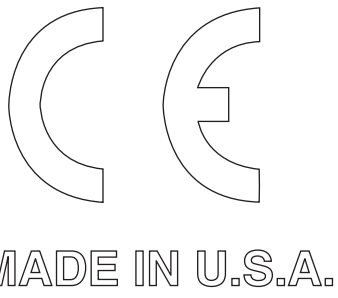

Figure 2 European compliance mark

laser safety

Pulstar p100 Declaration of Conformity

Declaration of Conformity

in accordance with ISO/IEC 17050-2:2004

We,

Manufacturer's Name: SYNRAD, Inc.

Manufacturer's Address: 4600 Campus Place
Mukilteo, WA 98275
U.S.A.

hereby declare under our sole responsibility that the following equipment:

Product Name: Pulstar OEM p100 Laser*

Model Number: PSP100SWB

conforms to the following Directive(s) and Standard(s):

Applicable Directive(s):	2004/108/EC	Electromagnetic Compatibility Directive
	2011/65/EU	RoHS Directive

Applicable Standard(s):

EN 61010-1:2001	Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use - Part 1
CISPR 11:2009	Conducted and Radiated Emissions, Group 1, Class A
EN 61000-6-4 (2007)	Emission Standard for Industrial Environments
EN 61000-6-2 (2005)	Immunity for Industrial Environments
EN 61000-4-2:1995 +A1:1998 +A2:2001	Electrostatic Discharge
EN 61000-4-3:2006 +A1:2008	Radiated RF Immunity
EN 61000-4-4:2004 +C1:2006 +C2:2007	Electrical Fast Transient/Burst
EN 61000-4-5:2006	Surge Immunity
EN 61000-4-6:2009	Conducted RF Immunity
EN 61000-4-8:1994 +A1:2000	Power Frequency H-Field Immunity

*OEM lasers do not comply with EN 60825-1:2007, *Safety of Laser Products*. Buyers of OEM laser products are solely responsible for meeting applicable Directives and Standards for CE compliance and marking.

Corporate Officer:

Dave Clarke, President of SYNRAD, Inc.

Dated 6 April 2012

European Contact:

Synrad Europe
Münchener Straße 2A
D-82152 Planegg, Germany

CE

MADE IN U.S.A.

getting started

Use information in this chapter to prepare your Pulstar p100 laser for operation. The order of information presented in this chapter is the same as the order of tasks that you will need to perform. The best way to get your laser ready for operation is to start at *Unpacking* and work your way through *Connecting*.

This chapter contains the following information:

- Introduction – introduces the Pulstar p100 laser, lists important features, and describes Pulstar nomenclature.
- Unpacking – provides important information about unpacking your Pulstar p100 laser.
- Inventory – displays and describes all components shipped with your p100 laser.
- Mounting – describes how to attach your p100 laser to a mounting surface.
- Connecting – explains how to connect cooling tubing, power, and control cabling.

getting started

Introduction

The *Introduction* section includes subsections:

- Pulstar nomenclature
- Model numbers

The Pulstar OEM p100 laser is the first in a new line of pulsed, high peak power lasers from SYNRAD. Designed primarily for pulse operation, the p100 is still controlled by a PWM Command signal; however, the duty is limited to maximum duty cycle of 37.5% and a maximum pulse length of 600 microseconds (µs). The p100's pulsed RF design overdrives the laser gas, resulting in substantially higher peak power than our ti-Series CW laser even though the average power output of these two lasers is almost the same. Like our integrated ti-Series lasers, the p100 features a built-in RF power supply so no external RF cables are required. This compact, lightweight design mounts easily to flatbed cutters, robotic arms, or gantry systems making integration into your production line simple and fast.

Pulstar p100 features include:

- Peak power > 390 watts
- Peak pulse energy > 190 millijoules (mJ)
- Rise times < 40 microseconds (µs)
- Pulse widths up to 600 µs
- Built-in gas purge port
- Color-coded LEDs mirror user output status
- "Industrial-strength" ±5 V to 24 VDC I/O
- Weighs only 30 lbs (13.6 kg)

Pulstar nomenclature

Pulstar p100 lasers are currently available only as OEM lasers and are designed primarily for integration into larger processing systems by the Original Equipment Manufacturer (OEM) or System Integrator who bears the responsibility for meeting the appropriate laser safety requirements for Class 4 laser systems. As an OEM laser, the p100 does not comply with 21 CFR, Subchapter J or EN 60825-1 without additional safeguards.

Model numbers

The last three characters in the Pulstar model number serve to designate the functional category, cooling method, and model version. The functional category is indicated by either a "K" for Keyswitch or "S" (Switch-less) for OEM models. The next letter indicates the cooling method: "W" for water-cooled units, "F" for fan-cooled units, and "A" for air-cooled lasers. The last letter in the model number indicates the current model version beginning with "B". The Pulstar OEM p100 laser is available only in an OEM water-cooled (SW) configuration.

getting started

Unpacking

The *Unpacking* section includes subsections:

- Incoming inspection
- Packaging guidelines

Incoming inspection

Upon arrival, inspect all shipping containers for signs of damage. If you discover shipping damage, document the damage (photographically if possible), then immediately notify the shipping carrier and SYNRAD, Inc.

The shipping carrier is responsible for any damage occurring during transportation from SYNRAD, Inc. to your receiving dock.

Packaging guidelines

- To prevent equipment damage or loss of small components, use care when removing packaging materials.
- After unpacking, review the *Inventory* section and verify that all components are on hand.
- Do not lift or support the laser using the cooling fittings; lift the laser by the lifting handles or base plate only.
- Save all shipping containers and packaging materials, including covers and plugs. Use these specialized packing materials when shipping the laser to another location.
- When packing a laser for shipment, be sure to remove all accessory items not originally attached to the laser including beam delivery components, cooling tubing, etc.
- Refer to *Packaging instructions* drawings in the Technical Reference chapter for details on packaging p100 lasers using SYNRAD-supplied shipping materials.
- When storing or shipping water-cooled lasers, remember to drain all cooling water from the laser and then cap the open fittings to prevent debris from entering the coolant path.

getting started

Inventory

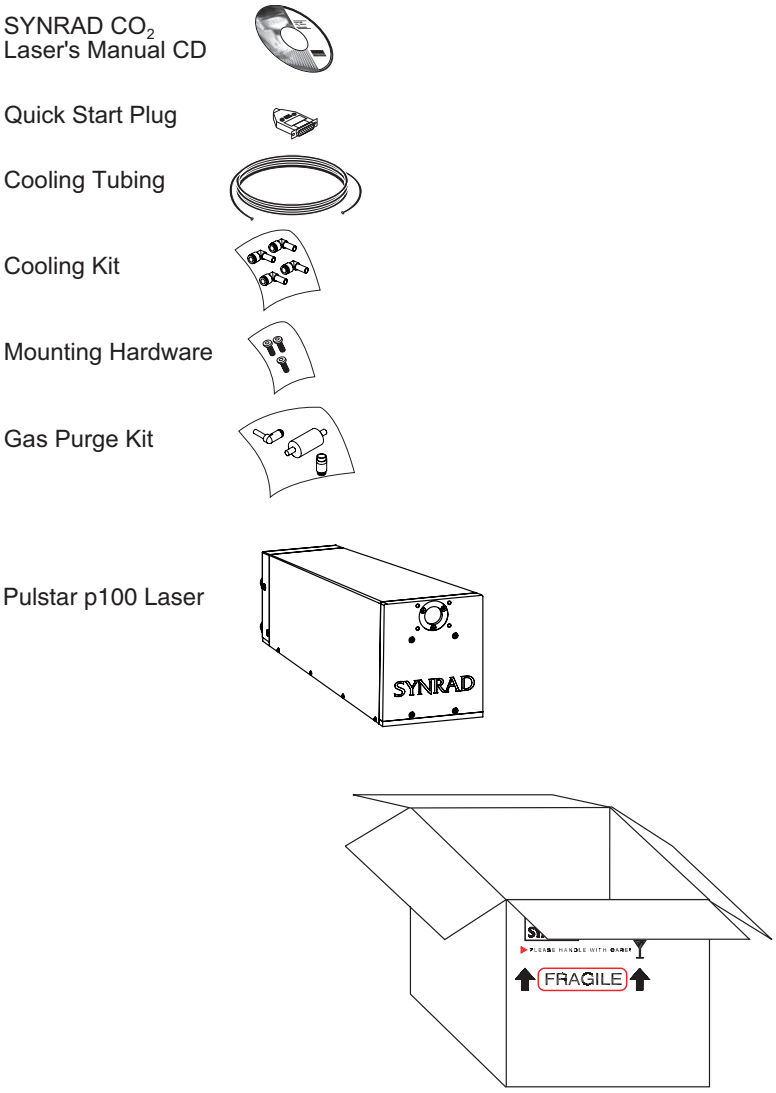

Figure 1-1 Pulstar p100 shipping box contents

Table 1-1 Pulstar p100 ship kit contents

Shipping Box Contents	Qty	Shipping Box Contents	Qty
Pulstar p100 Pulsed Laser	1	Mounting Bolts	3
SYNRAD CO_2 Lasers Manual CD	1	Gas Purge Kit	1
Quick Start Plug	1	Cooling Kit	1
Cooling Tubing	1	Spare Fuses (not shown)	2
DC Power Cable Set (not shown)	1	Final Test Report (not shown)	1

getting started

Inventory

Contents description

Each item listed in Table 1-1 is described below:

Pulstar p100 Pulsed Laser – The Pulstar p100 laser is a compact laser generating 100 W average power and peak power greater than 390 W with rise times less than 40 microseconds (µs).

SYNRAD CO_2 Lasers Manual CD – contains a Pulstar p100 manual that provides setup, operation, and maintenance information for your OEM p100 laser.

Quick Start Plug – connects to the *User I/O* connector. Jumpers are built into the plug to enable the laser's interlock circuits for initial start-up and testing.

DC Power Cable Set (not shown) – connects 48 VDC from the DC power supply to the Pulstar p100 laser. Standard cable length is 1.8 meters (6.0 ft).

Cooling Tubing – carries cooling water from the chiller (not included) to the laser and back. This black polyethylene tubing is 1/2-inch O.D. by 30 feet and must be cut to length.

Mounting Bolts – Three each 1/4–20 × 5/8" UNC capscrews are provided for mounting the Pulstar p100 laser to your mounting surface.

Gas Purge Kit – provides a filtering and connection point to the laser from your facility's gas purge system.

Cooling Kit – adapts the laser's straight 1/2-inch coolant fittings to 90° adaptor fittings for either 1/2-inch standard or 12-mm metric cooling tubing.

Spare Fuses (not shown) – fast-acting mini ATO-type fuses protects the p100's internal circuitry.

Final Test Report (not shown) – contains data collected during the laser's final pre-shipment test.

getting started

Mounting

The *Mounting* section includes subsections:

- Mount from below (into p100 base plate)
- Mount from above (using optional mounting feet)

The Pulstar p100 base plate (and the optional customer-installed mounting feet) are designed so the laser can be easily mounted using only three M6 × 1 ISO or 1/4—20 UNC fasteners. Always fasten the p100 laser directly to your mounting surface using either the base plate or the optional factory-designed mounting feet because they both incorporate a three-point ball bearing design that eliminates any possible distortion caused by variations in the flatness of the mounting surface.

Caution possible equipment damage	SYNRAD does not recommend mounting lasers in a vertical "head-down" or "tail-down" orientation. If you must mount your laser in this manner, please contact the factory for limitations as a vertical orientation increases the risk of damage to the laser's output optic.

Mount from below (into p100 base plate)

To fasten the Pulstar OEM p100 laser to your mounting surface using the base plate, perform the following steps:

1. Refer to Figure 4-19, the p100 outline and mounting drawing (sheet 1 of 2), for mounting hole locations, then drill three thru holes in your mounting surface. These holes should correspond with either the ISO (metric) or UNC fastener pattern shown in the O&M drawing.
2. Place the p100 laser on the mounting surface so the threaded holes in the base plate line up with the thru holes in your mounting surface as shown in Figure 1-2.

Figure 1-2 Pulstar p100 mounting locations (1/4–20 fastener locations shown)

Mounting

Important Note: Verify the correct fastener length for your mounting application. When fastening the Pulstar p100 to your mounting surface, ***be sure the fasteners do not extend further than 11.0 mm (0.433") into the laser's base plate***.

3 Insert three M6 × 1 ISO or 1/4–20 UNC fasteners through the mounting surface into the corresponding threaded holes in the p100 base plate. Turn the screws by hand until the threads engage.

4 Evenly tighten all three fasteners to a maximum torque of 6.1 N m (54 in lb).

Mount from above (using optional mounting feet)

To fasten the OEM p100 laser onto a mounting surface, you will need to purchase and install the optional p100 mounting kit, SYNRAD P/N 250-20440-01 (available separately from the factory).

Attach the optional mounting feet

To attach the optional mounting feet to the OEM p100 laser, perform the following steps:

1 Carefully place the p100 laser upside down on a padded work surface with the beam exit facing towards the left.

2 Locate the mounting feet in the optional mounting kit and orient the feet as shown in Figure 1-3. The arrow machined on the front foot should be visible and point towards the front of the laser.

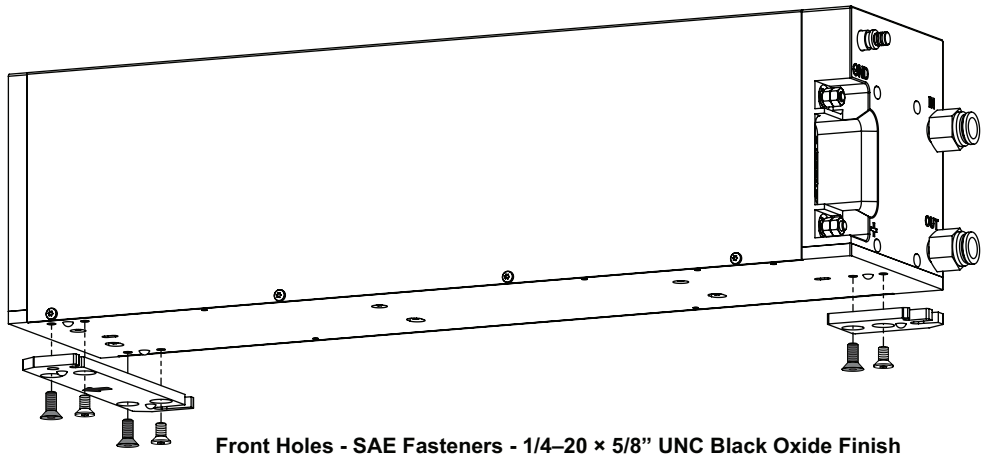

Figure 1-3 Attach optional p100 mounting feet

3 Locate the six flathead screws in the optional p100 mounting kit and refer to Figure 1-3 or Figure 4-20 (the p100 O&M drawing, sheet 2 of 2) for ISO and UNC fastener locations on the base plate.

Mounting

Caution possible equipment damage	The optional p100 mounting feet are fastened using three M6 × 1 metric ***and*** three 1/4–20 UNC fasteners. The M6 screws (stainless steel) fit the rear holes in each mounting foot while the 1/4–20 fasteners (black oxide finish) fit the front holes. Please review the drawings carefully because the threads in the p100 base plate can be damaged if these fasteners are threaded into the wrong holes.

4 Insert the three M6 × 1 metric fasteners (stainless steel finish) through the rear holes in each mounting foot and thread into the metric threaded holes in the p100 base plate. Then insert the three 1/4–20 UNC fasteners (black oxide finish) through the front holes in each mounting foot and thread into the p100 base plate. Turn the screws by hand until the threads engage.

5 Evenly tighten all six fasteners to a maximum torque of 6.1 N m (54 in lb).

Fasten p100 laser onto mounting surface

To fasten the OEM p100 laser (with feet) to your mounting surface, perform the following steps:

1 Refer to the p100 outline and mounting drawing (sheet 2 of 2) for hole locations, then drill and tap three M6 × 1 or 1/4–20 holes in your mounting surface. These holes locations should correspond with the two slots labeled "**A**" and the thru hole labeled "**B**" as shown in Figure 1-4.

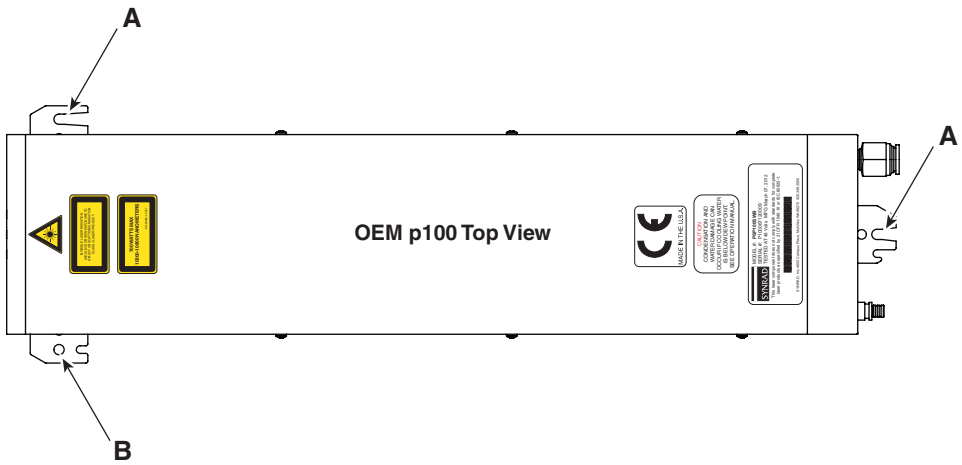

Figure 1-4 Pulstar p100 mounting locations (using optional feet)

2 Place the p100 laser on the mounting surface so the slots/hole on the mounting feet line up with the threaded holes in your mounting surface.

3 Insert three M6 × 1 ISO or 1/4–20 UNC fasteners through the slots/hole on the mounting feet into the corresponding threaded holes in the mounting surface. Turn the screws by hand until the threads engage.

4 Evenly tighten all three fasteners to a maximum torque of 6.1 N m (54 in lb).

getting started

Connecting

The *Connecting* section includes subsections:

- Cooling connections
- 48 V power supply connections
- Control connections
- Other connections

Cooling connections

Read *Guidelines for cutting and installing tubing* before installing any cooling tubing and then make sure to connect the cooling system exactly as described for your particular laser.

Guidelines for cutting and installing tubing

- Cut tubing lengths generously to allow for trimming.
- Cut tubing squarely; diagonal cuts may not seal properly. Trim away burrs if the cut is “ragged”.
- Avoid excessive stress on fittings; create gentle bends when routing tubing close to connectors. Excessive stress from sharp bends will compromise the sealing properties of the fitting.
- Never allow the tubing to kink, since kinking severely restricts coolant flow.
- Push tubing completely into the fitting, then pull the tubing to verify that it is locked into place. Tubing extends into the fitting approximately 22 mm (0.875").
- If tubing must be disconnected from a fitting, first push and hold the tubing slightly into the fitting. Next push the white fitting ring evenly towards the fitting, and then pull the tubing free.
- After disconnecting tubing from a fitting, trim 12.7 mm (0.5") from its end before reconnecting. Trimming the end of the tubing before reconnecting the fitting provides an undisturbed sealing surface.

Laser cooling fittings

If your integrated laser application uses metric cooling tubing, we recommend the installation of tubing adaptors to convert the laser’s existing water *IN*/*OUT* fittings from 1/2-inch standard to 12-mm metric tubing. The ship kit sent with your Pulstar p100 laser includes a cooling kit containing two each 1/2-inch male to 12-mm female 90° adaptors and two each 1/2-inch male to 1/2-inch female 90° adaptors. If required, many tubing and fitting manufacturers can supply 1/2-inch to 12-mm straight fittings.

Caution
possible equipment damage

Do not overtighten the water *IN*/*OUT* cooling fittings. Overtightening the cooling fittings may crack the cooling manifold, causing coolant leakage, or partially block the cooling channel, leading to reduced coolant flow and premature laser failure.

If you must install new fittings, wrap the threads with teflon pipe tape and carefully tighten the fittings, making sure the ***maximum insertion depth is no more than 6.6 mm (0.26") into the cooling manifold***.

getting started

Connecting

Chiller preparation guidelines

- You must provide fittings to adapt the laser's 1/2-inch O.D. polyethylene cooling tubing to the chiller's Inlet and Outlet ports. These fittings can be either "quick disconnect" or compression type fittings.
- Because Pulstar's cooling tubing is supplied in inch sizes, do not use metric tubing fittings unless you have installed the appropriate inch-to-metric tubing adaptors. The use of metric fittings on inch size tubing will lead to coolant leaks or may allow the pressurized tubing to blow off the fitting.

Coolants

SYNRAD recommends that the laser's cooling fluid contain at least 90% distilled water by volume. In closed-loop systems, use a corrosion inhibitor/algaecide such as Optishield® Plus or equivalent as required. Avoid glycol-based additives because they reduce the coolant's heat capacity and high concentrations may affect power stability. For SYNRAD lasers, the minimum coolant setpoint is 18 °C (64 °F) so glycol is not necessary unless the chiller is subjected to freezing temperatures. If tap water is used, chloride levels should not exceed a concentration of 25 parts per million (PPM) and total hardness should be below 100 PPM. Install a filter on the chiller's return line and inspect frequently. Pulstar p100 lasers incorporate the following wetted materials in the coolant path—nickel-plated brass, copper, Delrin®, nitrile, and stainless steel.

Note: DO NOT use de-ionized (DI) water as a coolant. DI water is unusually corrosive and is not recommended for mixed material cooling systems.

Setting coolant temperature

Choosing the correct coolant temperature is important to the proper operation and longevity of your laser. When coolant temperature is lower than the dew point (the temperature at which moisture condenses out of the surrounding air), condensation forms inside the laser housing leading to failure of laser electronics as well as damage to optical surfaces.

The greatest risk of condensation damage occurs when the laser is in a high heat/high humidity environment and the chiller's coolant temperature is colder than the dew point of the surrounding air or when the system is shut down, but coolant continues to flow through the laser for extended periods of time.

The chiller's temperature setpoint must always be set above the dew point temperature. In cases where this is not possible within the specified coolant temperature range of 18 °C to 22 °C (64 °F to 72 °F), then the following steps MUST be taken to reduce the risk of condensation damage.

- Use the *Gas Purge* port to introduce nitrogen or dry, filtered air into the laser housing.
- Air-condition the room or the enclosure containing the laser.
- Install a dehumidifier to reduce the humidity of the enclosure containing the laser.
- Stop coolant flow when the laser is shut down.
- Increase coolant flow by an additional 3.8 lpm (1.0 GPM). Do not exceed a coolant pressure of 414 kPa (60 PSI).
- Refer to Table 1-2 and gradually increase coolant temperature until it is above the dew point temperature and condensation disappears. Do not exceed a coolant temperature of 30 °C (86 °F).

Note: Pulstar OEM p100 lasers can be operated at coolant temperatures up to 30 °C to reduce problems associated with condensation; however, this may result in decreased laser performance and/or reduced laser lifetime.

Connecting

Table 1-2 provides dew point temperatures for a range of air temperature and relative humidity values. The laser's coolant temperature must be set ***above*** the dew point temperatures given in the chart; ***however, for best results and performance, use a coolant temperature in the range of 18 –22 °C (64–72 °F)***.

Table 1-2 Dew point temperatures

Dew Point Temperature Chart °F (°C)

	Relative Humidity (%)															
	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
Air Temp °F (°C)																
60 (16)	—	—	—	32 (0)	36 (2)	39 (4)	41 (5)	44 (7)	46 (8)	48 (9)	50 (10)	52 (11)	54 (12)	55 (13)	57 (14)	59 (15)
65 (18)	—	—	33 (1)	37 (3)	40 (4)	43 (6)	46 (8)	48 (9)	51 (11)	53 (12)	55 (13)	57 (14)	59 (15)	60 (16)	62 (17)	64 (18)
70 (21)	—	33 (1)	37 (3)	41 (5)	45 (7)	48 (9)	51 (11)	53 (12)	56 (13)	58 (14)	60 (16)	62 (17)	64 (18)	65 (18)	67 (19)	69 (21)
75 (24)	—	37 (3)	42 (6)	46 (8)	49 (9)	52 (11)	55 (13)	58 (14)	60 (16)	62 (17)	65 (18)	67 (19)	68 (20)	70 (21)	72 (22)	73 (23)
80 (27)	35 (2)	41 (5)	46 (8)	50 (10)	54 (12)	57 (14)	60 (16)	62 (17)	65 (18)	67 (19)	69 (21)	71 (22)	73 (23)	75 (24)	77 (25)	78 (26)
85 (29)	40 (4)	45 (7)	50 (10)	54 (12)	58 (14)	61 (16)	64 (18)	67 (19)	70 (21)	72 (22)	74 (23)	76 (24)	78 (26)	80 (27)	82 (28)	83 (28)
90 (32)	44 (7)	50 (10)	54 (12)	59 (15)	62 (17)	66 (19)	69 (21)	72 (22)	74 (23)	77 (25)	79 (26)	81 (27)	83 (28)	85 (29)	87 (31)	88 (31)
95 (35)	48 (9)	54 (12)	59 (15)	63 (17)	67 (19)	70 (21)	73 (23)	76 (24)	79 (26)	81 (27)	84 (29)	86 (30)	88 (31)	90 (32)	92 (33)	93 (34)
100 (38)	52 (11)	58 (14)	63 (17)	68 (20)	71 (22)	75 (24)	78 (26)	81 (27)	84 (29)	86 (30)	88 (31)	91 (33)	93 (34)	95 (35)	97 (36)	98 (37)

To use Table 1-2, look down the *Air Temp* column and locate an air temperature in Fahrenheit or Celsius (°C values are shown in parentheses) that corresponds to the air temperature in the area where your laser is operating. Follow this row across until you reach a column matching the relative humidity in your location. The value at the intersection of the *Air Temp* and *Relative Humidity* columns is the *Dew Point* temperature in °F (or °C). The chiller's temperature setpoint must be set ***above*** the dew point temperature. For example, if the air temperature is 85 °F (29 °C) and the relative humidity is 60%, then the dew point temperature is 70 °F (21 °C). Adjust the chiller's temperature setpoint to 72 °F (22 °C) to prevent condensation from forming inside the laser.

Caution
possible equipment damage

Operating the laser at coolant temperatures above 22 °C (72 °F) may result in decreased performance and/or premature failure of electronic components.

getting started

Connecting

Cooling tubing connections

To connect cooling tubing to your p100 laser, refer to Figure 1-5 and perform the following steps.

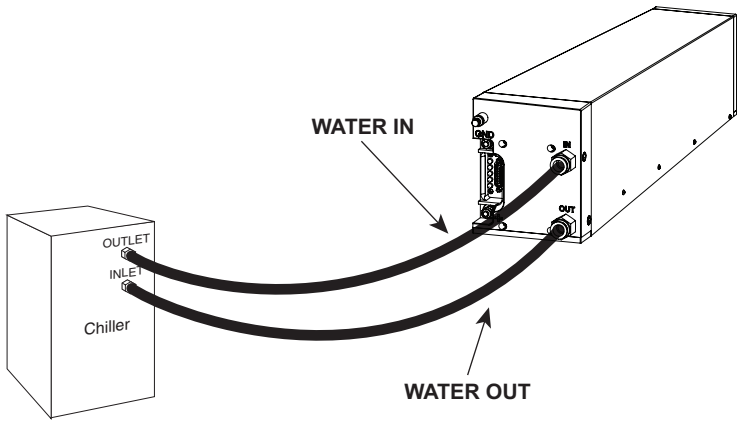

Figure 1-5 Pulstar p100 cooling connections

1 Locate the 1/2-inch O.D. polyethylene cooling tubing in the p100 ship kit.

Note: If using metric cooling tubing in the application, locate the two 1/2-inch male to 12-mm female 90° adaptors in the cooling kit and install them into the p100's *Water In* and *Water Out* ports.

2 Cut and connect a length of cooling tubing to fit between the chiller's Outlet port and the *WATER IN* port on the rear of the p100 laser.

3 Cut and connect a length of cooling tubing to fit between the *WATER OUT* port on the rear of the laser and the chiller's Inlet port.

Caution possible equipment damage	Inlet cooling water temperature must always be maintained above the dew point to prevent condensation and water damage to your Pulstar laser.

4 Turn on the chiller and adjust the temperature setpoint to 18 °C to 22 °C. Regulate coolant flow to 5.7–7.6 lpm (1.5–2.0 GPM) at less than 414 kPa (60 PSI) of pressure.

5 Closely examine all cooling connections and verify that there are no leaks.

Connecting

48 V power supply connections

Note: The negative (–) side of the DC input to the laser is internally connected so that the laser chassis serves as DC power ground. You should isolate the laser's DC power supply so that the only grounded connection is at the laser. Alternatively, you can mount the laser chassis on an insulating pad or film in order to electrically isolate the laser when other equipment is grounded to the laser's DC power supply.

The OEM p100 laser requires a DC power source capable of supplying a minimum of 40 A at 48 VDC (65 A peak for a minimum of 800 µs). We recommend the SYNRAD PS-48 DC power supply, which can provide a maximum of 50 A at 48 VDC. AC input requirements for the PS-48 supply are 180–264 VAC, single-phase (1Ø), 12.2 A max (@ 208 VAC), 47–63 Hz.

To connect DC power to your Pulstar p100, laser refer to Figure 1-6 and perform the following steps:

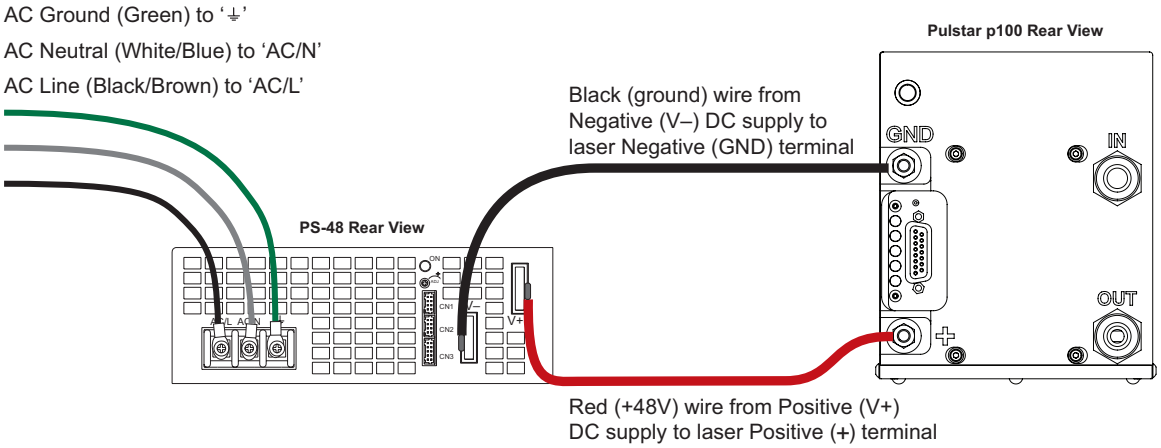

Figure 1-6 PS-48 power supply connections

Caution
possible equipment damage

Do not reverse polarity when connecting the DC power cables to your DC power source. Reversed DC polarity may damage the laser's internal RF power supply. Carefully follow the directions below to ensure that DC power cables are properly connected to the correct DC output terminals.

1. Verify that input AC power to the DC power supply is physically locked out or disconnected.
2. Locate the DC power cable set in the ship kit. Both red and black cables are manufactured from 8 AWG wire and have 1/4" (M6) terminals on one end—the PS-48 DC power supply connection—and 5/16" (M8) terminals on the other end—the p100 laser connection.
3. Connect the black DC power cable between the negative (V–) output terminal on the PS-48 supply and the negative (GND) terminal on the p100 laser.
4. Connect the red DC power cable between the positive (V+) output terminal on the PS-48 and the positive (+) terminal on the p100 laser.

getting started

Connecting

Note: Because AC input connections and requirements vary from facility to facility, customers must provide the AC power cable or wiring. AC input connections to the PS-48 DC power supply are made using a three-position terminal strip with M4 screw terminals on 13.0 mm centers.

5 Connect the ground (earth) wire, typically green, to the input terminal labeled with the ground symbol.

6 Connect the neutral AC wire, typically white or blue, to the input terminal labeled "AC/N".

7 Connect the hot AC wire, typically black or brown, to the AC input terminal labeled "AC/L".

Control connections

All control connections to Pulstar p100 lasers are made through the 15-pin *User I/O* connector on the rear panel. The *User I/O* port receives power commands from SYNRAD's UC-2000 Universal Laser Controller, or FH Flyer marking head, and also serves as the connection point for auxiliary signals between the laser and any parts handling, automation, or monitoring equipment.

⚠ Warning
serious personal injury

Always use shielded cable when connecting your pulse signal source to PWM Input / PWM Return inputs. In electrically-noisy environments, long lengths of unshielded wire act like an antenna and may generate enough voltage to trigger uncommanded lasing.

Quick Start Plug

⚠ Warning
serious personal injury

The use of the *Quick Start Plug* bypasses the laser's safety interlock function, potentially exposing personnel in the area to ***invisible*** infrared laser radiation.

Because this plug jumpers Remote Interlock and Shutter Open Request signals, the laser will fire immediately on application of a PWM Command signal. Your integrated control system should provide interlock and shutter signals directly to the DB-15 *User I/O* connector only after safe operating conditions are established.

The *Quick Start Plug* is intended only for initial testing and trouble-shooting by qualified personnel. In normal operation, the laser's Remote Interlock input should be connected to the machine's safety interlock circuitry.

getting started

Connecting

Caution
possible equipment damage

Turn off DC power before installing or removing any plug or cable from the *User I/O* connector. Ensure that user connections are made to the appropriate pins and that the appropriate signal levels are applied. Failure to do so may damage the laser.

In order for your Pulstar p100 laser to properly operate, several input signals must be applied to the DB-15 *User I/O* connector before lasing is enabled. Voltage must be applied to Remote Interlock (Pin 3) and Shutter Open Request (Pin 10) inputs before the laser becomes ready to fire. In applications where Pulstar lasers are integrated into automated systems and safety interlocks are required, these input signals must be provided by the customer's control system. The *Quick Start Plug* included in the ship kit has factory-installed shorting jumpers wired into it to enable these inputs. Connect the *Quick Start Plug* to the *User I/O* connector when performing initial start-up and testing of your Pulstar laser.

To install the *Quick Start Plug*, perform the following steps:

1. Disconnect DC power from the laser.
2. Locate the *Quick Start Plug* in the ship kit.
3. Connect the *Quick Start Plug* to the *User I/O* connector on the rear of the p100 laser.

UC-2000 Universal Laser Controller

Important Note: Except for bench testing, we ***do not*** recommend using a UC-2000 Controller with the Pulstar p100 laser. The tickle signal from the UC-2000 may interfere with pulsing performance of the laser.

PWM or pulse signal source

To connect your PWM or pulse signal source to the p100 laser, perform the following steps:

1. Attach the BNC connector from your PWM or pulse signal source to the BNC connector on the rear of the *Quick Start Plug*.

Alternately, you can wire your PWM or pulse signal source (and inputs/outputs from your automation controller) to the DB-15 *User I/O* connector on the rear of the laser.

Important Note: Because the Pulstar p100 is a pulse laser, it will not operate when a constant 5V (100% duty cycle) PWM signal is applied. If this occurs, lasing will halt and status LED's/outputs will indicate a fault condition (see *Troubleshooting* in the Maintenance/Troubleshooting chapter for further information). The laser will recover immediately when the PWM duty cycle drops below 100%.

For further information about the *User I/O* connector, see *User I/O connections* in the Technical Reference chapter for *User I/O* pinouts and signal descriptions. See *Integrating Pulstar safety features*, also in the Technical Reference chapter, for detailed instructions on integrating the Pulstar p100's shutter, and remote interlock functions with automated control systems.

getting started

Connecting

Other connections

Gas Purge port

A gas purge is highly recommended when operating the laser. Purging the laser creates positive pressure inside the laser housing that prevents dirt and debris from accumulating on optical surfaces inside the laser housing. In condensing atmospheres, a gas purge helps to reduce the potential for condensation damage.

To connect the Pulstar p100 gas purge port, perform the following steps:

1 Locate the gas purge kit in the p100 ship kit. The kit consists of one male/female 90° quick-disconnect fitting, a straight fitting, and a low-flow gas filter.

2 Insert the filter into the *Gas Purge* port on the rear of the laser. Be sure the directional arrow on the filter is pointing towards the laser.

Note: To mount the filter vertically, insert the 90° fitting into the *Gas Purge* port and then press the filter into the 90° fitting. The directional arrow on the filter must point towards the laser.

3 Connect the straight fitting to the end of the gas filter.

4 Connect nitrogen or breathing-grade air to the fitting on the filter using 1/4-inch plastic tubing.

Note: To disconnect gas purge tubing, first push and hold the tubing slightly into the fitting. Next push the white fitting ring evenly towards the fitting, and then pull the tubing free.

Caution possible equipment damage	Do not exceed a gas purge pressure of 34.5 kPa (5 PSI). Excessive pressure may damage the purge assembly or other internal laser components. Do not use argon as a purge gas. Use only nitrogen or clean, dry air as described in Table 1-3, *Purge gas specifications*.

8 Set a purge pressure between 13.8–34.5 kPa (2–5 PSI). This provides just enough positive airflow to prevent dust from entering the laser. If a flowmeter is available, set a flow rate of 0.85–1.7 m^3/hr (30–60 SCFH, Standard Cubic Feet per Hour) at a pressure not to exceed 34.5 kPa (5 PSI).

The *Gas Purge* port on the Pulstar p100 laser must be connected to a source of nitrogen or clean, dry air only; do not use any other gases for purging. Purge gas specifications are listed in Table 1-3 below.

Table 1-3 Purge gas specifications

Purge Gas	Specification	
Nitrogen	High Purity Grade	≥ 99.9500% purity; filtered to ISO Class 1 particulate level
Air	Breathing Grade	≥ 99.9996% purity; filtered to ISO Class 1 particulate level
Air	Compressed	Instrument-grade air filtered and dried to ISO 8573-1:2010 Class 1, 2, 1 (≤ 10 1.0–5.0 µm particles/m^3; ≤ –40 °F dew point; ≤ 0.01 mg/m^3 oil vapor).

operation 2

Use information in this chapter to familiarize yourself with Pulstar p100 controls and indicators and to begin operating the laser.

This chapter contains the following information:

- Controls and indicators – displays and describes exterior controls and indicators on Pulstar p100 lasers.
- Start-up and pulsed operation – explains how to start your Pulstar p100 laser while verifying proper operation and how to operate the laser in pulsed mode.

operation

Controls and indicators

The *Controls and indicators* section includes subsections:

- OEM p100 front panel
- OEM p100 rear panel

OEM p100 front panel

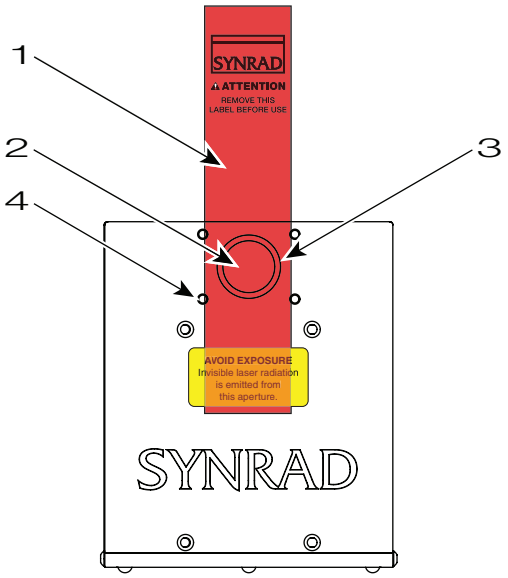

Figure 2-1 Pulstar OEM p100 front panel controls and indicators

1 Aperture Seal – prevents dust from damaging laser optics during shipping. Remove the red self-adhesive label before applying power to the laser.

2 Laser Aperture – provides an opening in the p100's front panel from which the beam exits.

3 Output Window – seals the internal beam path from contamination and is field-replaceable if it becomes damaged. See *Output window replacement* in the Maintenance/Troubleshooting chapter for details.

4 Optical Accessories Mounting – provides four threaded holes (8–32 UNC) for mounting optional beam delivery components. Because excessive weight may damage the laser, consult SYNRAD before mounting components not specifically designed as Pulstar options. Refer to the OEM p100 package outline drawings in the Technical Reference chapter for mounting dimensions.

Note: When mounting optical components to OEM p100 lasers, the 8–32 UNC fasteners must extend no further than 4.8 mm (0.25") into the laser's faceplate.

Controls and indicators

OEM p100 rear panel

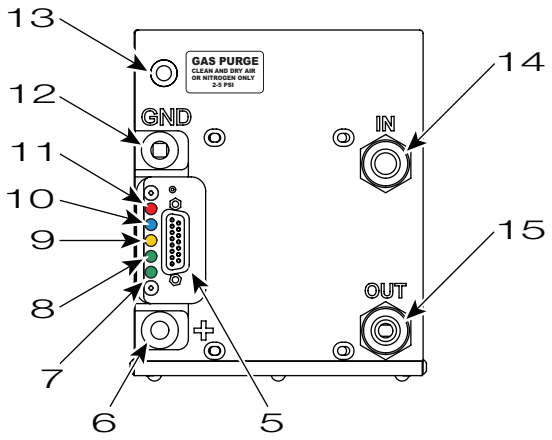

Figure 2-2 Pulstar OEM p100 rear panel controls and indicators

5 *User I/O* Port – provides a connection point for auxiliary output power, as well as input and output signals. Refer to the Technical Reference chapter for interface details and signal descriptions.

6 +48 VDC Input Terminal – M6 threaded stud receives 48 VDC from the DC power supply.

7 *INT* (Remote Interlock) LED – illuminates green to indicate the remote interlock circuit is closed and lasing may be enabled; the LED is red and lasing is disabled if the interlock input is open.

8 *TMP* (Temperature) LED – illuminates green to indicate laser temperature is within limits and lasing may be enabled; the LED is red and lasing is disabled if laser temperature rises above safe operating limits.

9 *RDY* (Ready) LED – illuminates yellow when the laser is enabled to indicate that lasing will begin when a PWM Command signal is applied, provided the *SHT* LED is illuminated.

10 *SHT* (Shutter) LED – illuminates blue to indicate that a Shutter Open Request signal is connected to the *User I/O* port and lasing may be enabled.

11 *LASE* LED – illuminates red to indicate the OEM p100 is actively lasing. The *LASE* LED is off when tickle pulses are being generated and illuminates red when PWM Command signal pulses are long enough to produce laser output

12 *GND* (–) Terminal – M6 threaded stud provides connection point for negative (ground) side of the 48 VDC power supply.

13 *Gas Purge* Port – provides a low pressure nitrogen (or pure air) connection to prevent dust and debris from damaging electronic or optical components inside the laser housing.

14 *WATER IN* Port – labeled IN, this connection provides the coolant inlet to the laser's cooling system using straight 1/2-inch fittings. When using metric tubing, first install the 90° tubing adaptors from the cooling kit.

15 *WATER OUT* Port – labeled OUT, this connection provides the coolant outlet from the laser's cooling system using straight 1/2-inch fittings. When using metric tubing, first install the 90° tubing adaptors from the cooling kit.

operation

Start-up and pulsed operation

The *Start-up and pulsed operation* section includes subsections:

- Initial start-up with UC-2000 Controller
- Pulsed operation from PWM signal source

⚠ Danger
serious personal injury

This Class 4 laser product emits ***invisible*** infrared laser radiation in the 10.6 µm CO_2 wavelength band. Since direct or diffuse laser radiation can inflict severe corneal injuries, always wear eye protection when in the same area as an exposed laser beam. Do not allow the laser beam to contact a person. This product emits an invisible laser beam that is capable of seriously burning human tissue.

Always be aware of the beam's path and always use a beam block while testing.

⚠ Warning
serious personal injury

Remote interlock faults are not latched on Pulstar OEM p100 lasers. Clearing the fault condition re-enables the *RDY* indicator and the laser will fire ***immediately*** provided the *SHT* indicator is lit and a PWM Command signal is applied. Because exposure to 10.6 µm CO_2 laser radiation can inflict severe corneal injuries and seriously burn human tissue, the OEM or System Integrator must ensure that appropriate safeguards are in place to prevent unintended lasing.

⚠ Warning
serious personal injury

The use of the *Quick Start Plug* bypasses the laser's safety interlock function, potentially exposing personnel in the area to ***invisible*** infrared laser radiation.

The *Quick Start Plug* is intended only for initial testing and trouble-shooting by qualified personnel. In normal operation, the laser's Remote Interlock input should be connected to the machine's safety interlock circuitry.

Caution
possible equipment damage

Contamination on the laser's output window (or on any beam delivery optic) can absorb enough energy to damage optical components in the beam path. Periodically inspect the p100's output window and all other beam delivery optics for signs of contaminants and then carefully clean as required. In dirty environments, purge laser optics using filtered air or nitrogen to prevent vapor and debris from accumulating on optical surfaces.

operation

Start-up and pulsed operation

Initial start-up with UC-2000 Controller

Before your Pulstar OEM p100 laser is put into service for the first time, follow this procedure to verify the laser system is operating at optimum performance. For this procedure, use the UC-2000 as a stand-alone controller; do not attempt to control the laser or UC-2000 externally.

Important Note: Except for bench testing, we ***do not*** recommend using a UC-2000 Controller with the Pulstar OEM p100 laser. The automatically-generated tickle signal from the UC-2000 may interfere with the laser's pulsing performance.

Note: Before performing the initial start-up sequence, you must first connect the *Quick Start Plug* or you must provide the required Remote Interlock and Shutter Open Request signals to the *User I/O* connector. See *User I/O* connections in the Technical Reference chapter for interface details and signal descriptions.

Starting auxiliary equipment

1 Ensure that all personnel in the area are wearing protective eyewear.

2 Remove the red self-adhesive aperture seal covering the laser aperture.

3 Place a power meter, or appropriate beam block, 61 cm (24 in) from the laser aperture to prevent the beam from traveling beyond the work area.

4 Connect the *Quick Start Plug* to the *User I/O* connector on the rear of the laser and then connect the UC-2000 (or alternate PWM signal source) to the BNC connector on the *Quick Start Plug*.

Caution possible equipment damage	Inlet cooling water temperature must always be maintained above the dew point to prevent condensation and water damage to your Pulstar laser.

5 Turn on the chiller and set a temperature setpoint between 18 °C–22 °C. Verify that the chiller is delivering a flow rate of 5.7–7.6 lpm (1.5–2.0 GPM) at less than 414 kPa (60 PSI) of pressure.

Examine all cooling connections carefully and ensure that they do not leak.

Caution possible equipment damage	Do not exceed a gas purge pressure of 34.5 kPa (5 PSI). Excessive pressure may damage the purge assembly or other internal laser components. Do not use argon as a purge gas. Use only nitrogen or clean, dry air as described in Table 1-3, *Purge gas specifications*.

operation

Start-up and pulsed operation

6 Start purge gas flow at a rate of 0.85–1.7 m^3/hr (30–60 SCFH, Standard Cubic Feet per Hour) at a pressure not to exceed 34.5 kPa (5 PSI). If a flowmeter is not available, set a purge pressure between 13.8–34.5 kPa (2–5 PSI).

Note: If you have not yet operated your UC-2000 Universal Laser Controller, refer to the *UC-2000 Laser Controller Operator's Manual* for setup and operation instructions before continuing.

7 Set the UC-2000 to *MANUAL* mode, and then set the *PWM Adj Knob* to provide zero percent output (0.0%). The UC-2000's *Lase* indicator should be Off.

⚠ Warning
serious personal injury

Because of phase differences, tickle pulses from the UC-2000 may combine with the OEM p100's internally-generated tickle signal causing the *LASE* LED to flicker during the transition from tickle to lasing. Laser output may occur if the *LASE* LED flickers.

8 Turn on the +48 VDC power supply.

If the factory-wired *Quick Start Plug* is installed, the *INT* indicator will illuminate green, the *SHT* indicator will illuminate blue, and the *RDY* LED will illuminate yellow. The *TMP* indicator will illuminate green if laser temperature is within safe operating limits.

Note: On cold starts, provide five to ten seconds of tickle before sending PWM Commands to the laser.

Starting your Pulstar OEM p100 laser

Note: Pulstar *RDY* and *SHT* LEDs denote separate control functions. Although the *RDY* lamp may light while the *SHT* LED is Off (Shutter Open Request signal missing), no power is applied to the RF drivers until both *RDY* and *SHT* indicators are illuminated.

1 Press the UC-2000's *Lase On/Off* button. The *Lase* indicator on the UC-2000 should illuminate.

2 Use the *PWM Adj Knob* on the UC-2000 Controller to slowly increase power by increasing the duty cycle of the PWM Command signal (up to a maximum of 37.5%). The *LASE* LED turns red when PWM Command signal pulses are long enough to produce laser output and the power meter should indicate increased power output.

3 Reduce the PWM duty cycle to 0.0% and press the UC-2000's *Lase On/Off* button to stop lasing. *Lase* indicators on the UC-2000 and the laser should both turn off.

4 Remove DC power from the laser.

Start-up and pulsed operation

Caution possible equipment damage	Do not flow coolant through the laser for an extended period of time when the laser is shutdown. This causes condensation to form inside the laser which may result in catastrophic damage to internal optics and electronic circuits.

5 Shut off the chiller or otherwise stop coolant flow through the laser.

6 Shut off gas purge flow to the laser. In dirty or dusty environments; however, it may be necessary to purge the laser continuously to prevent contamination of internal optics.

If your Pulstar OEM p100 laser fails to lase, refer to *Troubleshooting* in the Maintenance/Troubleshooting chapter for troubleshooting information.

Pulsed operation from PWM signal source

Follow these basic steps to operate the OEM p100 as a pulsed laser. Although a tickle signal is not required, you will need to provide PWM Command signal pulses as well as Remote Interlock and Shutter Open Request input signals to the p100's *User I/O* connector. Refer to *User I/O connections* in the Technical Reference chapter for interface details and refer to *Controlling laser power* in the Technical Reference chapter for PWM Command signal descriptions.

Starting auxiliary equipment

1 Ensure that all personnel in the area are wearing protective eyewear.

2 Remove the red self-adhesive aperture seal covering the laser aperture.

3 Use an appropriate beam block to prevent the beam from traveling beyond the work area.

4 Connect your PWM pulse signal source so that the output is connected to PWM Input (Pin 9) on the *User I/O* connector and connect the ground or return of the source to PWM Return (Pin 1).

Caution possible equipment damage	Inlet cooling water temperature must always be maintained above the dew point to prevent condensation and water damage to your Pulstar laser.

5 Turn on the chiller and set a temperature setpoint between 18 °C–22 °C. Verify that the chiller is delivering a flow rate of 5.7–7.6 lpm (1.5–2.0 GPM) at less than 414 kPa (60 PSI) of pressure.

operation

Start-up and pulsed operation

Caution possible equipment damage	Do not exceed a gas purge pressure of 34.5 kPa (5 PSI). Excessive pressure may damage the purge assembly or other internal laser components. Do not use argon as a purge gas. Use only nitrogen or clean, dry air as described in Table 1-3, *Purge gas specifications*.

6 Start purge gas flow at a rate of 0.85–1.7 m^3/hr (30–60 SCFH, Standard Cubic Feet per Hour) at a pressure not to exceed 34.5 kPa (5 PSI). If a flowmeter is not available, set a purge pressure between 13.8–34.5 kPa (2–5 PSI).

7 Ensure that your PWM pulse signal source is set to zero percent output (0.0%) at the intended pulse frequency (repetition rate).

8 Turn on the +48 VDC power supply.

If input signals are properly applied to the *User I/O* connector or the factory-wired *Quick Start Plug* is installed, the *INT* indicator will illuminate green, the *SHT* indicator will illuminate blue, and the *RDY* LED will illuminate yellow. The *TMP* indicator will illuminate green if laser temperature is within safe operating limits.

Starting your Pulstar OEM p100 laser

Important Note: Because the Pulstar p100 is a pulsed laser, it will not operate when a constant 5V (100% duty cycle) PWM signal is applied. If this occurs, lasing will halt and status LEDs/outputs will indicate a fault condition (see *Troubleshooting* in the Maintenance/Troubleshooting chapter for further information). The laser will recover immediately when the PWM duty cycle drops below 100%.

Note: Pulstar *RDY* and *SHT* LEDs denote separate control functions. Although the *RDY* lamp may light while the *SHT* LED is Off (Shutter Open Request signal missing), no power is applied to the RF driver until both *RDY* and *SHT* indicators are illuminated.

⚠ Warning serious personal injury	Always use shielded cable when connecting your PWM Command signal source to PWM Input/PWM Return inputs. In electrically-noisy environments, long lengths of unshielded wire act like an antenna and may generate enough voltage to trigger uncommanded lasing.

1 Apply PWM Command pulses between PWM Input (Pin 9) and PWM Return (Pin 1) on the p100's *User I/O* connector at pulse frequencies ranging from a single-shot to 100 kHz with pulse widths up to 600 microseconds (µs).

Note: The Pulstar OEM p100 laser is limited to a maximum pulse width of 600 µs for any single pulse.

Start-up and pulsed operation

Note: The laser's maximum duty cycle percentage is limited at higher frequencies (see Table 2-1) to maintain DC current within published specifications. If the duty cycle limit is reached, internal control circuitry limits the duty cycle applied to the RF driver and continues lasing. The laser will recover immediately and begin following the actual commanded duty cycle percentage when it is lowered below the limits shown in Table 2-1.

Table 2-1 Pulse frequency/duty cycle range

Input Frequency	Duty Cycle Range
< 50 kHz	0% – 37.5%
50 – 75 kHz	0% – 31.5%
> 75 kHz	0% –25.0%

2 When laser processing is complete, halt PWM pulse signals to the laser. The *LASE* indicator will turn off.

3 Remove DC power from the laser.

Caution
possible equipment damage

Do not flow coolant through the laser for an extended period of time when the laser is shutdown. This causes condensation to form inside the laser which may result in catastrophic damage to internal optics and electronic circuits.

4 Shut off the chiller or otherwise stop coolant flow through the laser.

5 Shut off gas purge flow to the laser. In dirty or dusty environments; however, it may be necessary to purge the laser continuously to prevent contamination of internal optics.

If your Pulstar p100 laser fails to lase, refer to *Troubleshooting* in the Maintenance/Troubleshooting chapter for troubleshooting information.

operation

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technical reference

3

Use information in this chapter as a technical reference for your Pulstar p100 laser.

This chapter contains the following information:

- Technical overview – briefly describes the Pulstar p100's pulsed technology and basic optical setup.
- Controlling laser power – explains various aspects of Pulstar control signals.
- User I/O connections – describes input/output signals and specifications for the 15-pin *User I/O* connector.
- Integrating Pulstar safety features – describes how to integrate Pulstar p100 safety features into your automated control system.
- Pulstar p100 general specifications – provides specifications for the Pulstar p100 laser.
- Pulstar p100 outline & mounting drawings – illustrate laser package outline and mounting dimensions for OEM p100 lasers.
- Pulstar p100 packaging instructions – illustrates how to package Pulstar p100 lasers for shipment.

technical reference

Technical overview

The *Technical overview* section includes subsections:

- Laser design
- OEM p100 pulse performance
- Optical setup

Laser design

The Pulstar p100 is a pulsed 100-watt laser based on SYNRAD's popular ti-Series laser. While the average power of the p100 is similar to the ti100 at 100 W, the p100's pulsed output power can be as high as 400 W. This high peak power in combination with a maximum duty cycle of 37.5% provides high-intensity, short duration pulses that are excellent for minimizing the Heat Affected Zone (HAZ) on many materials.

The p100 incorporates Pulstar's patented "t" technology, based on a combination of free-space and waveguide resonator designs, which enables SYNRAD to economically produce a symmetrical laser beam from a small but powerful laser capable of operating for many years with virtually no maintenance. Pulstar's unique extruded aluminum envelope offers excellent heat transfer, long gas life, and low operating costs in contrast to other laser tube technologies. In addition to being the vessel that maintains the lasing environment, the aluminum tube is also the structural platform that integrates the laser's optical, electrical, and cooling components.

Optical resonator

The optical resonator, in conjunction with the electrodes and the gas mixture, generates the laser beam. Pulstar p100 resonator is comprised of three optical elements: a front mirror, a rear mirror, and an output window. These optical elements are fastened to the tube's exterior and are exposed to its interior through holes in the end caps. O-rings are sandwiched between optical elements and the end cap to form a gas seal and to provide a flexible cushion that allows the slight movement necessary for alignment. All optical elements are aligned and locked into place by factory technicians before the laser is shipped.

The output beam, quite circular as it exits the resonator, transitions to a Gaussian-like mode in the far-field region. The structure of the resonator and external beam conditioning optics combine to produce a near Gaussian mode quality (M^2 factor) of < 1.2 with no side lobes. Beam waist diameter is approximately 5.6 mm at the output aperture and full-angle divergence due to diffraction is less than 3 milliradians (a 3 mrad divergence means that beam diameter increases 3 mm over every one meter distance traveled).

RF and control circuitry

The p100 is driven by two compact radio frequency (RF) power supplies mounted internally in the laser chassis. The 48 VDC input voltage is converted into a high-power RF signal using an RF power oscillator. The output from the RF oscillator (nominally at 83.5 MHz) drives the laser directly by exciting carbon dioxide (CO_2) gas in the tube to produce lasing.

Control circuitry built into the laser interrupts operation if any critical parameter is violated. Switches and sensors on the control board monitor various conditions and parameters that, if exceeded, pose a risk of potential damage to the laser. Additionally, laser operation is interrupted in response to the following conditions: (1) the Shutter Open Request input signal is missing; (2) an over temperature condition occurs; (3) the Remote Reset/Start Request input signal is enabled; (4) the Remote Interlock input signal is missing; or (5) any fault is present.

Technical overview

Beam conditioning

The OEM p100 laser incorporates a compact internal beam conditioning system that spatially filters the raw beam output from the resonator to remove any undesirable side lobes. In addition, the beam conditioning system incorporates a beam expansion factor of 2.5 that converts the 2.2 mm diameter resonator beam to a 5.6 mm diameter output beam. This larger beam diameter reduces the power density incident on the laser's output window thereby reducing the likelihood of damaged optics.

OEM p100 pulse performance

Figures 3-1 through 3-5 illustrate representative temporal pulse profiles of the OEM p100 laser at various PWM duty cycles and pulse repetition frequencies (PRF).

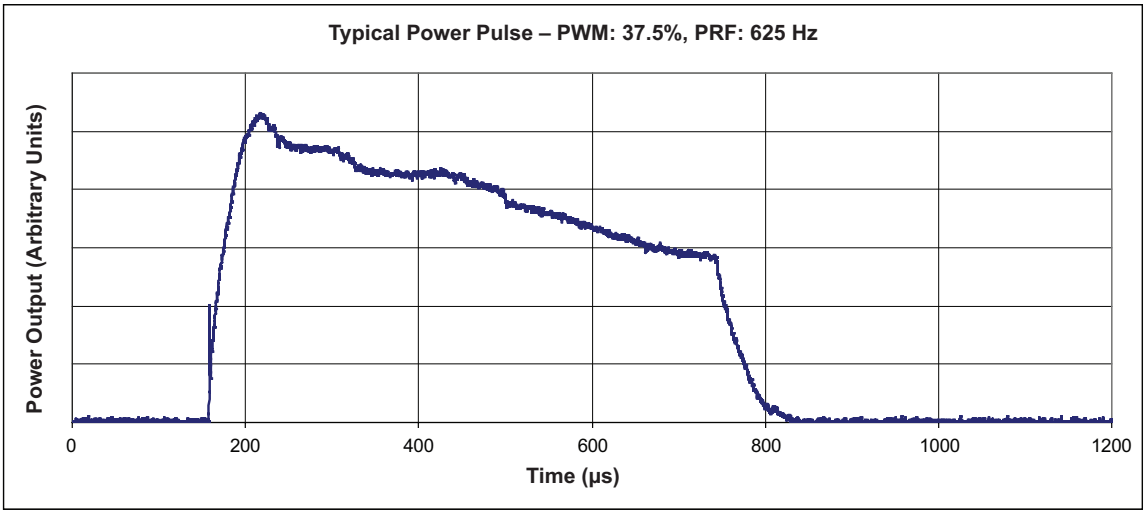

Figure 3-1 Pulstar p100 pulse profile – 37.5% duty cycle at 625 Hz

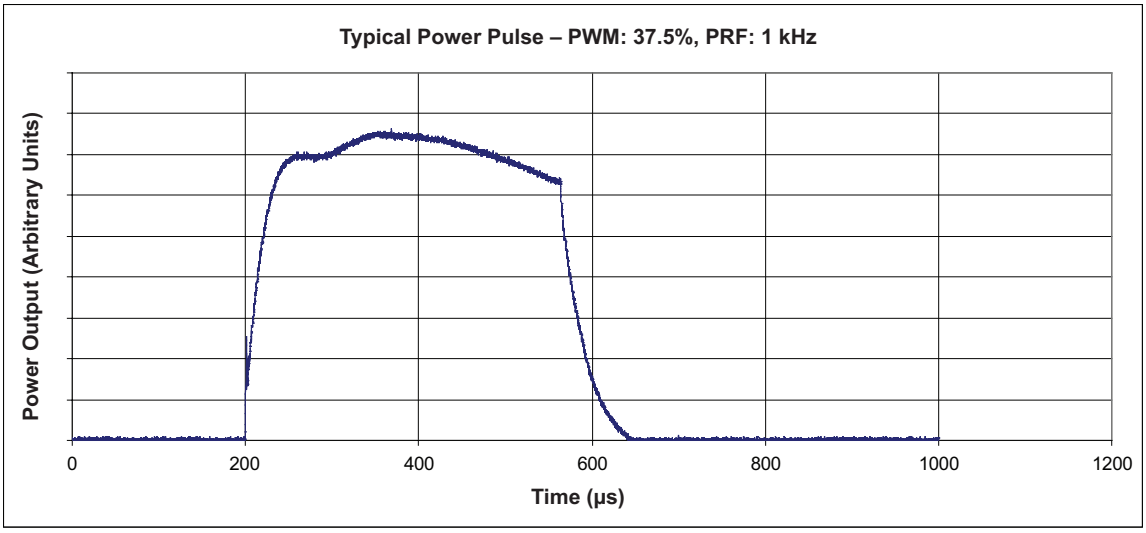

Figure 3-2 Pulstar p100 pulse profile – 20% duty cycle at 1 kHz

Technical overview

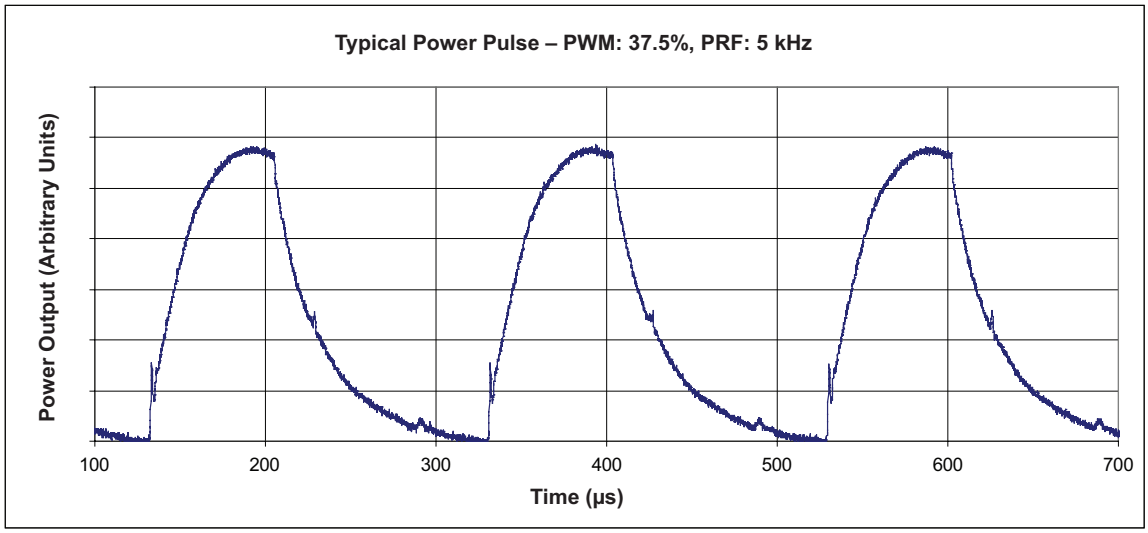

Figure 3-3 Pulstar p100 pulse profile – 37.5% duty cycle at 5 kHz

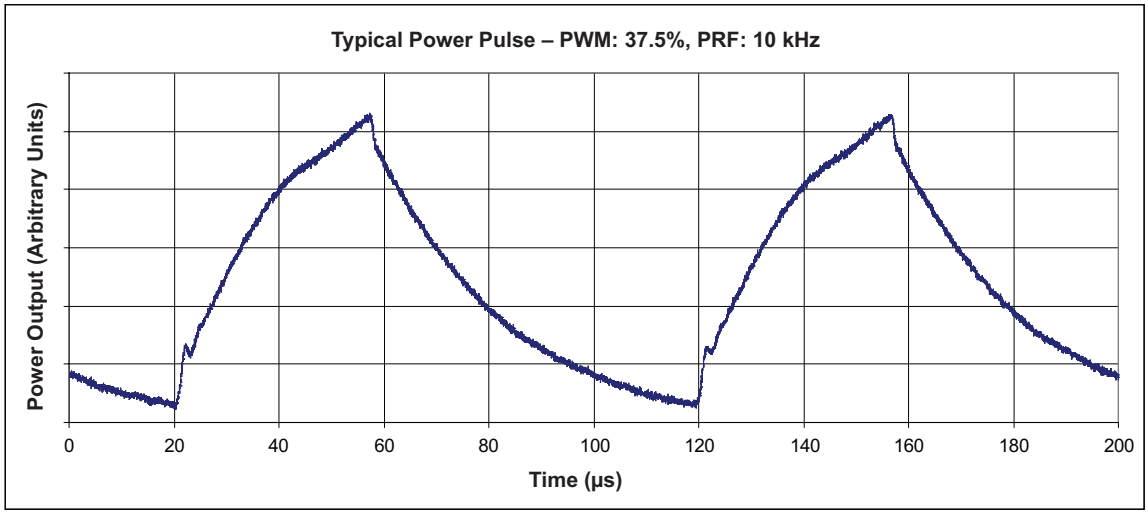

Figure 3-4 Pulstar p100 pulse profile – 37.5% duty cycle at 10 kHz

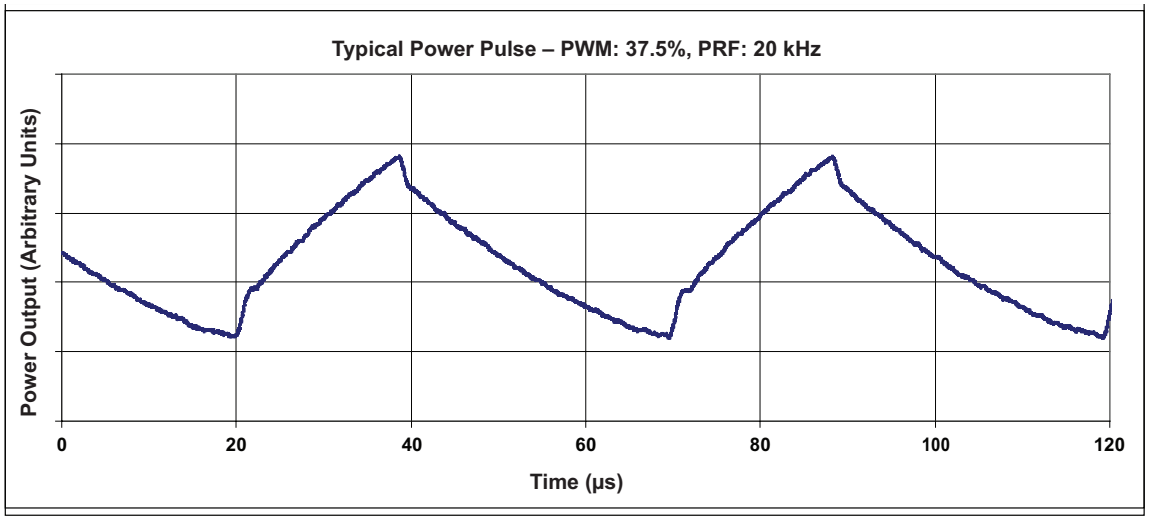

Figure 3-5 Pulstar p100 pulse profile – 37.5% duty cycle at 20 kHz

Optical setup

After selecting a laser for a CO_2 laser processing system, the two most important elements to consider are: (1) beam delivery optics to transmit the beam to the work area; and (2) focusing optics to focus the beam onto the part or material to be processed. Each element is crucial in the development of a reliable laser-based material processing system and each element should be approached with the same careful attention to detail.

Beam delivery optics

Divergence, or expansion, of the laser beam is important in materials processing since a larger beam entering the focusing optic produces a smaller focused spot. Expander/collimators are optical devices that reduce beam divergence while at the same time increasing beam diameter by a selectable magnification factor. Adding an expander/collimator substantially reduces beam divergence and any variance in beam diameter caused by the changing optical path length in an XY ("flying optics") table application. In fixed-length delivery systems where the laser is positioned only one meter away from the focusing optic and a small spot size is required, an expander/collimator is again the best solution to provide the required beam expansion before reaching the focusing optic.

Note: Optical components in the beam path must always be aligned to the actual beam path, not the laser faceplate. Because of slight variations in laser construction, the beam path may not always be centered in, or perpendicular to, the aperture in the faceplate.

Focusing optics

When selecting a focusing optic, the primary consideration should be material thickness and any vertical tolerances that occur during final part positioning rather than making a selection based only on minimum spot size. The chosen focal length should create the smallest possible focused spot while providing the depth of field required for the material to be processed.

technical reference

Technical overview

Caution
possible equipment damage

Any contaminants on the laser's output window (or on any optic in the beam path) can absorb enough energy to damage the optic. Inspect all beam delivery optics periodically for signs of contaminants and carefully clean as required. In dirty environments, purge laser optics using filtered air or nitrogen to prevent vapor and debris from accumulating on optical surfaces.

Optics are fragile and must be handled carefully, preferably by the mounting ring only. Be careful to select optics that are thick enough to withstand the maximum assist gas pressure available for the process. This is especially important in metal cutting applications using high-pressure assist gases.

Cleanliness is another important issue affecting performance; a dirty or scratched lens will under perform and exhibit a vastly shortened lifetime. When the laser application requires air as an assist gas, use only breathing quality air available in cylinders from a welding supply company. Compressed shop air contains minute particles of oil and other contaminants that will damage optical surfaces. If compressed shop air is the only choice available, it must be filtered to the specifications shown in Table 3-1.

Table 3-1 Assist gas purity specifications

Assist Gas	Typical Purpose	Specification	
Air	Cutting/Drilling	Breathing Grade	≥ 99.9996% purity; filtered to ISO Class 1 particulate level
Air	Cutting/Drilling	Compressed	Instrument-grade air filtered and dried to ISO 8573-1:2010 Class 1, 2, 1 (≤ 10 1.0–5.0 µm particles/m^3; ≤ –40 °F dew point; ≤ 0.01 mg/m^3 oil vapor).
Argon	Welding	High Purity Grade	≥ 99.998% purity; filtered to ISO Class 1 particulate level
Helium	Welding	High Purity Grade	≥ 99.997% purity; filtered to ISO Class 1 particulate level
Nitrogen	Cutting/Drilling	High Purity Grade	≥ 99.9500% purity; filtered to ISO Class 1 particulate level
Oxygen	Cutting/Drilling	Ultra Pure Grade	≥ 99.9998% purity; filtered to ISO Class 1 particulate level

technical reference

Controlling laser power

The *Controlling laser power* section includes subsections:

- Tickle pulse
- Pulse Width Modulation (PWM)
- Command signal

Important Note: Except for bench testing, we ***do not*** recommend using a UC-2000 Controller with the Pulstar OEM p100 laser. The automatically-generated tickle signal from the UC-2000 may interfere with the laser's pulsing performance.

To control the p100's output power and pulsing characteristics, thoroughly review this section, *Controlling laser power*, for an understanding of the signal parameters necessary to control Pulstar pulsed lasers.

Tickle pulse

Note: Because all Pulstar OEM p100 lasers incorporate a built-in tickle generator, there is no need to supply external tickle pulses. The application of external tickle pulses may affect the p100's pulsing performance.

Tickle pulses pre-ionize the laser gas to just below the lasing threshold so that a further increase in pulse width adds enough energy to the plasma to cause laser emission. Tickle pulses cause the laser to respond predictably and almost instantaneously to PWM Command signals, even when there is considerable delay (laser off time) between applied Command signals.

Internal circuitry monitors the incoming PWM signal and determines the amount of time the laser was on (lasing) during the last 200 microsecond (µs) interval. If the laser's on time was greater than the preset tickle value, then no tickle pulse is generated because the PWM signal was sufficient to maintain a plasma state. If no PWM signal was applied during the 200-µs measurement period (or was *shorter* than the preset tickle value), internal circuitry generates a tickle pulse such that the laser always receives a pre-set amount of RF drive averaged over any 200-µs interval.

Pulse Width Modulation (PWM)

Pulse Width Modulation, or PWM, controls laser power by varying the duty cycle of Pulstar's RF amplifiers, which in turn control the time-averaged RF power applied to the laser. Typically, Pulstar p100 laser output follows the PWM input with a rise and fall time constant of ~ 40 µs; however, the laser cannot precisely follow PWM input signals of the "On" pulse is less than 40 µs in duration. The laser's percentage of optical output increases as duty cycle increases (at a constant PWM frequency) or as PWM frequency decreases (at a constant duty cycle).

Pulstar p100 lasers are designed to operate at Command signal frequencies ranging from a single-shot up to 100 kHz; however, the choice of PWM frequency depends on the user's specific application.

technical reference

Controlling laser power

Command signal

⚠ Warning
serious personal injury

Always use shielded cable when connecting your PWM Command signal source to PWM Input/PWM Return inputs. In electrically-noisy environments, long lengths of unshielded wire act like an antenna and may generate enough voltage to trigger uncommanded lasing.

The modulated Command signal applied between Pin 9, PWM Input, and Pin 1, PWM Return, on the *User I/O* connector has three parameters: signal amplitude, pulse frequency, and PWM duty cycle. By changing these parameters, you can command the beam to perform a variety of cutting, drilling, perforating, or marking operations.

The first Command signal parameter, signal amplitude, is either logic low—corresponding to laser beam off, or logic high—corresponding to beam on. The laser off voltage, typically 0 V, can range from 0.0 V to +0.8 VDC while the laser on voltage, typically 5 V, can range from +3.5 V to +6.7 VDC.

Pulse frequency, the second parameter, is the repetition rate of the PWM input signal. The p100's pulse frequency can range from a single-shot up to a maximum frequency of 100 kHz.

The third Command signal parameter, PWM duty cycle, is the percentage of the period that the Command signal is high. For example, if the Command signal's amplitude (at 5 kHz) is high for 100 µs and low for 100 µs, it has a 50% duty cycle; if the amplitude is high for 190 µs and low for 10 µs, it has a 95% duty cycle. Figure 3-6 illustrates typical PWM Command signal parameters.

Important Note: Because the Pulstar p100 is a pulsed laser, it will not operate when a constant 5V (100% duty cycle) PWM signal is applied. If this occurs, lasing will halt and status LEDs/outputs will indicate a fault condition (see *Troubleshooting* in the Maintenance/Troubleshooting chapter for further information). The laser will recover immediately when the PWM duty cycle drops below 100%.

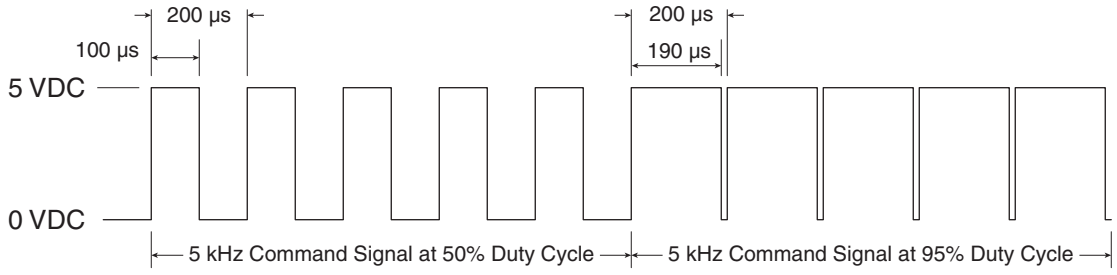

Figure 3-6 PWM Command signal waveform

The Pulstar OEM p100 is limited to a maximum pulse width of 600 µs for any single pulse while the laser's maximum duty cycle percentage is limited at higher frequencies to maintain DC current within published specifications. If the duty cycle limit is reached, internal control circuitry limits the duty cycle applied to the RF driver and continues lasing. The laser will recover immediately and begin following the actual commanded duty cycle percentage when it is lowered below the limits shown in Table 3-2.

Table 3-2 Pulse frequency/duty cycle range

Input Frequency	Duty Cycle Range
< 50 kHz	0% – 37.5%
50 – 75 kHz	0% – 31.5%
> 75 kHz	0% –25.0%

Pulstar's *User I/O* PWM input consists of a high-speed optoisolator LED with a forward voltage drop (Vf) of 1.5 VDC. The PWM input frequency can range from a single-shot up to 100 kHz. Table 3-3 provides minimum, maximum, and nominal PWM signal specifications.

Table 3-3 PWM Command signal specifications

Laser State	Minimum	Nominal	Maximum
Laser Off	0.0 VDC	0.0 VDC	+0.8 VDC
Laser On	+3.5 VDC (3 mA)	+5.0 VDC	+6.7 VDC (10 mA), continuous
Frequency Range	Single-shot	— —	100 kHz
Duty Cycle	0%	— —	37.5%[1]

1 Varies by pulse frequency. Refer to Table 3-2 for details.

User I/O connections

The *User I/O connections* section includes subsections:

- User I/O connection summary
- Input/output signals
- Sample I/O circuits

The PWM Command signal and all input/output (I/O) control signals are connected to the Pulstar p100's *User I/O* port, a 15 pin female D-type subminiature connector, on the rear panel. Figure 3-7 illustrates the pin arrangement of the *User I/O* connector.

Caution possible equipment damage

Turn off DC power before installing or removing any plug or cable from the *User I/O* connector. Ensure that user connections are made to the appropriate pins and that the appropriate signal levels are applied. Failure to do so may damage the laser.

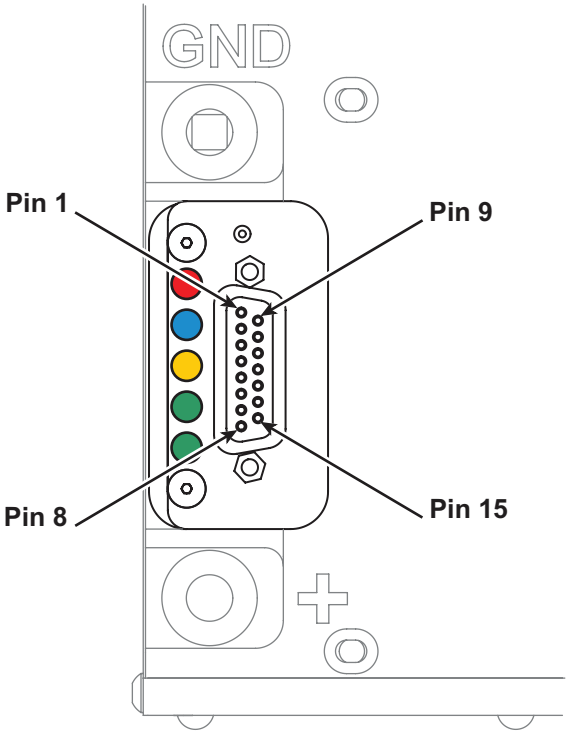

Figure 3-7 User I/O connector pinouts

User I/O connection summary

Table 3-4 below provides a quick reference summary to Pulstar p100 *User I/O* connections.

Table 3-4 User I/O pin descriptions

Pin	Function	Description
1	PWM Return	Use this input pin as the return side of the PWM Command signal.
2	Remote Reset/Start Request input	Apply a positive or negative voltage (±5–24 VDC) with respect to Pin 11, Input Common, to reset or remote keyswitch the laser. The laser remains disabled while voltage is applied. Removing voltage from the Remote Reset/Start Request input causes the laser's *RDY* indicator to illuminate, indicating that lasing is enabled.
3	Remote Interlock input	Apply a positive or negative voltage (±5–24 VDC) with respect to Pin 11, Input Common, to enable lasing. If your system does not use a remote interlock, this pin must be connected to a voltage source in the range of ±5–24 VDC. Refer to Figure 3-9 for a diagram showing how the Remote Interlock input is factory-jumpered on the *Quick Start Plug*.
4	+ 5 VDC Auxiliary Power	This connection provides +5 VDC for driving external inputs or outputs. The +5 VDC Auxiliary Power output can source up to 0.5 A and is protected by a 0.5 A self-resetting fuse. The return (ground) path must be through Pin 12, Auxiliary DC Power Ground.
5	+ 24 VDC Auxiliary Power	This connection provides +24 VDC for driving external inputs or outputs. The +24 VDC Auxiliary Power output can source up to 0.5 A and is protected by a 0.5 A self-resetting fuse. The return (ground) path must be through Pin 12, Auxiliary DC Power Ground.
6	Laser Active output	This bi-directional switched output is internally connected to Pin 13, Output Common, when the laser is actively lasing (*LASE* indicator illuminated red). This output is open, in a high-impedance state, when no beam is being emitted (*LASE* indicator Off). **Important Note:** Because of the output circuit response time, the Laser Active output's turn-on/turn-off time may lag the PWM input pulse by up to 205 µs.
7	Fault Detected output	This bi-directional switched output is internally connected to Pin 13, Output Common, when an over temperature fault (*TMP* LED is red) or other improper operating condition (*SHT* indicator is flashing) exists. The output is open, in a high-impedance state, when laser operation is within limits (*TMP* LED green and *SHT* LED blue).

technical reference

User I/O connections

Pin	Function	Description
8	Laser Ready output	This bi-directional switched output is internally connected to Pin 13, Output Common, when the laser is enabled (*RDY* LED illuminated yellow), indicating that lasing will occur when a PWM Command signal is applied to Pin 9 and Pin 1 if other operating conditions are met. This output is open, in a high-impedance state, when the laser is disabled (*RDY* indicator Off).
9	PWM Input	Connect your modulated PWM Command signal to this input pin to control laser output power. Refer back to *Controlling laser power* for further information on laser control signals.
10	Shutter Open Request input	Apply a positive or negative voltage (±5–24 VDC) with respect to Pin 11, Input Common, to enable lasing. If your system does not supply a Shutter Open Request signal, this pin must be connected to a voltage source in the range of ±5–24 VDC. Refer to Figure 3-9 for a diagram showing how the Shutter Open Request input is factory-jumpered on the *Quick Start Plug*.
11	Input Common	Use this input pin to connect return lines for Remote Interlock, Shutter Open Request, and Remote Reset/Start Request lines.
12	Auxiliary DC Power Ground	This connection provides a ground (earth) connection for +5 and +24 VDC auxiliary power outputs. This pin is the only *User I/O* pin that is connected to chassis ground. Do not use this pin for grounding if DC power to external I/O circuits is supplied from an external customer-supplied DC power source.
13	Output Common	Use this pin to complete the return path for output connections (Pin 6, 7, 8, 14, or 15). The Output Common line is protected by a 0.3 A self-resetting fuse.
14	Shutter Open output	This bi-directional switched output is internally connected to Pin 13, Output Common, when a Shutter Open Request signal is present (*SHT* indicator illuminated blue), indicating that lasing may be enabled if other operating conditions are met. This output is open, in a high-impedance state, when the laser is disabled (*SHT* indicator Off).
15	Interlock Open output	This bi-directional switched output is internally connected to Pin 13, Output Common, when remote interlock circuitry is open (*INT* indicator illuminated red), indicating that lasing is disabled. The output is open, in a high-impedance state, when lasing is enabled (*INT* indicator green).

Input/output signals

The Pulstar p100's input/output signals are divided into three categories: auxiliary DC power, input signals, and output signals. Signals in each category are fully described in the following sections.

Auxiliary DC power

Pulstar's *User I/O* connector provides auxiliary DC power for driving external inputs or outputs connected to the *User I/O* port. Pin 4, +5 VDC Auxiliary Power, and Pin 5, +24 VDC Auxiliary Power, are protected by self-resetting fuses rated at 0.5 A. Pin 12, Auxiliary DC Power Ground, is connected to chassis ground while all other *User I/O* pins are floating with respect to chassis ground. Figure 3-8 illustrates Pulstar's internal DC supply wiring.

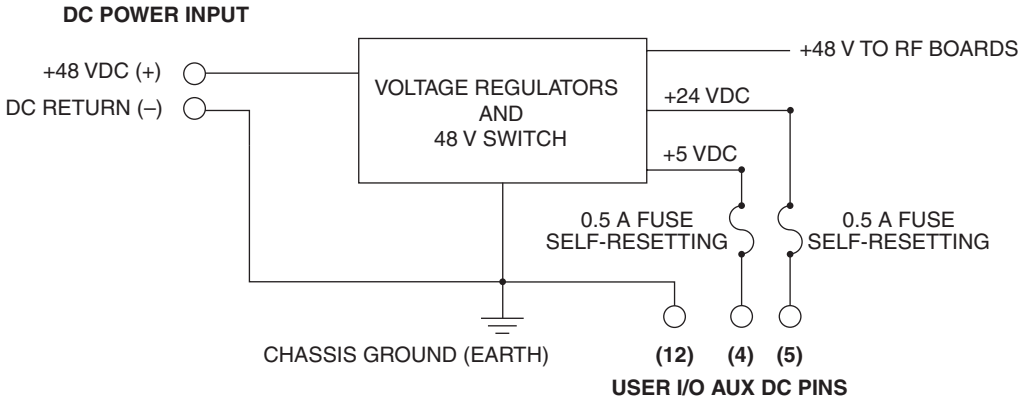

Figure 3-8 Auxiliary DC power diagram

Pin 4 + 5 VDC Auxiliary Power

This connection provides +5 VDC for driving external inputs or outputs. The +5 VDC Auxiliary Power output can source up to 0.5 A and is protected by a 0.5 A self-resetting fuse. The return (ground) path must be through Pin 12, Auxiliary DC Power Ground.

Pin 5 + 24 VDC Auxiliary Power

This connection provides +24 VDC for driving external inputs or outputs. The +24 VDC Auxiliary Power output can source up to 0.5 A and is protected by a 0.5 A self-resetting fuse. The return (ground) path must be through Pin 12, Auxiliary DC Power Ground.

Pin 12 Auxiliary DC Power Ground

This connection provides a ground (earth) connection for +5 and +24 VDC auxiliary power outputs. This pin is the only *User I/O* pin that is connected to the laser's chassis ground. Do not use this pin for grounding if I/O circuits are powered from an external customer-supplied DC power source.

technical reference

User I/O connections

Input signals

A total of four user inputs allow control of Pulstar lasers. Remote Interlock, Shutter Open Request, and Remote Reset/Start Request inputs are optoisolated and bi-directional, allowing for positive or negative polarity signal inputs. These three signals also share a common return connection, Input Common, which is separate from chassis ground to completely isolate control signals for optimal EMI performance. The fourth input, PWM Input, is optoisolated and has a separate return, PWM Return, to fully isolate PWM signals from the other three user inputs. Note that throughout this manual, input voltage levels are specified with respect to their corresponding return line.

Pin 1 PWM Return

Connect the return side of your PWM Command signal to this pin. Refer to Table 3-5 for input circuit specifications.

Pin 2 Remote Reset/Start Request input

Apply a positive or negative voltage (±5–24 VDC) with respect to Pin 11, Input Common, to disable the laser. The laser remains disabled while voltage is applied to this pin. Removing voltage from the Remote Reset/Start Request pin causes the laser's *RDY* lamp to illuminate, indicating that lasing is enabled. Because all DC power is removed from the RF driver when this input is active, no lasing can occur until voltage is removed from Pin 2. Refer to Table 3-5 for input circuit specifications.

Pin 3 Remote Interlock input

Apply a positive or negative voltage (±5–24 VDC) with respect to Pin 11, Input Common, to enable lasing. If your system does not use a remote interlock, this pin must be connected to a voltage source in the range of ±5–24 VDC. Refer to Figure 3-9 for a diagram showing how the Remote Interlock input is factory-jumpered on the *Quick Start Plug*. Because all DC power is removed from the RF driver when this input is inactive, no lasing can occur until voltage is applied to Pin 3. Refer to Table 3-5 for input circuit specifications.

Remote Interlock faults (*INT* LED illuminates red) are not latched on OEM p100 lasers. Reapplying a voltage to Pin 3 enables the *RDY* indicator and lasing is possible, provided the Shutter Open Request signal is also present (*SHT* indicator illuminated).

Pin 9 PWM Input

Connect your PWM Command signal to Pin 9. This pulse width modulated Command signal controls laser output in relation to modulation frequency and duty cycle. Refer to *Controlling laser power* in this chapter for further information on laser control signals. Connect the PWM signal source return to Pin 1, PWM Return. See Table 3-5 for input circuit specifications.

Pin 10 Shutter Open Request input

Apply a positive or negative voltage (±5–24 VDC) with respect to Pin 11, Input Common, to enable lasing. If your system does not supply a Shutter Open Request signal, then this pin must be connected to a voltage source in the range of ±5–24 VDC. Refer to Figure 3-9 for a diagram showing how the Shutter Open Request input is factory-jumpered on the *Quick Start Plug*. Because all DC power is removed from the RF driver when this input is inactive, no lasing can occur until voltage is applied to Pin 10. See Table 3-5 for input circuit specifications.

User I/O connections

Pin 11 Input Common

Use this pin to connect return lines for Remote Interlock, Shutter Open Request, and Remote Reset/Start Request lines. Refer to Table 3-5 for input circuit specifications.

Figure 3-9 illustrates how Remote Interlock and Shutter Open Request inputs are factory-jumpered on the *Quick Start Plug* to enable lasing for initial testing and troubleshooting purposes.

⚠ Warning
serious personal injury

The use of the *Quick Start Plug* bypasses the laser's safety interlock function, potentially exposing personnel in the area to ***invisible*** infrared laser radiation.

The *Quick Start Plug* is intended only for initial testing and trouble-shooting by qualified personnel. In normal operation, the laser's Remote Interlock input should be connected to the machine's safety interlock circuitry.

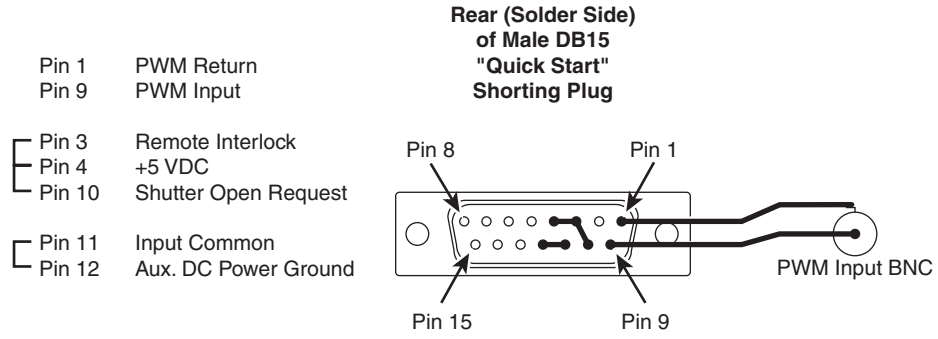

Figure 3-9 Quick Start Plug wiring diagram

User I/O connections

Figure 3-10 illustrates the input circuit's equivalent internal schematic while Table 3-5 provides Pulstar p100 input circuit specifications.

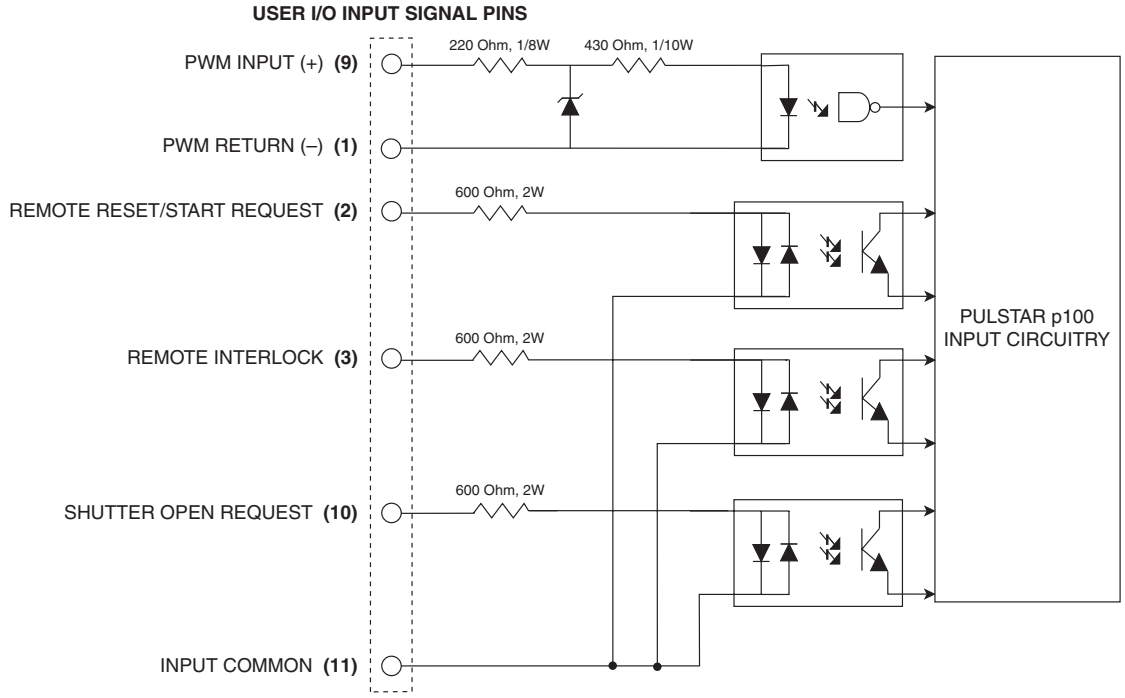

Figure 3-10 Input equivalent schematic

Table 3-5 Input circuit specifications

Input Signal Name	Input Device Type and Specifications
PWM Input	High-speed optoisolator LED, forward voltage drop (Vf) 1.5 VDC Off state Vmax +0.8 VDC On state Vmin +3.5 VDC @ 3 mA On state (continuous) Vmax +6.7 VDC @ 10 mA Frequency, max. 100 kHz
Remote Reset/Start Request Remote Interlock Shutter Open Request	Bi-directional optoisolator LED, forward voltage drop (Vf) 1.15 VDC Off state Vmax < 1.0 VDC On state Vmin ±5.0 VDC @ 7 mA On state (continuous) Vmax ±24.0 VDC @ 40 mA

Note: The Remote Reset/Start Request input must not be sent until Pulstar's +5 VDC power supply has stabilized (approximately 200 ms after DC power-up).

User I/O connections

Output signals

Pulstar's five user outputs correspond to the status functions described below. These outputs are optoisolated solid-state relays that allow for high-side or low-side switching. The shared connection, Output Common, is separate from the laser's chassis ground to allow high-side or low-side switching and to isolate control signals for optimum EMI performance.

Pulstar's optically-isolated outputs are useful for sending laser status to a Programmable Logic Controller (PLC) or computerized control system. Each of the five outputs can source 50 mA at ±24 VDC maximum for a total load of 250 mA. For controlling larger loads, use these outputs to drive a control relay.

Note: Laser Ready and Shutter Open output signals are separate control functions. The Laser Ready output (*RDY* LED On) may close while the Shutter Open output is open (*SHT* LED Off), but the RF driver is disabled until both Laser Ready and Shutter Open outputs are closed (*RDY* and *SHT* LEDs On).

Pin 6 Laser Active output

This bi-directional switched output is internally connected to Pin 13, Output Common, when the laser is actively lasing (*LASE* indicator red). This output is open, in a high-impedance state, when no beam is being emitted (*LASE* indicator Off). Refer to Table 3-6 for output circuit specifications.

Important Note: Because of the output circuit response time, the Laser Active output's turn-on/turn-off time may lag the PWM input pulse by up to 205 µs.

Pin 7 Fault Detected output

This bi-directional switched output is internally connected to Pin 13, Output Common, when an over temperature fault (*TMP* LED is red) or other improper operating condition (*SHT* indicator is flashing) exists. The output is open, in a high-impedance state, when laser operation is within limits (*TMP* LED green and *SHT* LED blue). Refer to Table 3-6 for output circuit specifications.

Pin 8 Laser Ready output

This bi-directional switched output is internally connected to Pin 13, Output Common, when the laser is enabled (*RDY* indicator yellow), indicating that lasing will occur when a PWM Command signal is applied to Pin 9 and Pin 1 if other operating conditions are met. This output is open, in a high-impedance state, when the laser is disabled (*RDY* LED Off). Refer to Table 3-6 for output circuit specifications.

Pin 13 Output Common

Use this pin to complete the return (ground) path for any output connection (Pin 6, 7, 8, 14, or 15). The Output Common line is protected by a 0.3 A self-resetting fuse.

Pin 14 Shutter Open output

This bi-directional switched output is internally connected to Pin 13, Output Common, when a Shutter Open Request signal is present (*SHT* LED blue), indicating that lasing may be enabled if other operating conditions are met. This output is open, in a high-impedance state, when the laser is disabled (*SHT* LED Off). Refer to Table 3-6 for output circuit specifications.

User I/O connections

Pin 15 Interlock Open output

This bi-directional switched output is internally connected to Pin 13, Output Common, when remote interlock circuitry is open (*INT* indicator red), indicating that lasing is disabled. This output is open, in a high-impedance state,when the laser is enabled (*INT* indicator green). See Table 3-6 for output circuit specifications.

Figure 3-11 illustrates the output circuit's equivalent internal schematic and Table 3-6 provides Pulstar p100 output circuit specifications.

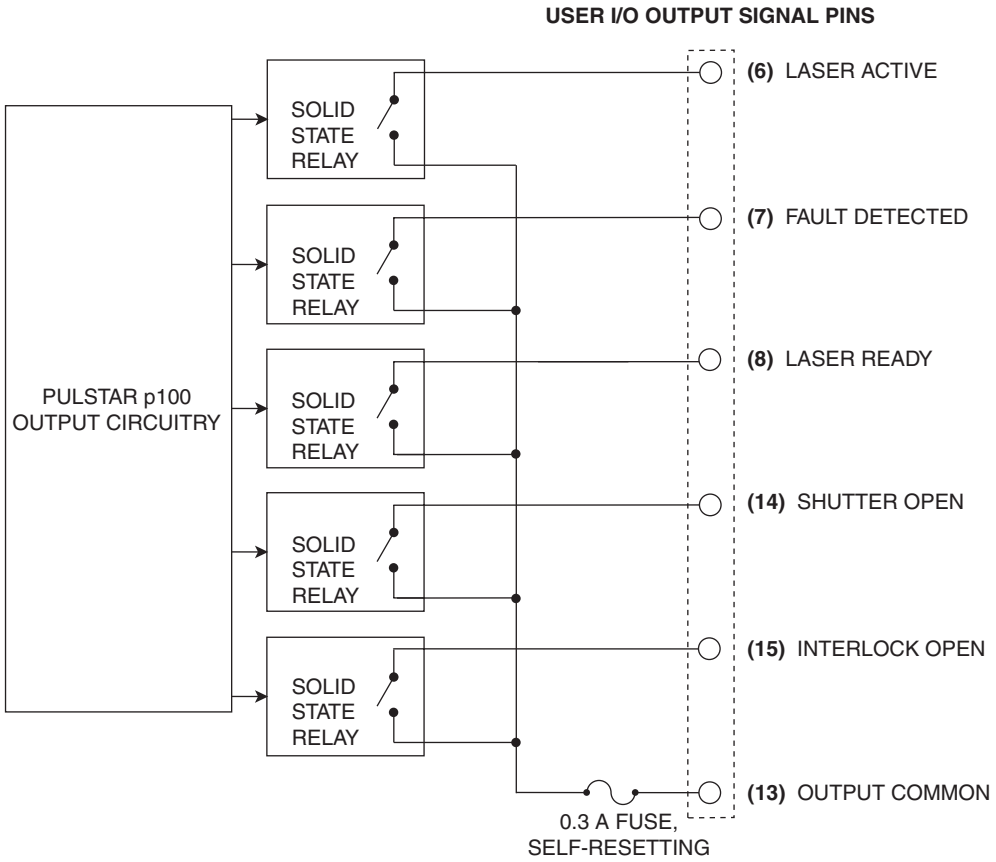

Figure 3-11 Output equivalent schematic

Table 3-6 Output circuit specifications

Output Device	Specifications
Bi-directional MOSFET	2.5 Ohms Rdson 10 MOhms Off Voltage ±24 VDC, max. Current 50 mA, max.

Sample I/O circuits

Sample inputs

Figure 3-12 illustrates one method of supplying a Remote Interlock signal using a customer-supplied limit switch. Pulstar's +24 VDC Auxiliary Power output powers the circuit. Note that Pin 4, +5 VDC Auxiliary Power, could have been used instead, depending on circuit voltage requirements.

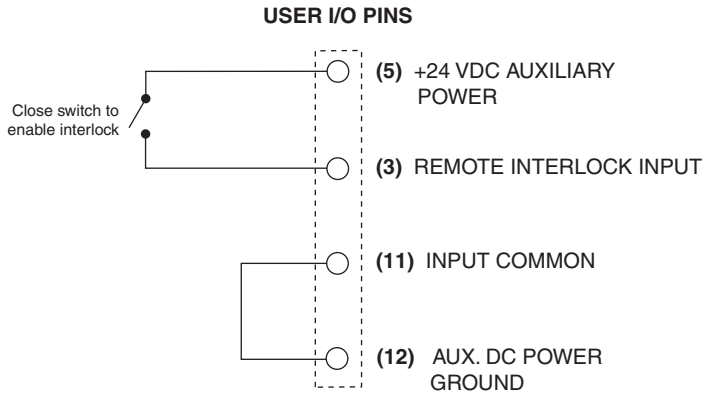

Figure 3-12 Customer-supplied interlock

Figure 3-13 shows another variation for supplying a Remote Interlock signal to the laser. In this case, the customer is using a limit switch and supplying a negative voltage to drive Pulstar's input circuit.

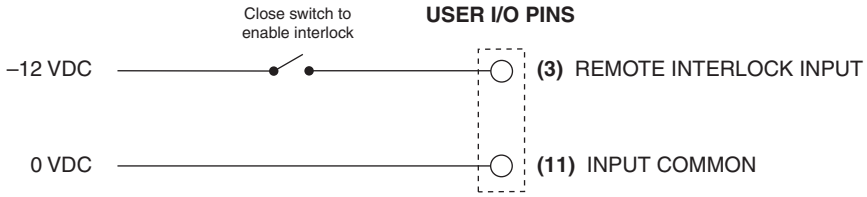

Figure 3-13 Customer-supplied interlock, negative voltage

User I/O connections

A Programmable Logic Controller (PLC) can also drive Pulstar inputs. Figure 3-14 shows a typical method for connecting to a PLC output module when only one Pulstar input is used.

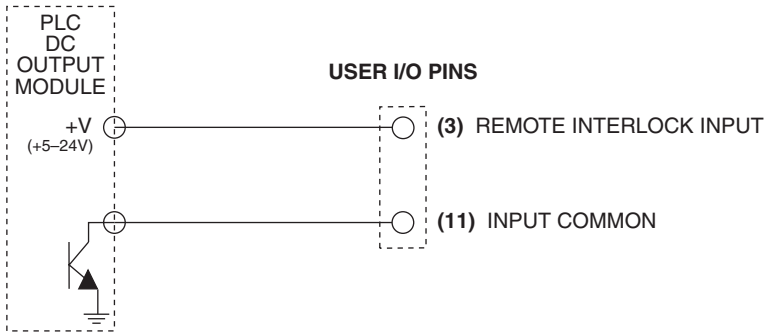

Figure 3-14 PLC driven interlock signal

When multiple PLC outputs are used, connect Pulstar inputs to the PLC as shown in Figure 3-15. By supplying voltage (+VDC) to Pin 11, Input Common, and pulling individual inputs to ground, each input can be independently activated by the PLC's output module.

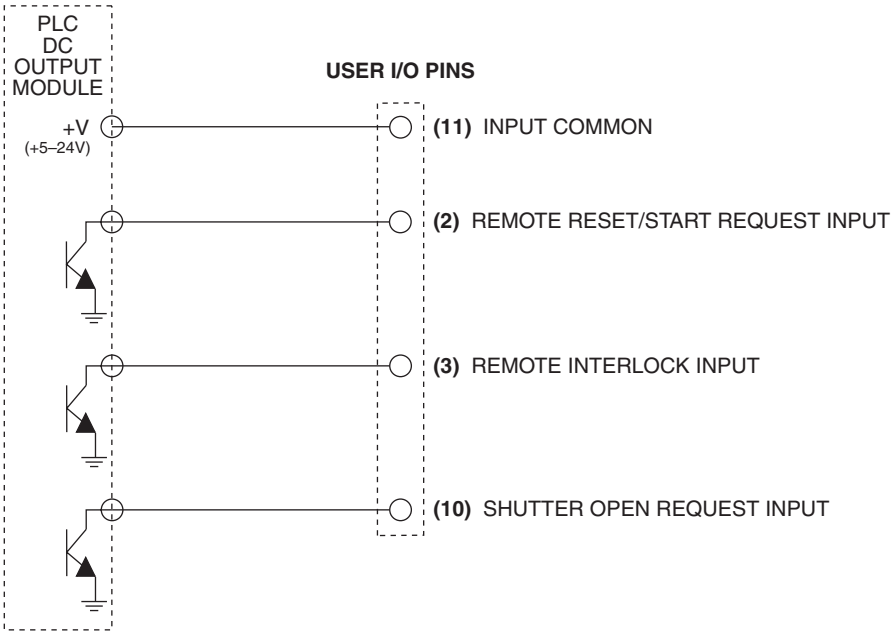

Figure 3-15 Multiple PLC driven inputs

Sample outputs

Pulstar's optoisolated, bi-directional switched outputs can drive small loads (50 mA max), PLC inputs, or relays that can control higher current loads. Figure 3-16 illustrates one method of controlling a remote warning lamp using power supplied by Pulstar's +24 VDC Auxiliary Power output. Remember to size current-limiting resistor, R1, so that the current draw does not exceed 50 mA.

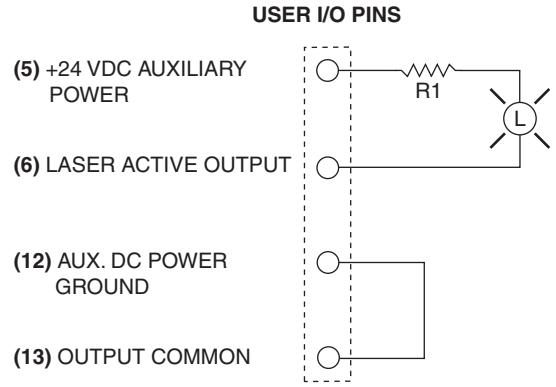

Figure 3-16 Pulstar output driving warning lamp

Figure 3-17 illustrates a method for controlling a higher voltage, higher current load by using a 24V control relay. Ensure that the relay coil's pull-in current does not exceed 50 mA. A diode or surge suppressor must be installed across the relay coil to prevent voltage spikes from damaging Pulstar outputs.

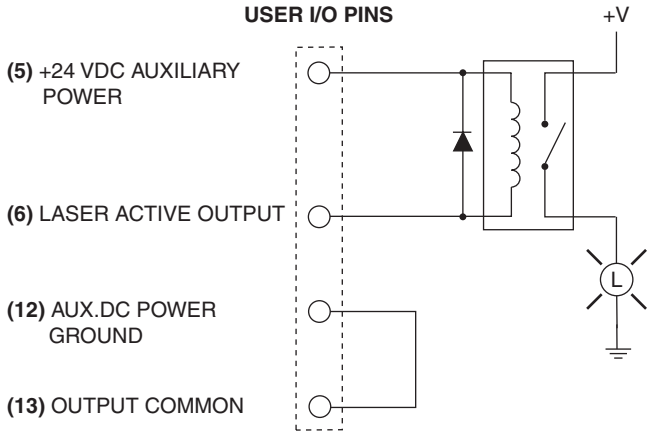

Figure 3-17 Pulstar output driving relay

User I/O connections

Figure 3-18 illustrates how Pulstar's outputs can drive the DC Input Module of a Programmable Logic Controller (PLC). By supplying voltage (+VDC) to Pin 13, Output Common, each Pulstar output is independently switched to activate individual PLC inputs.

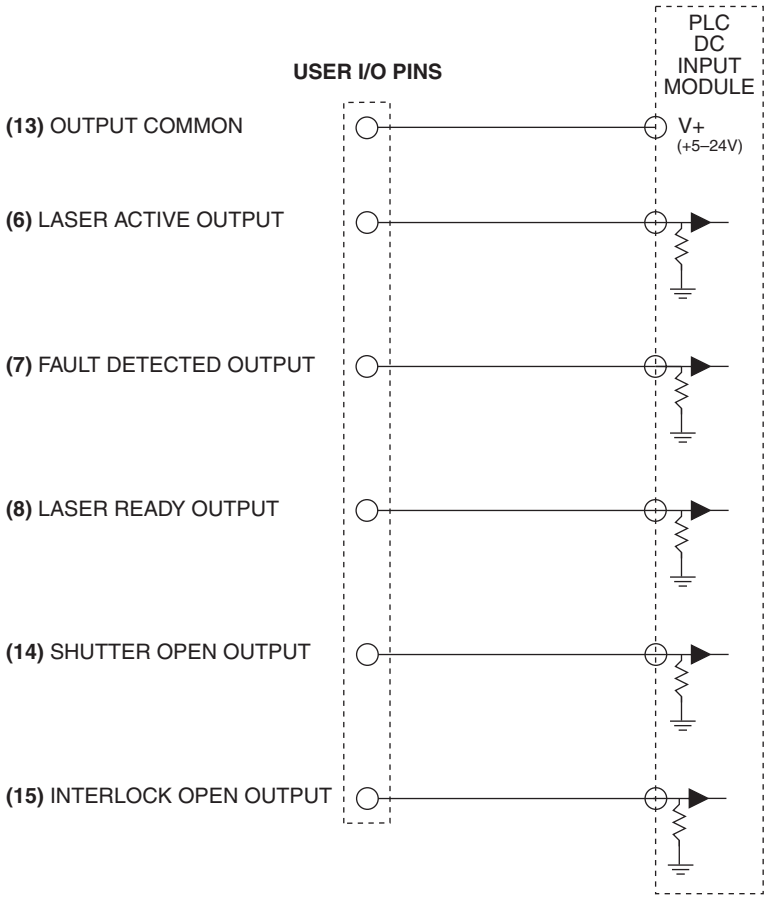

Figure 3-18 Pulstar output driving PLC input module

technical reference

Integrating Pulstar safety features

The *Integrating Pulstar safety features* section includes subsections:

- Keyswitch functions
- Shutter functions
- Remote interlock functions

The Pulstar p100's DB-15 *User I/O* connector allows system integrators or end-users to integrate Pulstar safety features into their control system. Pulstar's keyswitch, shutter, and remote interlock functions serve to enable or disable DC power to Pulstar's RF drive. Without DC power, the RF driver cannot supply RF energy to the resonator, causing the CO_2 gas to remain in a zero-energy state. Pulstar status indicators provide users with a quick visual indication of the laser's operational status. All power to the laser's RF driver is removed whenever *RDY* or *SHT* indicators are Off (Laser Ready or Shutter Open outputs open).

Keyswitch functions

OEM lasers

On OEM p100 lasers, the *RDY* LED illuminates on DC power-up (provided *INT* and *TMP* LEDs are illuminated green). DC power is applied to the RF driver if the *SHT* LED is illuminated blue. Remote interlock faults are not latched; the *RDY* LED illuminates yellow as soon as the interlock circuit is closed (when the *INT* LED turns from red to green) and lasing is enabled. Over temperature faults are reset by removing and then re-applying DC power after the laser has cooled.

Although a Remote Reset/Start Request input is not required to reset OEM faults, it can be used to inhibit (disable) lasing. Disable the laser by applying a voltage in the range of ±5–24 VDC to Pin 2, the Remote Reset/Start Request input. Removing voltage allows power to reach the RF driver and lasing is enabled (*RDY* LED illuminates yellow). The RF driver is disabled as long as voltage is applied to Pin 2.

Your control system can monitor the laser's ready status on the *User I/O* connector by connecting your system's input between Pin 8, Laser Ready, and Pin 13, Output Common (see Figure 3-18). The Laser Ready output closes when the laser is enabled (*RDY* LED illuminated yellow), indicating that lasing is possible. The output is open (in a high-impedance state) and the *RDY* LED is Off when lasing is disabled.

Shutter functions

For OEM p100 lasers in automated systems, the shutter function is provided by the Shutter Open Request signal via Pin 10 on the *User I/O* connector. To use this feature, apply a voltage in the range of ±5–24 VDC to Pin 10, Shutter Open Request. This input signal causes the *SHT* LED to illuminate and sends DC power to the RF driver, provided the *RDY* LED is illuminated yellow.

Your control system can monitor the laser's shutter status on the *User I/O* connector by connecting your system's input to Pin 14, Shutter Open, and Pin 13, Output Common (see Figure 3-18). The Shutter Open output closes when a Shutter Open Request signal is present (*SHT* LED illuminated blue). The output is open (in a high-impedance state) and the *SHT* LED is Off when the Shutter Open Request signal is removed.

Integrating Pulstar safety features

Remote interlock functions

Interlock circuits are often used to disable machinery when a shield, panel, or door is opened. Pulstar's remote interlock function allows you to connect into an external remote interlock circuit and prevent lasing by removing DC power from the laser's RF driver when the circuit is electrically "open".

Lasing is enabled when a Remote Interlock signal is present (*INT* LED illuminated green), if *RDY* and *SHT* LEDs are illuminated. Lasing is disabled when the Remote Interlock signal is removed (*INT* LED red, *RDY* LED off). DC power is applied to the RF driver only when the *INT* LED is green and the *RDY* LED is yellow (and the *SHT* LED is illuminated blue). Remote interlock functionality is provided by the Remote Interlock input signal via Pin 3 on the *User I/O* connector.

To use Pulstar's remote interlock feature, apply a voltage in the range of ±5–24 VDC to Pin 3, Remote Interlock. Applying an interlock signal causes the *INT* LED to turn green and sends DC power to the laser's RF driver, which enables lasing (provided the *RDY* LED is yellow and the *SHT* LED is blue). Removing the interlock signal causes the *INT* LED to turn red and the *RDY* LED to turn Off, removing power from the RF driver. Lasing remains disabled until a Remote Interlock signal is reapplied to Pin 3.

Your control system can monitor the laser's remote interlock status on the *User I/O* connector by connecting your system's input to Pin 15, Interlock Open, and Pin 13, Output Common (see Figure 3-18). This output is closed when remote interlock circuitry is open (*INT* LED illuminated red). The output is open (in a high-impedance state) and the *INT* LED is green when interlock circuitry is closed.

Pulstar p100 general specifications

Table 3-7 Pulstar p100 general specifications

Parameter	Pulstar OEM p100
Output Specifications	
Wavelength†	10.5–10.7 µm
Average Power Output[1, 2]	> 100 W
Peak Power[3]	> 390 W
Peak Pulse Energy[3]	> 190 mJ
Power Stability[4]	±7%
Power Stability[5]	±5%
Mode Quality	M^2 < 1.2
Beam Waist Diameter (at $1/e^2$)[6]	5.6 mm ±0.3 mm
Beam Divergence, full angle (at $1/e^2$)	< 3 mrad
Ellipticity	< 1.2
Polarization	Linear, vertical
Rise Time[3]	< 40 µs
Input Specifications	
Power Supply	
Voltage	48 ±1.0 VDC
Current, max	40 A
Command Input Signal	
Voltage	+3.5 to +6.7 VDC (5V nominal)
Current	10 mA @ +6.7 VDC
Frequency Range[7]	Single shot–100 kHz
Duty Cycle Range[7]	
< 50 kHz	0%–37.5%
50–75 kHz	0%–31.5%
> 75 kHz	0%–25%
Pulse Length, max	600 µs
Logic Low State (Vmin–Vmax)	0.0 to +0.8 VDC
Logic High State (Vmin–Vmax)	+3.5 to +6.7 VDC
Cooling Specifications	
Maximum Heat Load, laser	2000 Watts
Flow Rate[8]	1.5–2.0 GPM, < 60 PSI (5.7–7.6 lpm, <414 kPa)
Pressure Drop	18 PSI @ 1.5 GPM/32 PSI @ 2.0 GPM (124 kPa @ 5.7 lpm/221 kPa @ 7.6 lpm)
Coolant Temperature[8]	18–22 °C

technical reference

Pulstar p100 general specifications

Parameter	Pulstar OEM p100
Environmental Specifications	
Operating Temperature[9]	15 °C–40 °C
Humidity	0–95%, non-condensing
Physical Specifications	
Length	22.2 in (56.3 cm)
Width	5.2 in (13.2 cm)
Height	6.1 in (15.5 cm)
Weight	30.0 lb (13.6 kg)

* Specifications subject to change without notice. Measurements performed at 5 kHz, 37.5% duty cycle unless otherwise noted.

† Typical. Actual wavelength range may vary from 10.2–10.8 µm.

1 This power level is guaranteed for 12 months regardless of operating hours.

2 Specification applies over recommended coolant flow rate and temperature range.

3 Measured at 625 Hz.

4 From cold start (guaranteed).

5 After two minutes (typical).

6 Measured at laser output.

7 Maximum duty cycle is limited at higher frequencies to keep DC current with specifications.

8 At coolant temperatures above 22 °C, allow a 0.5 W/°C to 1W/°C power derating for coolant temperatures up to 30 °C.

9 Published specifications guaranteed at a temperature of 22 °C. Some performance degradation may occur in ambient temperatures above 22 °C. Typically, laser output power decreases 0.5–1% per degree Celsius increase in ambient temperature.

Pulstar p100 outline & mounting drawings

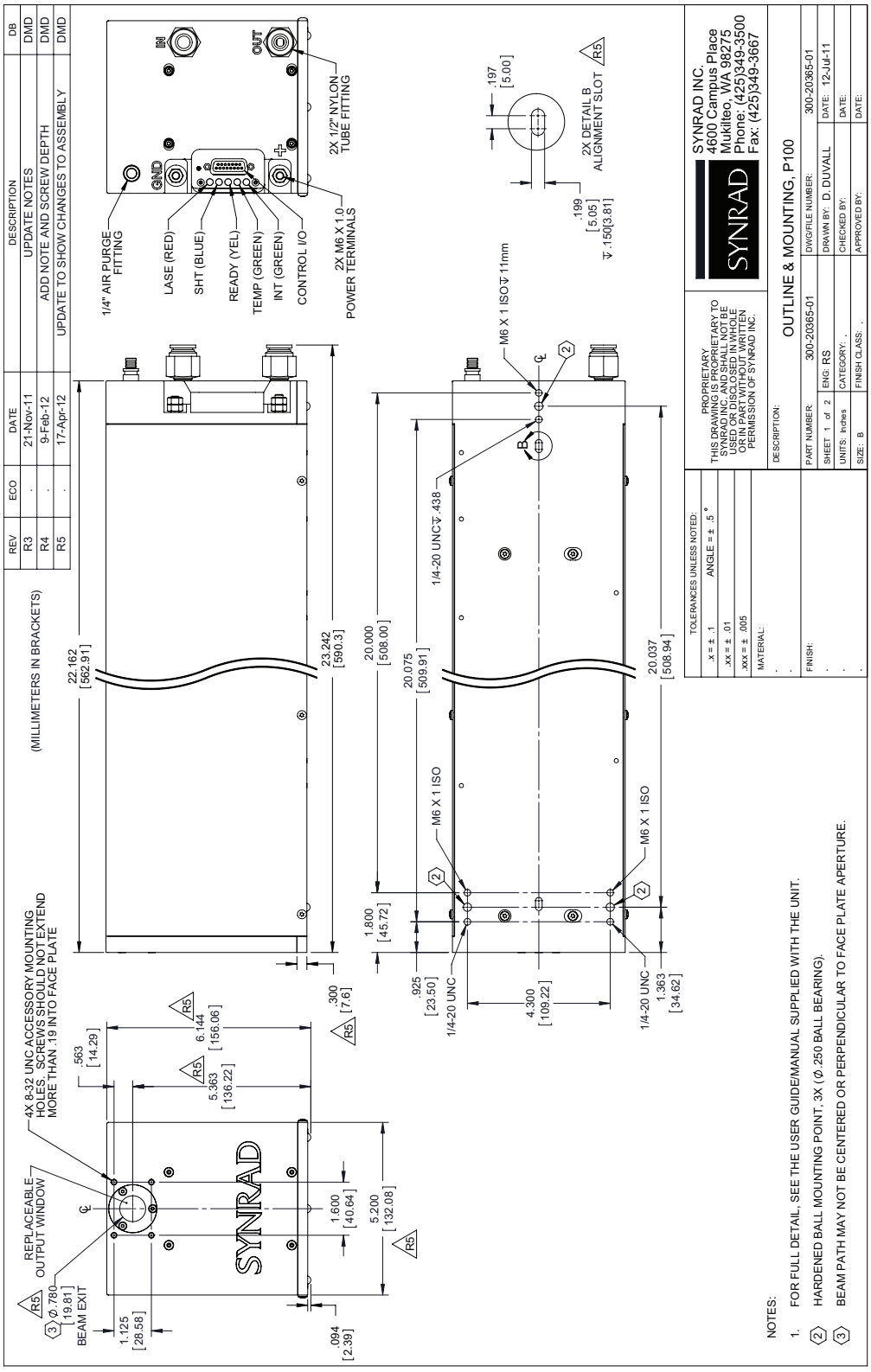

Figure 3-19 Pulstar p100 outline & mounting dimensions, sheet 1 of 2

Pulstar p100 outline & mounting drawings

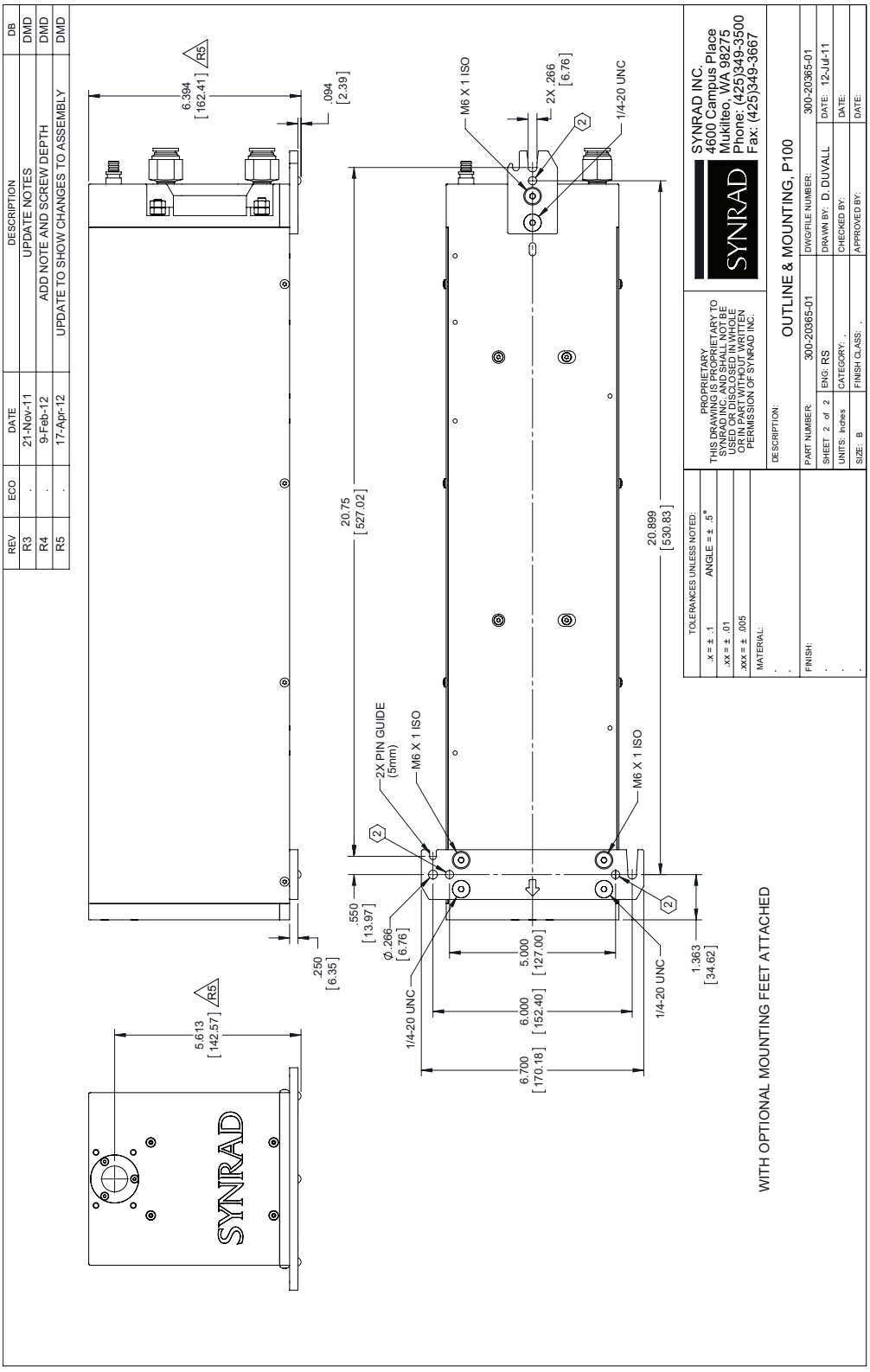

Figure 3-20 Pulstar p100 outline & mounting dimensions, sheet 2 of 2

Pulstar p100 packaging instructions

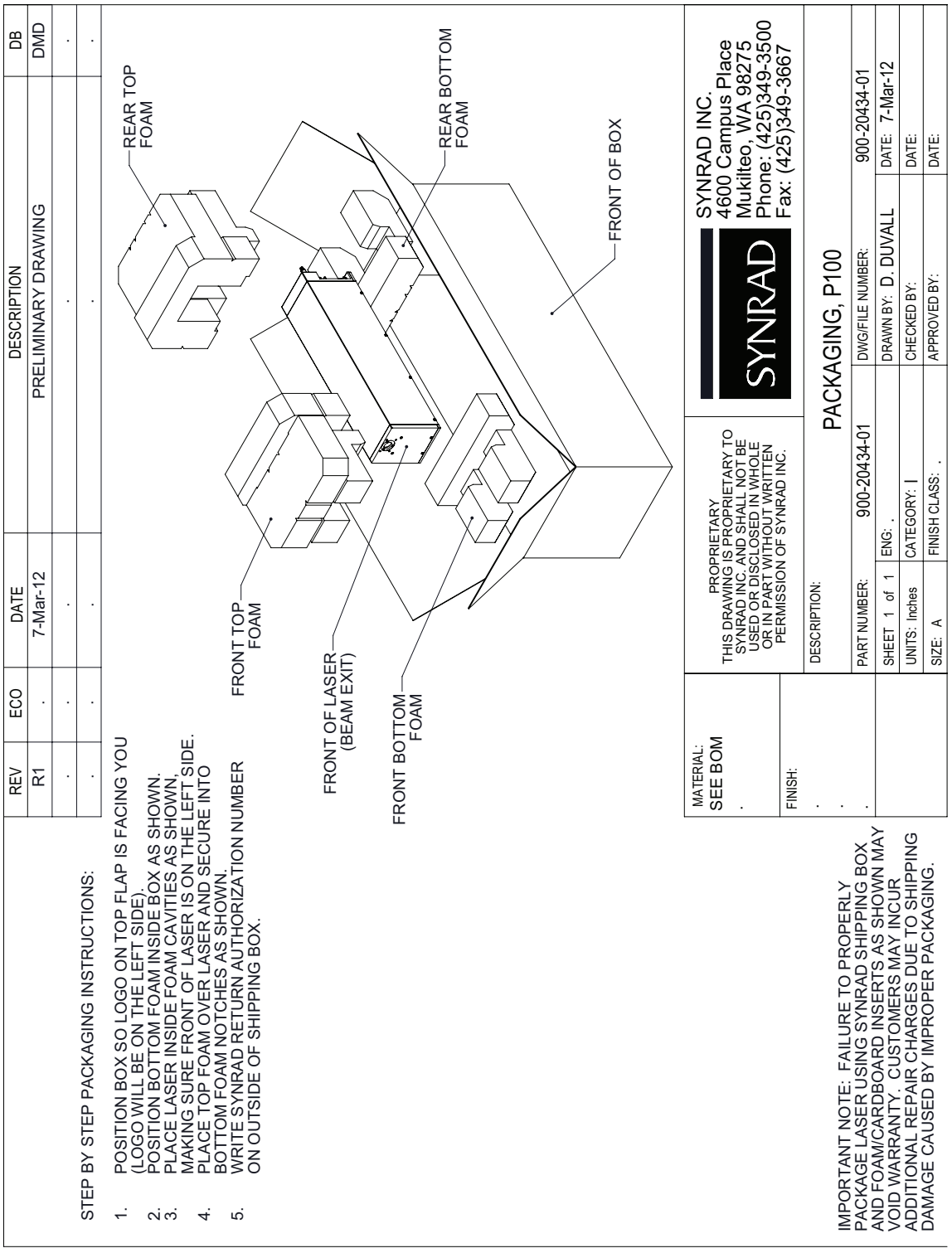

Figure 3-21 Pulstar p100 packaging instructions

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4 maintenance/ troubleshooting

Use information in this chapter to perform maintenance or troubleshoot your Pulstar OEM p100 laser.

This chapter contains the following information:

- Maintenance – describes typical Pulstar p100 maintenance procedures.
- Troubleshooting – explains how to troubleshoot common Pulstar p100 problems.

maintenance/ troubleshooting

Maintenance

The *Maintenance* section includes subsections:

- Disabling the p100 laser
- Daily inspections
- Storage/shipping
- Cleaning optical components
- Output window replacement

Disabling the p100 laser

Before performing any maintenance on your Pulstar p100 laser, be sure to completely disable the laser by disconnecting the DC power cables from the DC power supply.

Daily inspections

Perform the following steps daily to keep your Pulstar p100 laser in optimum operating condition. Except for the procedures described below, no other service is required or should be attempted.

⚠ Warning serious personal injury	A risk of exposure to toxic elements, like zinc selenide, may result when certain optical or beam delivery components are damaged. In the event of damage to laser, marking head, or beam delivery optics, contact SYNRAD, Inc. or the optics manufacturer for handling instructions.

Caution possible equipment damage	If you operate your laser or marking head in a dirty or dusty environment, contact SYNRAD about the risks of doing so and precautions you can take to increase the longevity of your laser, marking head, and associated optical components.

1. Inspect all cooling tubing connections for signs of leakage. Check for signs of condensation that may indicate the cooling water temperature has been set below the dew point temperature. Condensation will damage electrical and optical components inside the laser. See *Setting coolant temperature* in the Getting Started chapter for details on preventing condensation.
2. When using compressed air as a purge gas on your p100 laser, empty water traps and oil separators on each filter and/or dryer between the laser and your compressed air source. Compressed air purity must meet the purge gas specifications shown in Table 1-3 in the Getting Started chapter.

maintenance/ troubleshooting

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3 Inspect the laser's output window signs of dust or debris and clean as required. If the output window is damaged or scratched, see the *Replacing the output window* subsection for information on installing a replacement window.

4 Inspect beam delivery components for signs of dust or debris and clean as required. When cleaning the optical surfaces of beam delivery components, carefully follow the manufacturer's instructions.

5 Visually inspect the exterior housing of the laser to ensure that all warning labels are present. Refer to the Laser Safety chapter for p100 label types and locations.

Storage/shipping

When preparing the laser for storage or shipping, remember to drain cooling water from the laser. In cold climates, any water left in the cooling system may freeze, which could damage internal components. After draining thoroughly, use compressed shop air at no more than 200 kPa (29 PSI)—while wearing safety glasses!—to remove any residual water. When finished, cap all connectors to prevent debris from entering the cooling system.

When shipping SYNRAD lasers to another facility, we highly recommend that you ship the unit in its original SYNRAD shipping container. If you no longer have the original shipping box and inserts, contact SYNRAD Customer Service about purchasing replacement packaging. Refer to *Packaging instructions* in the Technical Reference chapter for detailed instructions on properly packaging the laser for shipment.

Important Note: Failure to properly package the laser using SYNRAD-supplied shipping boxes and foam/cardboard inserts as shown in the *Pulstar p100 packaging instructions* drawing may void the warranty. Customers may incur additional repair charges for shipping damage caused by improper packaging.

Cleaning optical components

Debris or contaminants on external beam delivery components may affect laser processing and lead to damage or failure of the optics and/or the laser. Carefully follow the steps below to inspect and clean the optical components in the beam path. Before beginning the cleaning process, read this entire section thoroughly to ensure that all cleaning materials are available and that each step is completely understood.

Caution
possible equipment damage

Even small amounts of contamination on optics in the beam path can absorb enough energy to damage the optic. Inspect beam delivery optics periodically for signs of contaminants and carefully clean as required. In dirty environments, purge laser optics using filtered air or nitrogen to prevent vapor and debris from accumulating on optical surfaces.

Important – Pulstar p100 lasers have several beam conditioning optics between the output aperture and the faceplate. To prevent dust and debris from damaging these optical surfaces, always connect nitrogen or filtered air to the laser's *Gas Purge* port.

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Maintenance

⚠ Danger
serious personal injury

Ensure that DC power to the laser is turned off and locked out before inspecting optical components in the beam path. ***Invisible*** CO_2 laser radiation is emitted through the aperture. Corneal damage or blindness may result from exposure to laser radiation.

Important Note: Exercise great care when handling infrared optics; they are much more fragile than common glass materials. Optical surfaces and coatings are easily damaged by rough handling and improper cleaning methods.

Cleaning guidelines

- Wear latex gloves or finger cots (powder-free) to prevent contamination of optical surfaces by dirt and skin oils.
- Never handle optics with tools or bare hands; always use gloved hands or fingers.
- Hold optics by the outer edge; never touch the coated surface.
- Always place optics lens tissue for protection; never place optics on hard or rough surfaces.
- It may be necessary to use a cotton ball or fluffed cotton swab instead of a lens wipe to uniformly clean the entire surface of small-diameter mounted optics.
- Before using any cleaning agents, read Material Safety Data Sheets (MSDS) and observe all necessary safety precautions.

Required cleaning materials

Table 4-1 lists the type and grade of materials required to properly clean optical surfaces.

Table 4-1 Required cleaning materials

Cleaning Material	Requirements
Latex gloves or finger cots	Powder-free
Air bulb	Clean air bulb
Ethyl or isopropyl alcohol	Spectroscopic or reagent grade
Acetone	Spectroscopic or reagent grade
Lens wipe (preferred)	Optical (cleanroom) quality
Cotton balls or cotton swabs	High-quality surgical cotton/high-quality paper-bodied

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Maintenance

Cleaning optics

1 Shut off and lock out all power to the laser. You must verify that the laser is OFF (in a zero-energy state) before continuing with the optical inspection!

2 Visually inspect all optical surfaces in the beam path for contaminants.

Caution possible lens damage	Do not allow the nozzle of the air bulb to touch the optical surface. Any contact may damage the optic by scratching coatings on the optical surface. Do not use compressed shop air to blow contamination from the optic. Compressed air contains significant amounts of water and oil that form adsorbing films on the optical surface. Do not exert pressure on the surface of the optic during cleaning. Optical surfaces and coatings are easily scratched by dislodged contaminants. Use a new lens wipe on each pass as contaminants picked up by the wipe may scratch the optical surface.

3 Remove loose contaminants from the optic by holding a clean air bulb at an angle to the optic and blow a stream of air at a glancing angle across the lens surface. Repeat as necessary.

4 Dampen a lens wipe with the selected cleaning agent. Alcohol (least aggressive) is best for initial surface cleaning. Acetone (moderately aggressive) is best for oily residue or minor baked-on vapors and debris.

Important Note: If acetone is used as a cleaning solvent, a second follow-up cleaning of the optical surface using alcohol is required.

5 Gently, and without applying pressure, drag the damp lens wipe across the optical surface in a single pass. **Do not rub or apply any pressure**, especially when using a cotton swab. Drag the wipe without applying any downward pressure.

Note: Use a clean lens wipe on each pass. The wipe will pick up and carry surface contaminants that may scratch optical surfaces or coatings.

To prevent streaking during the final alcohol cleaning, drag the lens wipe slowly across the surface so that the cleaning liquid evaporates right behind the wipe

6 Carefully examine the optic under a good light. Certain contaminants or damage such as pitting cannot be removed. In these cases the optic must be replaced to prevent catastrophic failure.

7 Repeat Steps 4 through 6 as required, removing all traces of contaminants and deposits.

maintenance/ troubleshooting

Maintenance

Output window replacement

The replaceable output window on Pulstar p100 lasers is designed to seal the internal beam path from contamination and to be easily cleaned without removing the laser housing. The output window should be inspected daily as you inspect the rest of the laser systems beam delivery optics. Refer back to the *Cleaning optical components* subsection to clean the window, as required.

If the output window becomes pitted, scratched, or contains baked on debris that cannot be removed, then it should be replaced immediately. A damaged output window will absorb, rather than transmit, laser energy, leading to overheating that may cause the optic to crack or break. If this happens, other optical surfaces in the laser or the external beam path may become contaminated or damaged.

Important Note: If the output window has broken, do not attempt to replace the optic. A broken optic may have contaminated the laser's optical path with zinc selenide dust or vapor. Contact SYNRAD Customer Service immediately so the laser can be returned for service. Continued operation may result in catastrophic damage to the laser.

In addition to the Pulstar p100 Output Window Replacement Kit (SYNRAD P/N 95-18386-01), the following items are required to replace the Pulstar OEM p100's output window:

- 2.5 mm Allen hex wrench
- Optical quality lens wipes
- Latex gloves or finger cots
- Reagent-grade ethyl or isopropyl alcohol

Remove the output window assembly

To replace the p100 output window, refer to Figure 4-1 and perform the following steps:

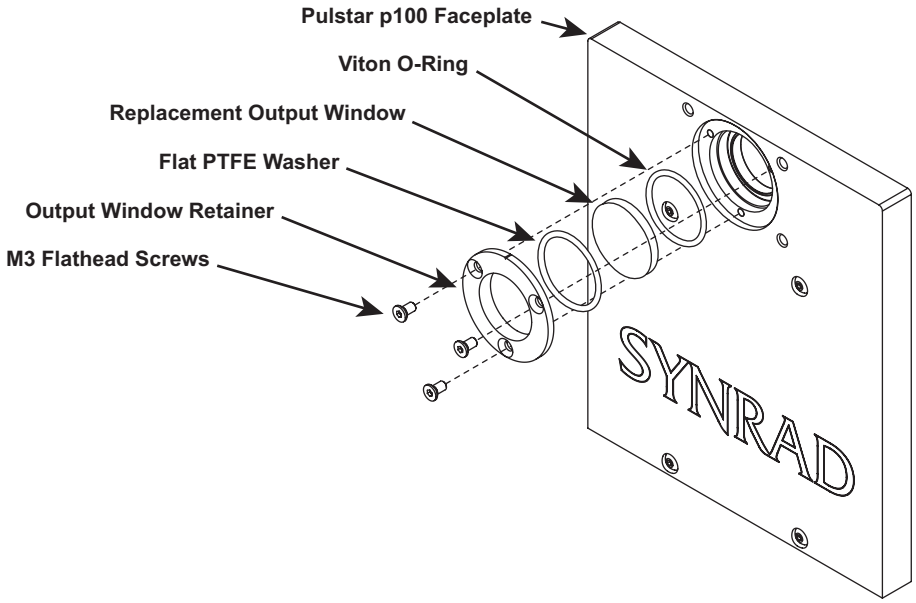

Figure 4-1 Output window replacement

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1 Disconnect the laser's DC power cables from the DC power supply.

2 Wear latex gloves or finger cots to protect optical surfaces from contamination by dirt or skin oils.

3 Remove the three M3 × 0.5 × 6 mm flathead Allen screws fastening the output window retainer to the p100 faceplate.

Note: On early Production units, the output window retainer was fastened with 4–40 × 1/4" Phillips flathead screws.

4 Set the window retainer aside for re-assembly.

5 Carefully remove the white PTFE washer from the laser faceplate.

6 Remove the output window optic.

Important Note: If the optic is damaged, place it inside a re-sealable plastic bag and discard appropriately as hazardous waste.

7 Remove the O-ring from the faceplate.

Replace the output window assembly

1 Carefully clean the counter-bored areas in the faceplate using. If the optic was damaged, place used lens wipes inside a re-sealable plastic bag and discard appropriately as hazardous waste.

2 Locate the replacement O-ring and insert it into the corresponding counterbore in the faceplate.

3 Using gloved hands or finger cots, carefully insert the replacement output window into the faceplate. Both sides of the optic must be free of any dust or skin oils.

4 Carefully insert the replacement PTFE washer and insert it into the corresponding counterbore in the faceplate.

Note: Before installing the output window retainer, be sure to orient it properly. The small notch on the outer edge of the retainer (shown in Figure 4-1) must be positioned so it is pointing towards the top of the faceplate.

5 Position the window retainer in the corresponding counterbore in the faceplate.

6 Insert the three M3 × .5 × 6 mm flathead fasteners through the retainer and into the faceplate. Turn the screws by hand until the threads engage.

7 Evenly tighten all three fasteners to a maximum torque of 1.8 N m (16 in lb).

8 The output window replacement procedure is complete.

maintenance/ troubleshooting

Troubleshooting

The *Troubleshooting* section includes subsections:

- Introduction
- Operational flowchart
- Functional block diagram
- Status LEDs
- Laser fault indications
- Resetting faults
- General laser fault conditions
- Beam delivery optics

Introduction

This section is designed to help isolate problems to the module level only. Problems on circuit boards or the laser tube are outside the scope of this guide because they are not user-serviceable assemblies; do not attempt to repair them. Contact SYNRAD or a SYNRAD Authorized Distributor for repair or replacement information.

To troubleshoot Pulstar p100 lasers, it is necessary to understand the sequence of events that must happen before the laser can operate. Before attempting any service, we advise you to read the entire troubleshooting guide and review both the operational flowchart and the functional block diagram.

⚠ **Danger** serious personal injury	This Class 4 laser product emits ***invisible*** infrared laser radiation in the 10.6 µm CO_2 wavelength band. Since direct or diffuse laser radiation can inflict severe corneal injuries, always wear eye protection when in the same area as an exposed laser beam. Do not allow the laser beam to contact a person. This product emits an invisible laser beam that is capable of seriously burning human tissue. Always be aware of the beam's path and always use a beam block while testing.

Caution possible equipment damage	Attempting repair of a SYNRAD Pulstar laser without the express authorization of SYNRAD, Inc. will void the product warranty. If troubleshooting or service assistance is required, please contact SYNRAD Customer Service.

Troubleshooting

Operational flowchart

The flowchart in Figure 4-2 illustrates the Pulstar OEM p100's start-up sequence.

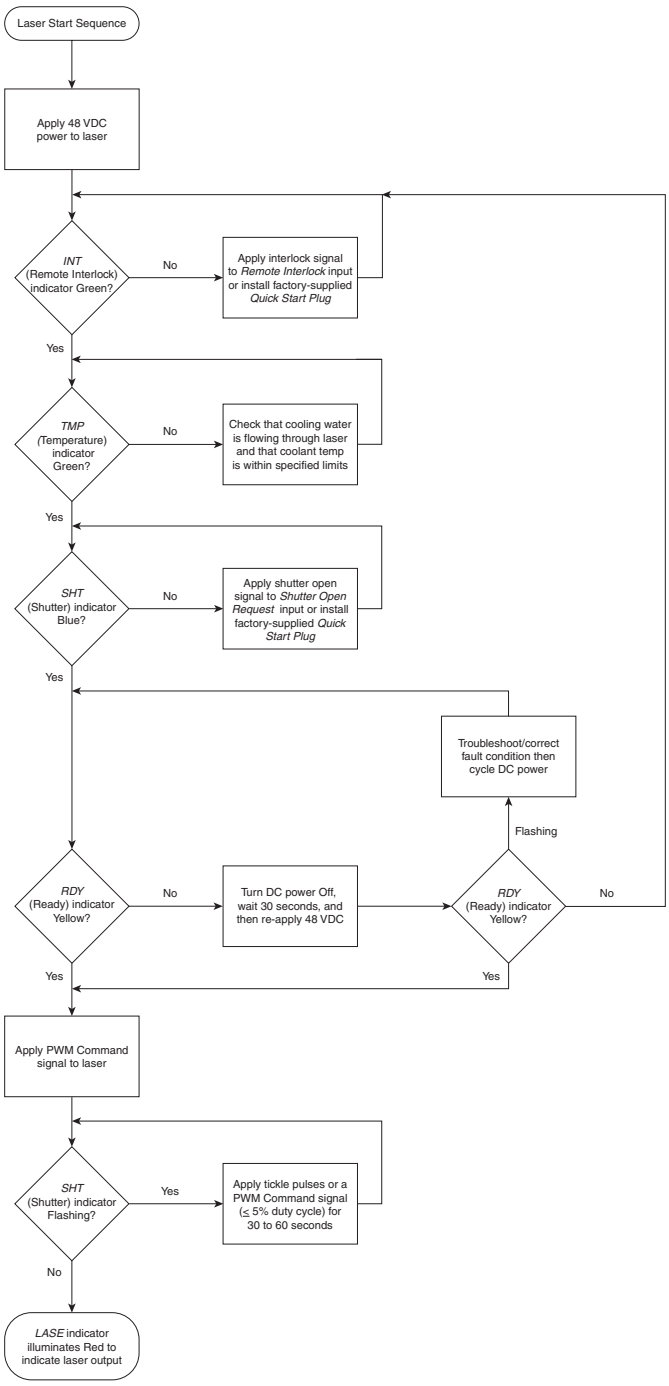

Figure 4-2 Pulstar p100 operational flowchart

maintenance/ troubleshooting

Troubleshooting

Functional block diagram

Figure 4-3 is a functional block diagram illustrating the p100's control architecture.

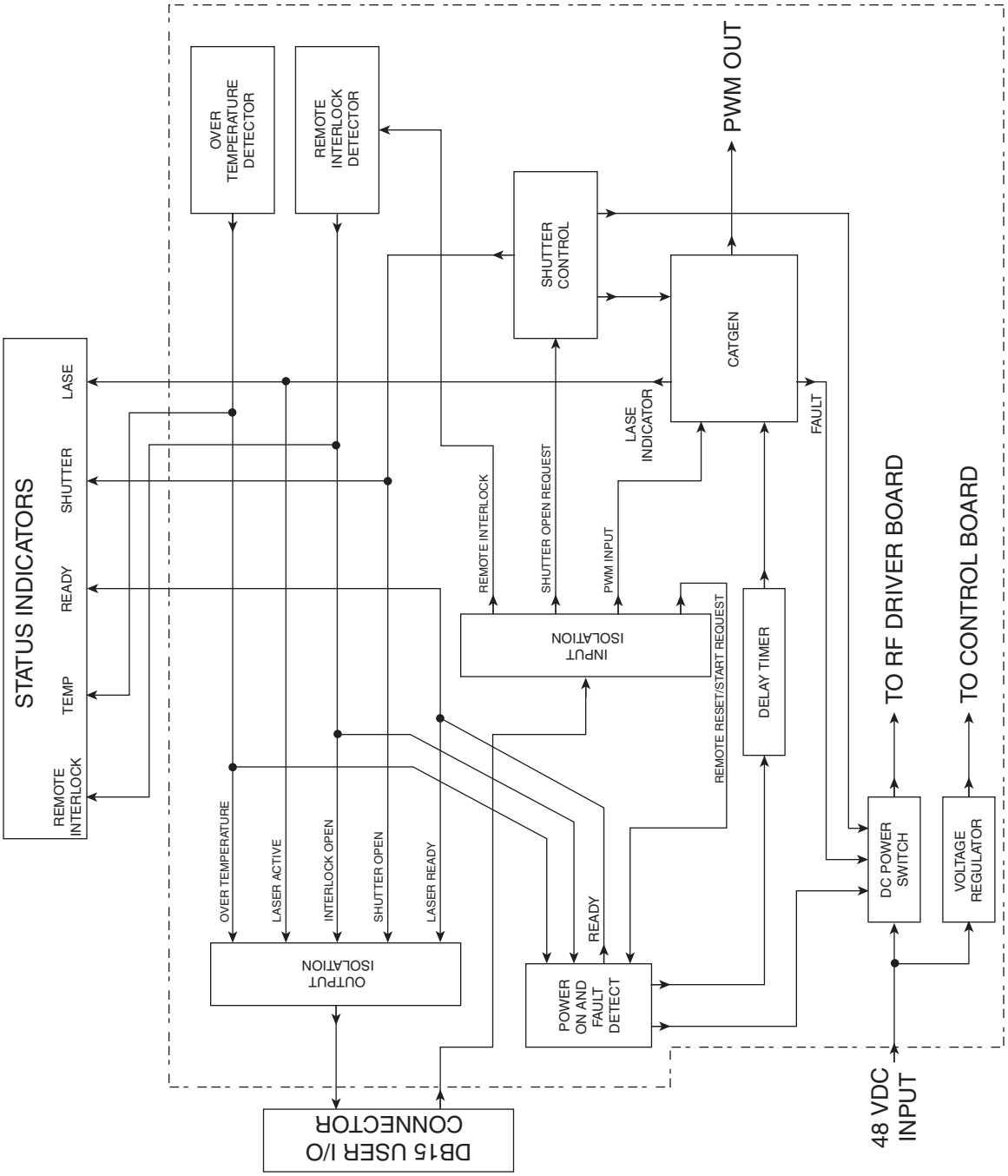

Figure 4-3 Pulstar p100 functional block diagram

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Status LEDs

Pulstar p100 LED indicators, also mirrored as output signals on the *User I/O* connector, provide status information to the user. Table 4-2 shows Pulstar output signal and LED indicator states during normal and fault conditions. *User I/O* outputs are Closed when the state indicated by the signal name is logically True.

Table 4-2 Status signals

LED	LED Status		Output Signal Name	User I/O Output Status	
	Normal	Fault		Normal	Fault
INT	Green	– –	Interlock Open	Open	– –
	– –	Red	Interlock Open	– –	Closed
TMP	Green	– –	Fault Detected	Open	– –
	– –	Red	Fault Detected	– –	Closed
RDY	Yellow	– –	Laser Ready	Closed	– –
	– –	Off/Flashing	Laser Ready	– –	Open
SHT	Blue	– –	Shutter Open	Closed	– –
	– –	Off	Shutter Open	– –	Open
	– –	Flashing	Fault Detected	– –	Closed
LASE	Red	– –	Laser Active	Closed	– –
	– –	Off	Laser Active	– –	Open

On DC power-up of an OEM p100 laser, the *RDY* lamp illuminates yellow when *INT* and *TMP* indicators illuminate green. The *SHT* LED illuminates blue when a Shutter Open Request signal is applied. When both *RDY* and *SHT* indicators are lit, the RF driver is enabled and internal tickle is applied. Once the RF driver is enabled, the application of a PWM Command signal causes the *LASE* indicator to illuminate red as lasing begins.

Note: Pulstar p100 *RDY* and *SHT* LEDs denote separate control functions. Although the *RDY* lamp may light while the *SHT* LED is Off (Shutter Open Request signal missing), no power is applied to the RF driver until both *RDY* and *SHT* indicators are illuminated.

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Troubleshooting

Tables 4-3 through 4-8 show how the Pulstar p100's LED and output signal status changes as various operating and fault conditions occur (fault conditions are shown in **bold** type).

Table 4-3 Normal operating condition

LED Indicator	LED Status	Signal Name	User I/O Signal Status
INT	Green	Interlock Open	Open
TMP	Green	Fault Detected	Open
RDY	Yellow	Laser Ready	Closed
SHT	Blue	Shutter Open	Closed
LASE (tickle active)	Off	Laser Active	Open
LASE (if PWM applied)	Red	Laser Active	Closed

Table 4-4 Quick Start Plug or interlock/shutter inputs not connected

LED Indicator	LED Status	Signal Name	User I/O Signal Status
INT	**Red**	Interlock Open	**Closed**
TMP	Green	Fault Detected	Open
RDY	**Off**	Laser Ready	**Open**
SHT	**Off**	Shutter Open	**Open**
LASE (tickle inactive)	Off	Laser Active	Open
LASE (if PWM applied)	Off	Laser Active	Open

Table 4-5 Interlock open condition

LED Indicator	LED Status	Signal Name	User I/O Signal Status
INT	**Red**	Interlock Open	**Closed**
TMP	Green	Fault Detected	Open
RDY	**Off**	Laser Ready	**Open**
SHT	Blue	Shutter Open	Closed
LASE (tickle inactive)	Off	Laser Active	Open
LASE (if PWM applied)	Off	Laser Active	Open

Troubleshooting

Table 4-6 Over Temperature fault

LED Indicator	LED Status	Signal Name	User I/O Signal Status
INT	Green	Interlock Open	Open
TMP	**Red**	Fault Detected	**Closed**
RDY	**Off**	Laser Ready	**Open**
SHT	Blue	Shutter Open	Closed
LASE (tickle inactive)	Off	Laser Active	Open
LASE (if PWM applied)	Off	Laser Active	Open

Table 4-7 Shutter closed condition

Signal Name	LED Indicator	LED Status	User I/O Signal Status
INT	Green	Interlock Open	Open
TMP	Green	Fault Detected	Open
RDY	Yellow	Laser Ready	Closed
SHT	**Off**	Shutter Open	**Open**
LASE (tickle inactive)	Off	Laser Active	Open
LASE (if PWM applied)	Off	Laser Active	Open

Table 4-8 No-Strike condition

Signal Name	LED Indicator	LED Status	User I/O Signal Status
INT	Green	Interlock Open	Open
TMP	Green	Fault Detected	**Closed**
RDY	Yellow	Laser Ready	Closed
SHT	**Blue (Flashing)**	Shutter Open	Closed
LASE (tickle active)	Off	Laser Active	Open
LASE (if PWM applied*)	Red	Laser Active	Closed

* A continuously flashing *SHT* LED indicates a No-Strike condition and the laser is limited to a 5% duty cycle (at 5 kHz) until the fault clears.

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Troubleshooting

Laser fault indications

Pulstar OEM p100 lasers have the ability to indicate various fault conditions. In the event of certain faults, the *RDY* LED will blink an error code, pause four seconds, and then repeat the error code. This sequence continues until the fault is corrected and the laser is reset by cycling DC power to the laser. If certain operating conditions are outside normal limits, the *SHT* LED will flash continuously or blink a specific sequence until proper operating conditions are restored.

Table 4-9 lists fault codes, the corresponding fault condition, and describes basic corrective action. See the following section, *Resetting faults*, for detailed corrective actions.

Table 4-9 Pulstar p100 fault codes

LED	# of Blinks	Fault Condition	Corrective Action in Field
RDY	1 blink	Under Voltage fault[1]	Verify 48.0 VDC (measured at laser under load)
RDY	2 blinks	Over Voltage fault[1]	Verify 48.0 VDC (measured at laser under load)
RDY	3 blinks	RF Drive Switch fault[1]	Remove DC power to laser, wait 30 seconds, and then reapply DC power
RDY	4 blinks	PWM Drive fault[1]	Remove DC power to laser, wait 30 seconds, and then reapply DC power
SHT	Continuous	No-Strike condition[2]	Apply tickle or PWM signal (≤5% duty cycle) for 30 to 60 seconds
SHT	2 blinks	Frequency Limit condition[3]	Lower PWM frequency below 100 kHz
SHT	3 blinks	100% D.C. condition[4]	Lower PWM duty cycle below 100%

1 The Laser Ready output opens (switches to a high impedance state) when a fault occurs.

2 A continuously flashing *SHT* LED indicates a No-Strike condition and the laser is limited to a 5% duty cycle (at 5 kHz). If the No-Strike condition clears, the laser will recover automatically without cycling power. Common causes of No-Strike condition (gas breakdown) issues are environmental conditions—like cold overnight temperatures when the laser is off. In situations like this, it may take 30 to 60 seconds for gas breakdown to occur and begin normal daily operation. The Fault Detected output closes for a minimum of 50 ms or until the No-Strike condition clears.

3 The *SHT* LED flashes a repeating sequence of 2 blinks followed by 2 pauses to indicate a frequency limit condition. The laser will recover automatically, without cycling power, when the incoming PWM Command signal frequency is lowered below 100 kHz. The Fault Detected output closes for a minimum of 50 ms or until the frequency limit condition clears.

4 The *SHT* LED flashes a repeating sequence of 3 blinks followed by 2 pauses to indicate a 100% duty cycle condition. The laser will recover automatically, without cycling power, when the incoming PWM duty cycle is lowered below 100%. The Fault Detected output closes for a minimum of 50 ms or until the 100% duty cycle condition clears.

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Resetting faults

⚠ Warning
serious personal injury

On OEM p100 lasers, remote interlock faults as well as No-Strike, Frequency Limit, and 100% Duty Cycle conditions are ***not*** latched. Clearing the fault or error condition re-enables the *RDY* LED and lasing will begin ***immediately*** provided the *SHT* LED is lit and a PWM Command signal is applied. Because exposure to 10.6 µm CO_2 laser radiation can inflict severe corneal injuries and seriously burn human tissue, the OEM or System Integrator must ensure that appropriate safeguards are in place to prevent unintended lasing.

Remote Interlock condition

A remote interlock condition occurs when there is no signal applied to the Remote Interlock input. When this occurs, the *INT* LED changes from green to red, the Interlock Open output Closes, the *RDY* LED turns Off, and the Laser Ready output Opens. Lasing is halted immediately.

On OEM p100 lasers, a remote interlock condition is not latched. Re-establish the Remote Interlock signal input (*INT* LED changes from red to green the Interlock Open output Opens, the *RDY* LED turns yellow, and the Laser Ready output Closes) and lasing will begin ***immediately*** provided the *SHT* indicator is illuminated blue and a PWM Command signal is applied.

Over Temperature fault

An over-temperature fault occurs when thermal limits in the laser are exceeded (the *TMP* LED changes from green to red, the Fault Detected output Closes, the *RDY* LED turns Off, and the Laser Ready output Opens).

To reset an over-temperature fault, lower coolant temperature below 30 °C, allow the laser to cool for a few minutes, and then cycle DC power to the laser. Once the *TMP* indicator turns green (Fault Detected output Opens), the *RDY* lamp illuminates yellow (Laser Ready output Closes) and lasing is enabled provided the *SHT* indicator is illuminated blue.

Note: Because of the over-temperature latch circuit, the *TMP* indicator remains red (and the Fault Detected output remains Closed) prior to cycling power even after the laser has cooled sufficiently to begin operation. If the *TMP* indicator remains red after cycling power, the laser is not sufficiently cooled. Continue to cool the laser for several more minutes and then cycle power.

Under Voltage fault

An under voltage fault occurs when DC input voltage falls below a preset limit of 46.5 VDC. This fault is indicated by the *RDY* LED flashing 1 blink (the Laser Ready output Opens). To reset an under voltage fault, first correct the voltage problem and ensure that 48 VDC is measured at the laser's DC power terminals under full-load conditions. Next, cycle DC power off and then on again. When the *RDY* LED illuminates, the Laser Ready output Closes, and lasing is enabled provided the *SHT* indicator is illuminated blue.

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Troubleshooting

Over Voltage fault

An over voltage fault occurs when DC input voltage rises above a preset limit of 49.5 VDC. This fault is indicated by the *RDY* LED flashing 2 blinks (the Laser Ready output Opens). To reset an over voltage fault, first correct the voltage problem and ensure that 48 VDC is measured at the laser's DC power terminals under full-load conditions. Next, cycle DC power off and then on again. When the *RDY* LED illuminates, the Laser Ready output Closes, and lasing is enabled provided the *SHT* indicator is illuminated blue.

RF Drive Switch fault

An RF Drive Switch fault occurs on power-up when the tube fails to breakdown or a fault occurs in the RF Driver's 48-volt switching circuitry. In this case, the *RDY* LED flashes 3 blinks and the Laser Ready output Opens. If an RF Drive Switch fault occurs, reset the laser by removing DC power to the laser, wait 30 seconds, and then reapply power. If the RF Drive Switch fault reappears, the laser requires service—contact SYNRAD or a SYNRAD Authorized Distributor.

PWM Drive fault

A PWM Drive fault indicates a problem in the laser's internal RF circuitry and causes the *RDY* LED to flash 4 blinks (the Laser Ready output Opens). Reset the laser by removing DC power to the laser, wait 30 seconds, and then reapply power. If the RF Drive DC fault reappears, the laser requires service—contact SYNRAD or a SYNRAD Authorized Distributor.

No-Strike condition

When a No-Strike condition occurs, lasing is limited to a maximum 5% duty cycle (at a PWM Command frequency of 5 kHz). This fault is annunciated by the *SHT* indicator flashing continuously (the Fault Detected output Closes). To clear a No-Strike condition, apply tickle pulses or a PWM Command signal (≤ 5% duty cycle) for 30 to 60 seconds. When the gas breaks down into a plasma state, the laser will recover and begin lasing ***immediately*** at the commanded power level without cycling DC power. If the No-Strike condition persists, contact SYNRAD or a SYNRAD Authorized Distributor.

Common causes of No-Strike (gas breakdown) issues are environmental conditions–like cold overnight temperatures when the laser is powered down. In situations like this, it may take 30 to 60 seconds for gas breakdown to occur before the laser can begin normal daily operation.

Frequency Limit condition

The *SHT* LED flashes 2 blinks, and the Fault Detected output Closes, to indicate the PWM Command signal frequency is above the 100-kHz limit. When the PWM frequency drops below 100 kHz, the laser will recover and begin lasing ***immediately*** at the commanded power level without cycling DC power.

100% Duty Cycle condition

The *SHT* LED flashes 3 blinks, and the Fault Detected output Closes, to indicate the PWM duty cycle is 100%—full continuous wave (CW) operation. When the PWM duty cycle drops below 100%, the laser will recover and begin lasing ***immediately*** at the commanded power level without cycling DC power.

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Troubleshooting

General laser fault conditions

Each Symptom listed below describes a particular fault condition. For each Symptom, specific causes and solutions are described in the Possible Causes section.

⚠ Warning
serious personal injury

On OEM p100 lasers, remote interlock faults as well as No-Strike, Frequency Limit, and 100% Duty Cycle conditions are ***not*** latched. Clearing the fault or error condition re-enables the *RDY* LED and lasing will begin ***immediately*** provided the *SHT* LED is lit and a PWM Command signal is applied. Because exposure to 10.6 µm CO_2 laser radiation can inflict severe corneal injuries and seriously burn human tissue, the OEM or System Integrator must ensure that appropriate safeguards are in place to prevent unintended lasing.

Symptom:

- A remote interlock condition is indicated by the following status LED and I/O states:

INT LED	– **Red**	Interlock Open	– **Closed**
TMP LED	– Green	Fault Detected	– Open
RDY LED	– **Off**	Laser Ready	– **Open**
SHT LED	– Blue	Shutter Open	– Closed
LASE LED	– Off	Laser Active	– Open

Possible Causes:

- No voltage is applied to Pin 3, the Remote Interlock input, on the *User I/O* connector.

On systems using remote interlocks, check to see that a positive or negative voltage in the range of ±5–24 VDC is applied to Pin 3, Remote Interlock, with respect to Pin 11, Input Common, on the *User I/O* connector (refer to *User I/O connections* in the Technical Reference chapter for details). For systems not using interlocks, connect the factory-supplied *Quick Start Plug* to the *User I/O* connector on the laser's rear panel or wire your male DB-15 connector so that Pin 11 (Input Common) is jumpered to Pin 12 (Auxiliary DC Power Ground) and Pin 3 (Remote Interlock) is jumpered to Pin 4 (+5 VDC Auxiliary Power).

Symptom:

- An over-temperature fault is indicated by the following status LED and I/O states:

INT LED	– Green	Interlock Open	– Open
TMP LED	– **Red**	Fault Detected	– **Closed**
RDY LED	– **Off**	Laser Ready	– **Open**
SHT LED	– Blue	Shutter Open	– Closed
LASE LED	– Off	Laser Active	– Open

Possible Causes:

- Coolant temperature is above 30 °C (86 °F) or there is inadequate coolant flow through the laser.

Verify that the chiller is maintaining a water temperature between 18 °C–30 °C (64 °F–86 °F).

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Troubleshooting

Note: OEM p100 lasers can be operated at coolant temperatures up to 30 °C (86 °F) to reduce problems associated with condensation; however, this may result in decreased laser performance and/or reduced laser lifetime.

If water temperature is OK, verify that the coolant flow is between 5.7–7.6 lpm (1.5–2.0 GPM). The simplest way to do this, if a flow meter is not available, is to disconnect the cooling tubing from the chiller inlet (or the drain) and run the cooling water for 60 seconds into a five-gallon bucket; you should have close to two gallons of water. If there is much less than two gallons of coolant, check the cooling path for kinked or pinched cooling tubes or check the chiller for a clogged or dirty filter.

On OEM p100 lasers, the over-temperature fault (indicated by the *TMP* indicator turning red) is latched. This means that if an over-temperature condition occurs the *TMP* indicator will turn red, the Fault Detected output will Close, the *RDY* light goes out, the Laser Ready output will Open, and lasing is disabled. Because of its latched condition, the *TMP* indicator will remain red even after the laser has cooled sufficiently to begin operation.

To reset an over-temperature fault, lower coolant temperature below 30 °C and then cycle DC power (remove DC power, wait 30 seconds, reapply DC power). When the *RDY* indicator illuminates, lasing is enabled provided the *SHT* indicator is illuminated blue. If the *TMP* indicator remains red after cycling power, continue to flow cooling water through the laser for a few more minutes and/or verify the coolant flow rate and then cycle DC power again.

Symptom:

- The *SHT* LED is flashing continuously because of a No-Strike condition as indicated by the following status LED and I/O states:

INT LED	– Green	Interlock Open	– Open
TMP LED	– Green	Fault Detected	– **Closed**
RDY LED	– Yellow	Laser Ready	– Closed
SHT LED	– **Blue (Flashing)**	Shutter Open	– Closed
LASE LED	– Off or Red	Laser Active	– Open or Closed

Possible Causes:

- A No-Strike condition has occurred, possibly due to cold environmental conditions that may prevent the gas from breaking down into a plasma state. If this occurs while a PWM signal is applied, laser output is limited to a PWM duty cycle of approximately 5% (at 5 kHz).

Apply tickle pulses or a PWM Command signal (≤ 5% duty cycle) for 30 to 60 seconds. When the gas breaks down into a plasma state, the laser will recover and begin lasing ***immediately*** at the commanded power level without cycling DC power.

Symptom:

- The *SHT* LED is repeating a two-blink error code and the following status LED and I/O states exist:

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INT LED	– Green	Interlock Open	– Open
TMP LED	– Green	Fault Detected	**– Closed**
RDY LED	– **Off**	Laser Ready	– **Open**
SHT LED	– **Blue (2-blinks)**	Shutter Open	– Closed
LASE LED	– Off	Laser Active	– Open

Possible Causes:

- The 100-kHz PWM frequency limit has been exceeded.

Lasing is disabled when the input frequency limit is exceeded. When the input drops below 100 kHz, the laser will recover and begin lasing ***immediately*** at the commanded power level without cycling DC power.

Symptom:

- The *SHT* LED is repeating a three-blink error code and the following status LED and I/O states exist:

INT LED	– Green	Interlock Open	– Open
TMP LED	– Green	Fault Detected	**– Closed**
RDY LED	– **Off**	Laser Ready	– **Open**
SHT LED	– **Blue (3-blinks)**	Shutter Open	– Closed
LASE LED	– Off	Laser Active	– Open

Possible Causes:

- A 100% duty cycle signal is applied to the laser's PWM input.

Lasing is disabled when the PWM duty cycle reaches 100% or full continuous wave (CW) operation. When the PWM duty cycle drops below 100%, the laser will recover and begin lasing ***immediately*** at the commanded power level without cycling DC power.

Symptom:

- A shutter closed condition is indicated by the following status LED and I/O states:.

INT LED	– Green	Interlock Open	– Open
TMP LED	– Green	Fault Detected	– Open
RDY LED	– Yellow	Laser Ready	– Closed
SHT LED	– **Off**	Shutter Open	– **Open**
LASE LED	– Off	Laser Active	– Open

Possible Causes:

- No voltage is applied to Pin 10, the Shutter Open Request input, on the *User I/O* connector.

Verify that a positive or negative voltage in the range of ±5–24 VDC is applied to Pin 10, Shutter Open Request, with respect to Pin 11, Input Common, on the *User I/O* connector (refer to *User I/O connections* in the Technical Reference chapter for details). If your system does not provide a Shutter Open Request signal, connect the factory-supplied *Quick Start Plug* to the *User I/O* connector on the laser's rear panel or wire your male DB-15 connector so that Pin 11 (Input Common) is jumpered to Pin 12 (Auxiliary DC Power Ground) and Pin 10 (Shutter Open Request) is jumpered to Pin 4 (+5 VDC Auxiliary Power).

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Symptom:

- Your OEM p100 laser has quit lasing or lasing halted and then restarted. The *LASE* LED may be Off or On depending on whether PWM Command signals are being applied, but no fault is indicated.

INT LED	– Green	Interlock Open	– Open
TMP LED	– Green	Fault Detected	– Open
RDY LED	– Yellow	Laser Ready	– Closed
SHT LED	– Blue	Shutter Open	– Closed
LASE LED	– Off or On	Laser Active	– Open or Closed

Possible Causes:

- The remote interlock circuit momentarily opened.

Remote interlock faults are not latched on OEM lasers. This means that if an interlock open fault occurs, the *INT* indicator will turn red, the Interlock Open output will Close, the *RDY* LED turns Off, the Laser Ready output will Open, and lasing is disabled. However, if the interlock circuit closes again, the *INT* indicator changes from red to green, the Interlock Open output Opens, the *RDY* light illuminates, the Laser Ready output Closes, and lasing is enabled.

Symptom:

- The following status indications and output states appear on power-up:

INT LED	– **Red**	Interlock Open	– **Closed**
TMP LED	– Green	Fault Detected	– Open
RDY LED	– **Off**	Laser Ready	– **Open**
SHT LED	– **Off**	Shutter Open	– **Open**
LASE LED	– Off	Laser Active	– Open

Possible Causes:

- The *Quick Start Plug* or Remote Interlock/Shutter Open Request inputs are not connected to the *User I/O* connector.

Connect the *Quick Start Plug* or interlock/shutter input field wiring to the DB-15 *User I/O* connector. See *User I/O connections* in the Technical Reference chapter for wiring details.

Symptom:

- Increasing the PWM Command signal's duty cycle percentage does not result in increased power output.

Possible Causes:

- The OEM p100 laser is duty cycle limited at different levels depending on PWM frequency.

When the maximum duty cycle for a given frequency range (shown in Table 4-10) is exceeded, the p100 laser continues lasing at the maximum duty cycle limit for that range. When the duty cycle drops below the limit, the laser will recover immediately and begin following the actual duty cycle.

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Table 4-10 Maximum duty cycle limits

Maximum Duty Cycle	Frequency Range
37.5%	Single-shot – 50 kHz
31.5%	50 –75 kHz
25.0%	75 – 100 kHz

- The power supply may not have enough current capacity.

Verify the DC power supply can supply 40 A continuous and 65 A peak (for ~800 µs).

Symptom:

- There is no output laser beam; all LED status indicators are Off.

Possible Causes:

- No DC voltage is applied.

Ensure that DC power cable connections are tight and verify that +48 VDC is available on the power supply terminals under full-load (99% duty cycle) conditions.

- A fuse inside the laser may have blown.

Contact SYNRAD Customer Service for information about accessing and replacing the fast-blow, 25 A mini automotive-type blade fuses (Littelfuse 997025 or equivalent) inside the Pulstar p100 laser.

Beam delivery optics

⚠ Warning
serious personal injury

The use of aerosol dusters containing difloroethane causes "blooming", a condition that ***significantly*** expands and scatters the laser beam. This beam expansion can effect mode quality and/or cause laser energy to extend beyond the confines of optical elements in the system, possibly damaging acrylic safety shielding. Do not use air dusters containing difloroethane in any area adjacent to CO_2 laser systems because difloroethane persists for long time periods over wide areas.

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Caution possible equipment damage	If you operate your laser or marking head in a dirty or dusty environment, contact SYNRAD about the risks of doing so and precautions you can take to increase the longevity of your laser, marking head, and associated optical components.

Symptom:

- The laser loses power over time; laser output power must be increased to maintain performance.

Possible Causes:

- Beam delivery optics are coated by vapor residue or debris.

⚠ **Danger** serious personal injury	Ensure that DC power to the laser is turned off and locked out before inspecting optical components in the beam path. ***Invisible*** CO_2 laser radiation is emitted through the aperture. Corneal damage or blindness may result from exposure to laser radiation.

Caution possible equipment damage	Contamination on the laser's output window (or on any beam delivery optic) can absorb enough energy to damage optical components in the beam path. Periodically inspect the p100's output window and all other beam delivery optics for signs of contaminants and then carefully clean as required. In dirty environments, purge laser optics using filtered air or nitrogen to prevent vapor and debris from accumulating on optical surfaces.

Shut down the laser and carefully inspect each optic in the beam delivery path. If the optic requires cleaning, refer back to *Maintenance* for cleaning instructions. Use only recommended cleaning materials (see Table 4-1) to prevent scratching delicate optical surfaces. If the focusing optic is pitted, it must be replaced immediately. Because of the extremely high power density of Pulstar lasers, pits or debris on the lens surface may absorb enough energy from the focused beam to crack the lens. If this happens, other optics in the beam path may be contaminated or damaged as well.

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⚠ Warning serious personal injury	A risk of exposure to toxic elements, like zinc selenide, may result when certain optical or beam delivery components are damaged. In the event of damage to laser, marking head, or beam delivery optics, contact SYNRAD, Inc. or the optics manufacturer for handling instructions.

When the application requires air (instead of nitrogen) as an assist gas, we recommend the use of breathing quality air available in cylinders from a welding supply company. Because compressed shop air contains minute particles of oil and other contaminants that will damage optical surfaces, it must be carefully filtered and dried before use as a purge or assist gas. Refer to Table 1-3, *Purge gas specifications*, in the Getting Started chapter for filtering and drying specifications.

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