



**SYNRAD**

A Novanta Company

# vi Series Operator's Manual

Version 4.0, October 2019

# Table of Contents

<b>Introduction</b>	
Contact Info.....	3
Warranty Information.....	3
Sales & Applications.....	4
Customer Service.....	4
Technical Support.....	5
Reference Materials.....	5
Shipping Contents.....	5
Packaging, Unpacking, and Shipping.....	5
Nomenclature.....	6
<b>Laser Safety</b>	
Hazard Information.....	6
Agency Compliance.....	9
European Union (EU) Requirements.....	11
Declaration of Conformity.....	14
Product Labeling.....	16
<b>Operation</b>	
Controls and Indicators.....	17
Getting Started – Mounting.....	18
Connecting – Electrical Connections.....	21
Initial Start-Up.....	23
<b>Technical Reference</b>	
Laser Design.....	25
Cooling.....	28
Controlling Laser Power.....	32
Operating Modes.....	32
DB-9 I/O Connections.....	35
General Specifications.....	40
<b>Maintenance</b>	
Procedures.....	41
<b>Troubleshooting</b>	
Procedures.....	44
Resetting Faults.....	46
<b>Addendum</b>	
vi40 Temperature Broadcast.....	48

# Introduction

## Contact Info

This Operator's Manual explains operation activities related to Synrad vi30+ and vi40 lasers. If you cannot operate the unit using the information described in this manual, contact SYNRAD:

### **Americas & Asia Pacific**

#### **Global Headquarters & Service Center**

Synrad  
4600 Campus Place  
Mukilteo, WA 98275  
P +1 (425) 349.3500  
F +1 (425) 349.3667

Technical support and product service requests: [customercare@synrad.com](mailto:customercare@synrad.com)

Order, delivery and shipment status: [custsupport@synrad.com](mailto:custsupport@synrad.com)

### **Europe, Middle East & Africa**

#### **Regional Sales Office & Service Center**

Novanta Europe GmbH  
Division Synrad Europe  
Parkring 57-59  
D-85748, Garching, Germany  
P +49 (0)89 31707 0  
F +49 (0)89 31707 22

[Sales-europe@synrad.com](mailto:Sales-europe@synrad.com)

### **China**

#### **Regional Sales Office & Service Center**

Synrad China Sales and Service Center  
Unit C, 5/F Ting Wei Industrial Park  
Liufang Road, Baoan District, Shenzhen  
Guangdong, PRC 518133  
P +86 (755) 8280 5395  
[sales-china@synrad.com](mailto:sales-china@synrad.com)

### **Japan**

#### **Regional Sales Office & Service Center**

Novanta Japan Corporation  
4666 Ikebe-cho Tsuzuki-ku  
Yokohama Kanagawa 224-0053 Japan  
P +81 45 932 9711  
F +81 45 932 9722  
[sales-japan@synrad.com](mailto:sales-japan@synrad.com)

## Warranty Information

This is to certify that Synrad vi Series lasers are guaranteed by SYNRAD to be free of all defects in materials and workmanship for a period of one year from the date of shipment. This warranty does not apply to any defect caused by negligence, misuse (including environmental factors), accident, alteration, or improper maintenance. This includes, but is not limited to,

damage due to corrosion, condensation, or failing to supply properly conditioned purge gas. We request that you examine each shipment within 10 days of receipt and inform SYNRAD 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 shipment, any part of the Synrad vi30+ or vi40 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 Synrad vi30+ or vi40 laser fails within the first 45 days after shipment, SYNRAD 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 Synrad vi30+ or vi40 laser, only authorized SYNRAD replacement parts can be used. This warranty is void if any parts other than those provided by SYNRAD are used.

SYNRAD and SYNRAD Authorized Distributors have the sole authority to make warranty statements regarding SYNRAD products. SYNRAD 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 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 by SYNRAD, or the use thereof, infringes upon any Patent, foreign or domestic.

## Sales & Applications

SYNRAD Regional Sales Managers work with customers to identify and develop the best CO<sub>2</sub> 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, or you can email us by sending a message to: [customercare@synrad.com](mailto:customercare@synrad.com).

# Technical Support

SYNRAD 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: [synradtechsupport@synrad.com](mailto:synradtechsupport@synrad.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 web site at <http://www.synrad.com>.

# Shipping Contents

Each vi30+ and vi40 laser shipment contains the following items:

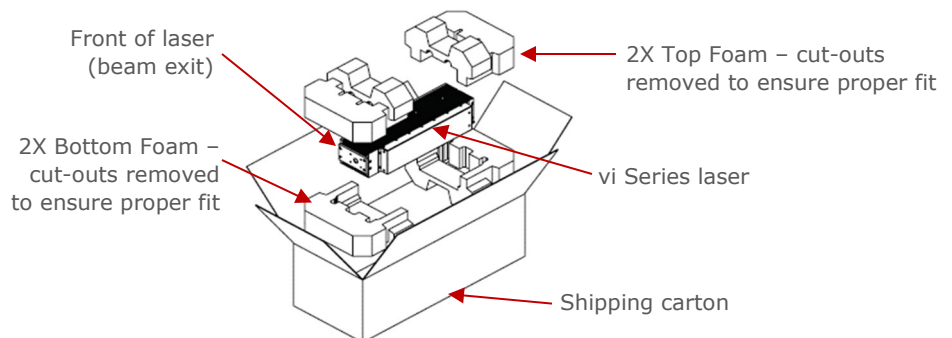
- **(1) vi30+ or vi40 CO<sub>2</sub> laser** – for cutting, welding, drilling, and marking a wide variety of products and materials
- **(3 ea.) Mounting bolts** - 1/4-20 x 5/8 UNC cap screws are provided for fastening the vi30+ or vi40 laser to your mounting surface.
- **(2) Spare Fuse** - Fast-blow vi30+ 12 A Cooper Bussmann BK/ABC-12-R or RoHS equivalent (Synrad P/N 521-00058-01), fast-blow fuses and two fast-blow vi40 20 A Cooper Bussmann ABC-20-R or equivalent 20 A (Synrad P/N521-00005-01), fast-blow fuses incorporated into the positive DC power cable protects the laser's internal circuitry. See Troubleshooting in the Maintenance and Troubleshooting chapter for additional information.
- **(1) Quick Start Plug** – only with fan and water cooled models
- **(1) Final Test Report** - Contains data collected during the laser's final pre-shipment test.

# Packaging, Unpacking, and Shipping

SYNRAD® recommends saving all of the laser's original packaging. Its unique design assists in preventing damage to your laser during storage, relocation and/or shipping. The Quick Start Guide (QSG) explains how to quickly and safely unpack and prepare your laser for installation. You can access the QSG on the SYNRAD website here:

[https://www.synrad.com/sites/default/files/2019-01/Quick%20Start%20Guide%20vi30\\_40%20Dual\\_0.pdf](https://www.synrad.com/sites/default/files/2019-01/Quick%20Start%20Guide%20vi30_40%20Dual_0.pdf)

Lift the laser by the baseplate only, do not lift or support the laser by the cooling fittings.



If you discover shipping damage to the laser, document the damage with a photograph, then immediately notify the shipping carrier and SYNRAD. After unpacking, review the shipping contents listed above to ensure all contents are received.

When re-packing the laser for relocation or shipment, nothing can be on the sides of the laser at any time as damage will occur. All components must be stowed under the laser. Take special care when re-packaging the wire harness, the wire harness and/or ports can be damaged in shipping.

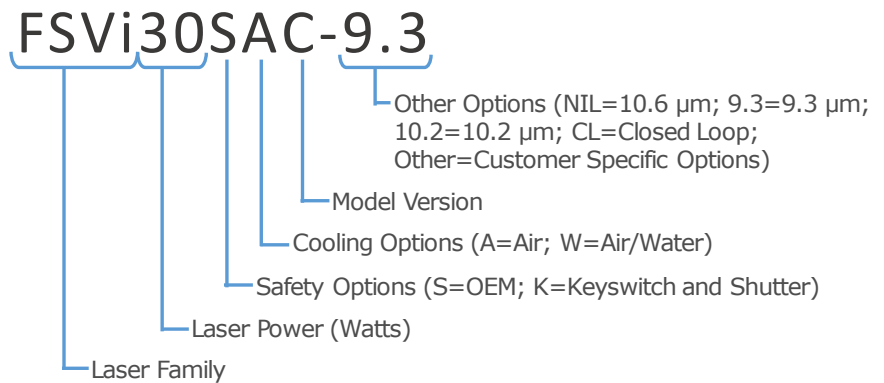
If you need replacement packing materials contact SYNRAD.

## Nomenclature

SYNRAD vi Series lasers have a Product ID label positioned on the top of the laser just above the printed laser name:



The Model number identifies the specific laser, and code designations provide details on the functions and features included.



## 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 IV laser equipment.

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



**WARNING** - Alerts operator of serious dangers, hazardous radiation, vapor hazard, & reflective dangers. Potential & Imminent hazards which, if not avoided, could result in death or serious injury.



**DANGER** - Alerts operator of lifting dangers. Hazards which, if not avoided, could result in minor or moderate injury.



**CAUTION** - Alerts operator of equipment dangers. Potential hazards or unsafe practices which, if not avoided, may result in product damage.



**IMPORTANT NOTES & TIPS** - Alerts operator of Content specific information and/or recommendations.

### Hazards and Unsafe Practices

Following are descriptions of 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.

- Enclose the beam path whenever possible. Exposure to direct or diffuse CO<sub>2</sub> 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.
- Materials processing with a laser can generate air contaminants such as vapors, fumes, and/or particles that may be noxious, toxic, or even fatal.
- Safety Data Sheets (SDS) 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:
  - 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.
- The use of aerosol dusters containing difluoroethane 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

difluoroethane in any area adjacent to CO<sub>2</sub> laser systems because difluoroethane persists for long time periods over wide areas.

### **Light Hazards**

Synrad vi Series 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, Safe Use of Lasers at all times when actively lasing.

Due to the specific properties of laser light, a unique set of safety hazards that differ from other light sources must be considered. Just like light, laser radiation can be reflected, refracted, diffracted or scattered.

- 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<sub>2</sub> laser is an intense energy 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.
- 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:

- Risk of injury when lifting or moving the unit
- Risk of exposure to hazardous laser energy through unauthorized removal of access panels, doors, or protective barriers
- 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
- Risk of exposure to hazardous or lethal voltages through unauthorized removal of covers, doors, or access panels
- 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® who, for a fee, will ensure adequate disassembly, recycling and/or disposal of the product.

### **Additional Laser Safety Information**

The SYNRAD website <http://www.synrad.com/LaserFacts/safetyinfo.html> contains an online laser safety handbook that provides information on:

- (1) Laser Safety Standards for OEM's/Sys-tem Integrators
- (2) Laser Safety Standards for End Users
- (3) References and Sources
- (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](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.lia.org>.

## Agency Compliance

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 vi Series 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 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, §1040 or IEC 60825-1:2007. SYNRAD 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 vi30+ and vi40 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 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). The following table(s), Class IV safety features, indicates which features are available on vi30+ and vi40 lasers, the type and description of the feature, and if the feature is required by CDRH regulations.

### **OEM models**

SYNRAD vi30+ and vi40 OEM 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.

### **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, §18, §§C.

SYNRAD vi30+ and vi40 lasers have been tested and found to comply by demonstrating performance characteristics that have met or exceeded the requirements of 47 CFR, §18, §§C for Radiated and Conducted Emissions.



**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, has not discovered any significant electrical interference traceable to SYNRAD vi30+ and vi40 lasers.

#### **System Maintenance**

Ensure that all exterior covers are properly fastened in position.

#### **Measures to Correct Interference**

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

- Use shielded cables to and from the equipment that is experiencing interference problems
- Ensure that the vi Series 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 vi Series lasers meet the requirements of the European Parliament and Council Directive 2015/863/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 Standards**

Under the Low Voltage Directive, 2014/35/EU, the International Standard specifies the minimum documentation, marking and labeling for all laser products classified in accordance with IEC 60825-1:2007 (hereafter referred to as EN 60825-1) including laser diodes and all laser devices defined in ISO 11145 was developed to provide laser safety guidance and includes clauses on Engineering Specifications, Labeling, Other Informational Requirements, Additional Requirements for Specific Laser Products, Classification, and Determination of the Accessible Emission Level. To develop a risk assessment plan/laser safety program for users, see the EN 60825-14:2004 Standard for the safety of laser products that includes clauses on Administrative Policies, Laser Radiation Hazards, Determining the MPE, Associated Hazards, Evaluating Risk, Control Measures, Maintenance of Safe Operation, Incident Reporting and Accident Investigation, and Medical Surveillance.

### **OEM Models**

SYNRAD vi Series OEM lasers are intended for incorporation as components in laser processing systems. As supplied by SYNRAD, these lasers do not meet the requirements of EN 60825-14:2004 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 60825-14:2004; EN 60204-1:2016, Safety of Machinery; the Machinery Directive, 2006/42/EC; and/or any other applicable Standards and in cases where the system is being imported into the U.S., it must also comply with CDRH regulations.

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. See the following table, Class IV safety features, summarizes SYNRAD vi Series product features, indicating the type and description of features and whether those features are required by European Union regulations.

### **Electromagnetic Interference Standards**

The European Union's Electromagnetic Compatibility (EMC) Directive, 2014/30/EU, 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 SYNRAD vi Series lasers, EN 61000-6-4:2018 defines radiated and conducted RF emission limits while EN 61000-6-2:2016 defines immunity requirements for industrial environments.

SYNRAD vi Series lasers have demonstrated performance characteristics that have met or exceeded the requirements of EMC Directive 2004(2014)/108/EC.

Feature	Location/Description	CDRH	EN60825-14	OEM vi Series
Keyswitch <sup>1</sup>	<b>Rear Panel Control</b> On/Off/Reset Keyswitch controls power to laser electronics. Key cannot be removed when switch the switch is in the "On" position.	Yes	Yes	No
Shutter <sup>1</sup> Function	<b>Laser Control</b> Functions as a beam attenuator to disable RF driver/laser output when closed.	Yes	Yes	No
Shutter <sup>1</sup> (SHT) Function	<b>Rear Panel Indicator (Blue)</b> Functions as a beam attenuator to disable RF driver/laser output when closed.	Yes	Yes	No
PWR (power) Indicator	<b>Rear Panel Indicator (Green)</b> Illuminates green to indicate DC power is applied	No	No	Yes
RDY (Ready) Indicator	<b>Rear Panel Indicator (Yellow)</b> Indicates that power is applied and lasing is enabled.	Yes	Yes	Yes
(LASE) Indicator	<b>Rear Panel Indicator (Red)</b> Indicates that the laser is actively lasing. Lase LED illuminates when the duty cycle of the Command signal is long enough to produce laser output.	No	No	Yes
Five Second Delay	<b>Laser Circuit Element</b> Disables RF driver/laser output for five seconds after laser enable signal is applied.	Yes	Yes	No
Remote Interlock	<b>Rear Panel Connection</b> (Laser Enable Input) Disables RF driver/laser output when a remote interlock switch on an equipment door or panel is opened.	Yes	Yes	Yes
Remote (INT) Interlock	<b>Rear Panel Indicator (Green/Red)</b> Illuminates green when Remote Interlock circuitry is closed, illuminates	No	No	Yes

	red when the interlock circuitry is opened.			
Over Temperature Protection	<b>Laser Circuit Element</b> Temperature shutdown occurs if temperature of the laser tube rises above safe operating limits	No	No	Yes
Temperature (TMP) Indicator	<b>Rear Panel Indicator (Green/Red)</b> Illuminates green when laser temperature is within operation limits. Illuminates red when thermal limits are exceeded.	No	No	Yes
Warning Labels	<b>Laser Exterior</b> Labels attached to various external housing locations to warn personnel of potential laser hazards.	Yes	Yes	Yes

<sup>1</sup> – Not available nor required on Vi Series OEM lasers

When integrating SYNRAD vi Series 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 testing program has demonstrated that SYNRAD vi Series lasers comply with the relevant requirements of 2004(2014)/108/EC, the Electromagnetic Compatibility Directive, as summarized below:

- 2004(2014)/108(30)/EC – Electromagnetic Compatibility Directive
- 2006/95/EC – Low Voltage Directive
- 2015/863/EU – RoHS Directive
- EN 61010-1 – Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General Requirements
- EN 61000-6-4 – Radiated Emissions Group 1, Class A
- EN 61000-6-4 – Conducted Emissions Group 1. Class A
- EN 61000-6-2 – Electrostatic Discharge Immunity
- EN 61000-6-2 – RF Electromagnetic Discharge Immunity
- EN 61000-6-2 – Electrical Fast Transient/Burst Immunity
- EN 61000-6-2 – 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 a Declaration of Conformity.

# Declaration of Conformity

SYNRAD vi30+ Declaration of Conformity

## Declaration of Conformity

in accordance with ISO / IEC 17050-2:2004

We,

**Manufacturer's Name:** SYNRAD® A ®Novanta Company

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

Hereby declare under our sole responsibility that the following equipment:

**Product Name:** OEM vi30+ Laser

**Model Number:** FSvi30S\*D-\* (OEM)

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

<b>Applicable Directive(s):</b>	2014/30/EU	Electromagnetic Compatibility Directive
	2014/35/EU	Low Voltage Directive
	(EU) 2015/863	RoHS Directive

**Applicable Standard(s):**

EN 61010-1:2010	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 Electronic Fields Immunity
EN 61000-6-2:2005	Electrical Fast Transient/Burst Immunity
EN 61000-6-2:2005	Conducted RF Disturbances Immunity

\*OEM lasers do not comply with EN 60825-1:2014, *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:**



Tim Freni, Quality Manager of SYNRAD

**European Contact:**

Novanta Distribution (USD) GmbH  
Parkring 57-59  
85748 Garching bei München, Germany

Date: 10/15/19



MADE IN THE U.S.A.  
900-20976-16 Rev D

## Declaration of Conformity

in accordance with ISO / IEC 17050-2:2004

We,

**Manufacturer's Name:** SYNRAD® A Novanta Company

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

Hereby declare under our sole responsibility that the following equipment:

**Product Name:** Firestar™ OEM vi40 Laser

**Model Number:** FSvi40SAC (\*OEM)

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

<b>Applicable Directive(s):</b>	2014/30/EU	Electromagnetic Compatibility Directive
	2014/35/EU	Low Voltage Directive
	(EU) 2015/863	RoHS Directive

**Applicable Standard(s):**

EN 61010-1:2010	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 Electronic Fields Immunity
EN 61000-6-2:2005	Electrical Fast Transient/burst Immunity
EN 61000-6-2:2005	Conducted RF Disturbances Immunity

\*OEM lasers do not comply with EN 60825-1:2014, *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:**



Glenn Gardner, President & GM of SYNRAD

**European Contact:**

Novanta Distribution (USD) GmbH  
Parkring 57-59  
85748 Garching bei München, Germany

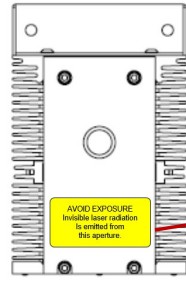
Date: 7/22/19

**CE**  
MADE IN THE U.S.A.  
900-20976-10 Rev C

# Product Labeling

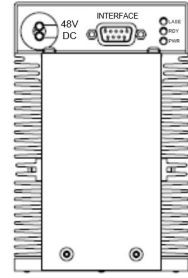
SYNRAD vi Series hazard label locations:

Laser Front



**AVOID EXPOSURE**  
Invisible laser radiation  
Is emitted from  
this aperture.

Laser Back



Laser Top

**INVISIBLE LASER RADIATION**  
AVOID EYE OR SKIN EXPOSURE TO  
DIRECT OR SCATTERED RADIATION  
CLASS 4 LASER PRODUCT

**SYNRAD** MODEL #: **FSVi30SAC-9.3**  
A Novanta Company SERIAL #: i050198162953  
MFG October 25, 2018  
TESTED AT 48 Volts

This laser component does not comply with standards for complete laser products as Specified by 21 CFR 1040.10 or IEC 60825-1.

4600 Campus Place, Mukilteo WA 98275 | 425.349.3500



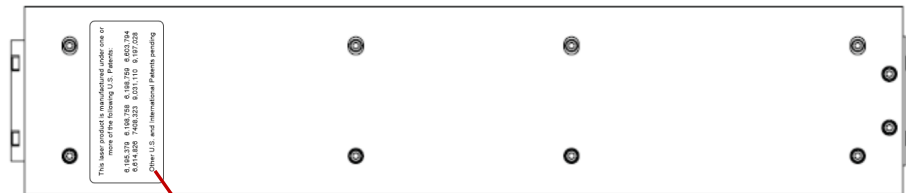
**75 WATTS MAX**  
10200-10800 nm  
EN-60825-1, 2007

vi30+

**150 WATTS MAX**  
10200-10800 nm  
EN-60825-1, 2007

vi40

Laser Bottom



This laser product is manufactured under one or more of the following U.S. Patents:  
4,805,182 5,065,405 6,195,379 6,603,794  
4,837,772 5,215,864 6,198,758 6,614,826  
5,008,894 5,602,865 6,198,759  
Other U.S. and International Patents pending.

# Operation

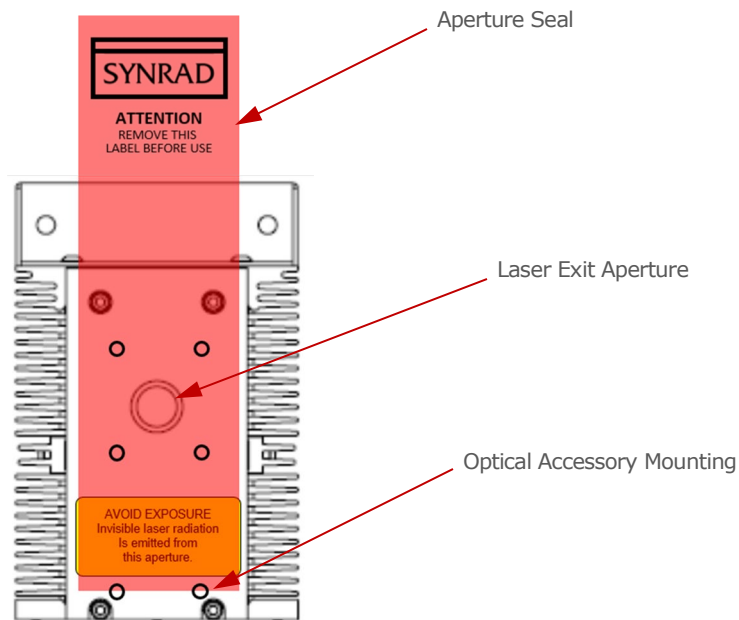
## Controls and Indicators



Controls and indicators – displays and describes exterior controls and indicators on vi-Series Keyswitch and OEM lasers.

- Any Class IV CO<sub>2</sub> laser product that emits invisible infrared laser radiation in the 9–11 μm wavelength band can seriously burn human tissue.
- Because 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.
- Always be aware of the beam's path and always use a beam block while testing.

### OEM vi Series laser front panel controls and indicators:



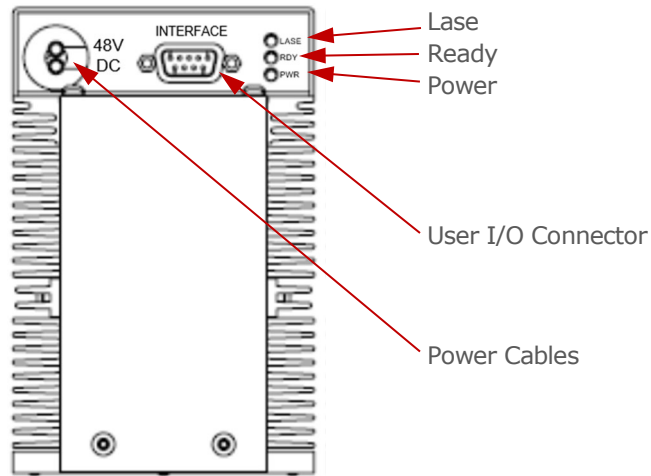
**Aperture Seal** – prevents dust from damaging laser optics during shipping. Remove the red self-adhesive label before applying power to the laser.

**Laser Aperture** – provides an opening in the front panel from which the laser beam exits.

**Optical Accessories Mounting** – provides six 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 options. Refer to the OEM vi30+ or vi40 outline drawings in the Technical Reference chapter for mounting dimensions.

To prevent damage when mounting optical components to the OEM vi30+ laser, the 8–32 UNC fasteners must extend no further than 4.8 mm (0.19”) into the laser's faceplate.

## OEM vi Series laser rear panel controls and indicators:



**DC Power Cables** – receives +48 VDC from the DC power supply. The DC power cables are manufactured from #12 AWG wire and measure 1 meter (42 inches) in length. The red (positive) cable contains a replaceable in-line fuse. If a fuse replacement is required, refer to the Getting Started section of this manual.

**DB-9 I/O Connector** – provides a connection point for auxiliary output power as well as input and output signals. Refer to DB-9 I/O connections in the Technical Reference chapter for pin-outs and signal descriptions.

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

**RDY (Ready) Indicator** – illuminates yellow when the laser is enabled, indicating that, after an initial five-second delay, lasing will begin when a PWM Command signal is applied.

**PWR (Power) Indicator** – illuminates green when +48 VDC power is applied to the laser.

## Getting Started Mounting

The OEM vi30+ base plate (and the optional customer-installed mounting feet) is designed so the laser is easily mounted to either vertical or horizontal surfaces using only three fasteners. Three ball bearing “feet” pressed into vi Series’ base plate (and the optional mounting feet) eliminate any possible distortion of the laser tube caused by variations in the flatness of the mounting surface. Refer to OEM vi30+ package outline drawings in the Technical Reference chapter for mounting locations and dimensions.



To prevent possible distortion of the tube, you must fasten the vi Series laser directly to your mounting surface using the base plate or the optional mounting feet.

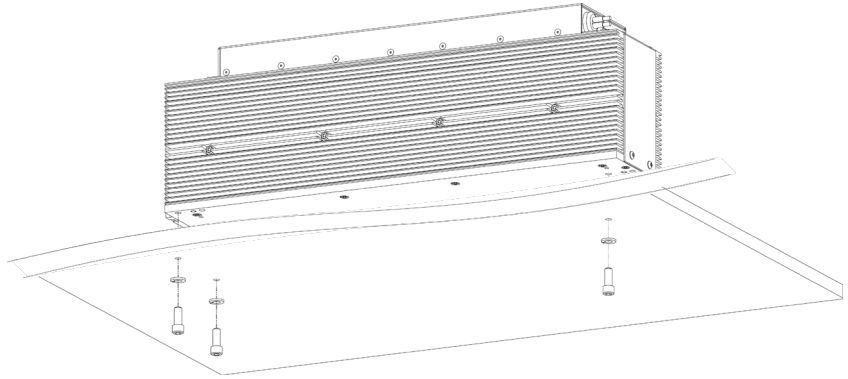


SYNRAD does not recommend mounting lasers in a vertical “tail-down” orientation. If you must mount your laser in this manner, please contact the factory for limitations as a vertical orientation increases the risk of damage to the laser’s output optic.

### Mounting the vi Series Laser

To fasten an OEM vi Series laser to your mounting surface, perform the following steps:

1. Refer to the appropriate vi Series outline & mounting drawing and drill three holes into your mounting surface that correspond to either the UNC or metric hole pattern.
2. Place the vi Series laser on the mounting surface so that the threaded holes in the base plate line up with the holes in your mounting surface as shown below:



OEM vi Series mounting locations shown above.

Insert three M6 × 1 ISO or 1/4–20 UNC cap screws through the mounting surface into the threaded holes of the vi30+ base plate. Turn the screws by hand until the threads engage.

3. Evenly tighten all three cap screws to a maximum torque of 6.1 N m (54 in lb.).
4. Mounting bolt must not extend farther than 6 mm (0.24 inches) into the vi Series baseplate.



### Mounting the vi Series with Optional Mounting Feet

For most customers, the standard vi Series base plate design provides the smallest physical footprint for mounting the OEM vi Series in a compact laser system. Where vi Series mounting compatibility is required, you can purchase and install one of two optional mounting kits (available separately from the factory). The "Tall" mounting kit (SYNRAD P/N 250-20190-01) raises the vi Series laser by 5.9 mm (0.231") to match the v Series beam exit height. Feet in the 'Tall/Wide' mounting kit (SYNRAD P/N 250-20190-02) raise the vi Series to match v Series beam exit height and mounting dimension exactly. All three mounting options are shown below. For dimensional information, see outline drawings in the Technical reference section.

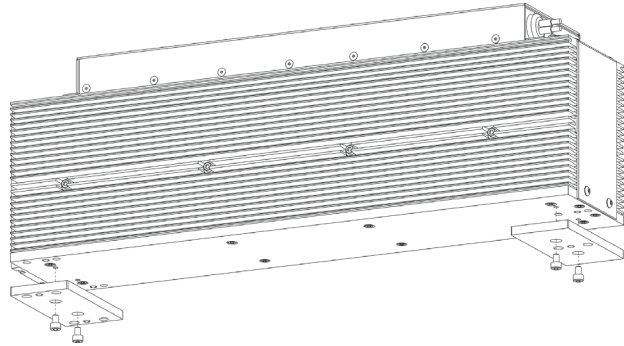
### Install the Optional Mounting Feet

To attach the optional 'Tall' or 'Tall/Wide' mounting feet to the vi Series laser, refer to image below and perform the following steps:



1. Carefully place the OEM vi30+ Series laser upside down on the work surface.
2. Orient the 'Tall' or 'Tall/Wide' mounting feet so the ball bearings are facing upwards and then position them over the existing ball bearings/mounting holes in the laser base plate.

Optional mounting feet installation:



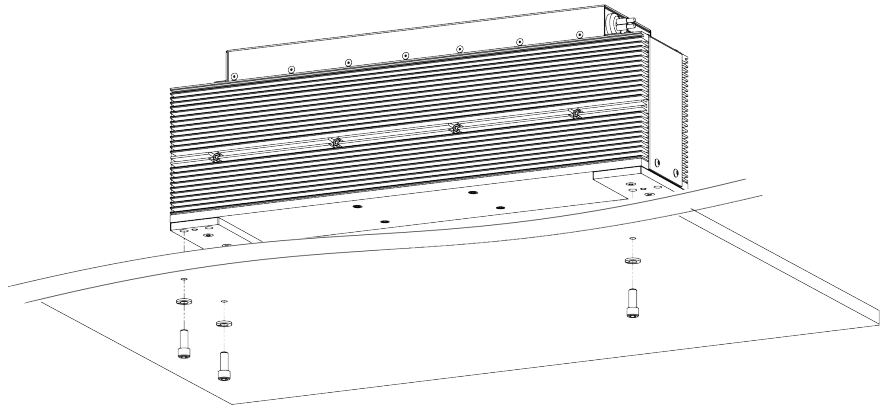
3. Locate the four M4 × .7 ISO Allen cap screws fasteners in the foot mounting kit and insert them through the mounting feet into the threaded holes of vi Series base plate. Turn the screws by hand until the threads engage.  
  
Foot mounting bolts must not extend further than 6.0 mm (0.24") into the vi Series base plate.
4. Evenly tighten all four cap screws to a maximum torque of 3.0 N m (26 in lb).

#### Mount the vi Series with Optional Feet

After the optional mounting feet are installed, perform the following steps to fasten the vi Series laser to your mounting surface:

1. Refer to the appropriate vi Series outline & mounting drawing and drill three holes into your mounting surface that correspond to either the UNC or metric hole patterns in the optional mounting feet.
2. Place the vi Series laser on the mounting surface so the threaded holes in the mounting feet line up with the holes in your mounting surface.

Feet mounting locations (1/4–20 fastener locations shown):



Mounting bolts must not extend further than 6.0 mm (0.24") into the vi Series mounting feet.

3. Insert three M6 × 1 ISO or 1/4–20 UNC cap screws through the mounting surface into the threaded holes of the mounting feet. Turn the screws by hand until the threads engage.
4. Evenly tighten all three cap screws to a maximum torque of 6.1 N m (54 IN LB).

## Connecting Electrical Connections

The following procedures describe how to complete electrical connections to vi Series lasers. OEM vi Series DC power cables are manufactured from #12 AWG wire and measure 1 meter (40 inches) in length. If additional wiring must be added to the power cables, consult Synrad Technical Support ([synradtechsupport@synrad.com](mailto:synradtechsupport@synrad.com)) for best practices.

### DC Power Supply



The negative (–) side of the DC input to the laser is internally connected so that the laser chassis serves as DC power ground. If your system must DC ground isolated from chassis 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.

### Connecting



Do not reverse polarity when connecting DC power cables to your DC power source. Reversed DC polarity may damage the vi Series’ internal RF and control board circuitry. Carefully follow the directions below to ensure that DC cable leads are properly connected to the correct DC output terminals.

The OEM vi Series lasers requires a DC power supply capable of providing 48 VDC. To connect vi Series lasers to a 48 VDC power supply, perform the following steps:

1. Verify that input AC power to the DC power supply is physically locked out or disconnected.
2. Locate the 48 VDC output terminals on the power supply’s output section and connect the black (–) DC power cable from the laser to the negative (V–) output terminal.
3. Connect the red (+) DC power cable from the laser to the positive (V+) 48 VDC output terminal.



To determine the recommended AC to DC power supply, please refer to this page on the Synrad website:

<https://www.synrad.com/index.php/en/products/accessories/acdc-power-supplies>

## Control Connections

All control connections to OEM vi30+ lasers are made through the DB-9 I/O connector on the vi Series' rear panel. The DB-9 interface connector receives tickle pulse and PWM Command signals and also serves as the connection point for auxiliary signals between the laser and any parts handling, automation, or monitoring equipment. See the DB-9 I/O connections section in the Technical Reference chapter for details.



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

Because the OEM vi Series control board does not incorporate a built-in tickle generator, an externally generated 5 kHz, 1  $\mu$ s tickle pulse between applied PWM signals is required to achieve optimum laser performance. See Controlling Laser Power in the Technical Reference chapter for tickle signal descriptions.

## UC-2000 Universal Laser Controller



Rack-mount model

The UC-2000 provides an easy user interface for total control of laser power, duty cycle, and modulation frequency.

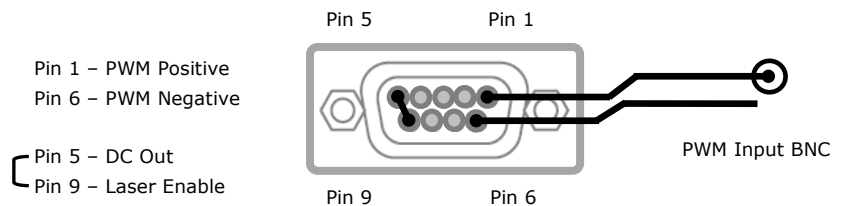


Standard model

For testing, troubleshooting, and basic operation, SYNRAD recommends using a UC-2000 Controller to generate the tickle pulses and Pulse Width Modulated (PWM) Command signals necessary to control laser output power. To connect a UC-2000 Controller (available separately from SYNRAD), perform the following steps:

1. Remove DC power from the laser.
2. Install the DB-9 Quick Start Plug to verify vi Series laser operation. If the laser was not shipped with a Quick Start Plug, you can fabricate one as shown below:

Rear (Solder Side) of Male DB-9 Quick Start



3. If your system does not provide an enable input to the DB-9 plug, then jumper Pin 9, Laser Enable, to Pin 5, DC Out.



**CAUTION**

Turn off DC power before installing or removing any plug or cable from the DB-9 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.

4. Connect the DB-9 plug to the DB-9 I/O connector on the rear of the laser.
5. Connect the miniature DC power plug on the UC-2000's Power/Control cable to the miniature connector on the wall plug transformer cable.
6. Connect the mini-DIN connector on the other end of the UC-2000's Power/Control cable to the Laser connector on the UC-2000's rear panel.
7. Plug the compact transformer into any 100–240 VAC, 50–60 Hz outlet.



**IMPORTANT**

OEM vi Series lasers can also be controlled from an alternate user-supplied Command signal source. Refer to Controlling Laser Power in the Technical Reference chapter for control signal descriptions and refer to DB-9 I/O connections, also in the Technical Reference chapter, for signal specifications and connection details.

## Operation Initial Start-Up

Use information in this chapter to familiarize yourself with OEM vi30+ controls and indicators and to begin operating the laser.

### Status LEDs

Three status LEDs on the rear of the OEM vi Series laser provide a visual indication of operating status. A green PWR LED illuminates when DC power is applied to the laser. The yellow RDY LED indicates that a Laser Enable signal has been applied and that, after a five-second delay, lasing will begin once a PWM Command signal is received. The LASE LED illuminates red to indicate that the PWM signal is sufficient to induce laser output.

This Class 4 laser product emits invisible infrared laser radiation in the 9.3– 10.6  $\mu\text{m}$  CO<sub>2</sub> wavelength band depending on model. Because 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 contact the laser beam. This product emits an invisible laser beam that is capable of seriously burning human tissue.



**DANGER**

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



**CAUTION**

Remove the aperture seal before firing the laser. The self-adhesive seal is installed to prevent dust from entering the laser housing during shipment and installation and must be removed before operation.

### With a UC-2000 Controller

Before your OEM vi Series laser is put into service for the first time, its functionality should be verified. 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. See the UC-2000 for more information: <https://www.synrad.com/sites/default/files/2019-05/Operators%20Manual%20UC2000.pdf>



**IMPORTANT**

After applying 48 VDC, but before operating the laser, you must provide a Laser Enable input signal to the DB-9 I/O connector. See DB-9 I/O connections in the Technical Reference chapter for pinouts 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 from the laser faceplate.
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.



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

4. Press the UC-2000's Lase On/Off button. The Lase indicator on the UC-2000 should illuminate
5. Use the UC-2000's PWM Adj Knob to slowly increase power. The vi Series LASE LED illuminates red when PWM Command pulses are long enough to produce laser output.
6. Press the UC-2000's Lase On/Off button to stop lasing. LASE indicators on the UC-2000 and the laser should turn off.

If your vi Series laser fails to lase, refer to the Maintenance & Troubleshooting section for more information.

### Without a UC-2000 Controller

If you are not using a UC-2000 to control the laser, follow the steps below to verify laser operation. For all vi Series lasers, an externally-generated tickle signal is required for optimum laser performance. Connect the signal generator for both tickle and PWM Command signals to the DB-9 I/O connector. Refer to DB-9 I/O connections in the Technical Reference chapter for connector pinouts and see Controlling laser power in the Technical Reference chapter for tickle and Command signal descriptions.



After applying 48 VDC, but before operating the laser, you must provide a Laser Enable input signal to the DB-9 I/O connector. See DB-9 I/O connections in the Technical Reference section for pinouts 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 from the laser faceplate
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 output of your PWM controller to PWM Positive (Pin 1) on the laser's DB-9 I/O connector and connect the ground or return of the Controller to PWM Negative (Pin 6)



Your controller must provide both tickle and PWM Command signals to the laser. See Controlling Laser Power in the Technical Reference section for tickle and Command Signal descriptions.

5. Ensure your controller is set to provide a 1  $\mu$ s square wave tickle pulse at a frequency of 5 kHz during any 200- $\mu$ s measurement period where a PWM signal is not applied.
6. Set your PWM controller to a frequency of 5 kHz (at a +5 volt level) and ensure that the controller's duty cycle is set to zero percent output (0.0%).

### Starting your OEM vi Series Laser

1. If the laser has a Diode Pointer installed, remove its aperture dust cover.
2. Turn on the +48 VDC power supply. The vi Series' PWR LED should illuminate green
3. Apply a Laser Enable signal to the DB-9 I/O connector. The yellow RDY lamp turns on to indicate that, after a five-second delay, lasing is enabled when a PWM Command signal is received.



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

4. Using your PWM controller, apply tickle pulses (a +5 VDC, 5 kHz square wave of 1  $\mu$ s duration). After five to ten seconds, slowly increase the duty cycle of the square wave. The LASE indicator illuminates red when PWM pulses are long enough to produce laser output.
5. Remove the PWM Command signal from the laser and re-apply tickle pulses every 200  $\mu$ s. The LASE indicator on the laser should turn off.



If your vi Series laser fails to lase, refer to the Maintenance & Troubleshooting section for more information.

## Technical Reference

### Laser Design

#### Laser Tube

SYNRAD vi Series lasers are based on a waveguide resonator design, which produces a high quality symmetrical beam in a very small form factor. Synrad lasers are capable of operating for many years with virtually no maintenance. The 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.

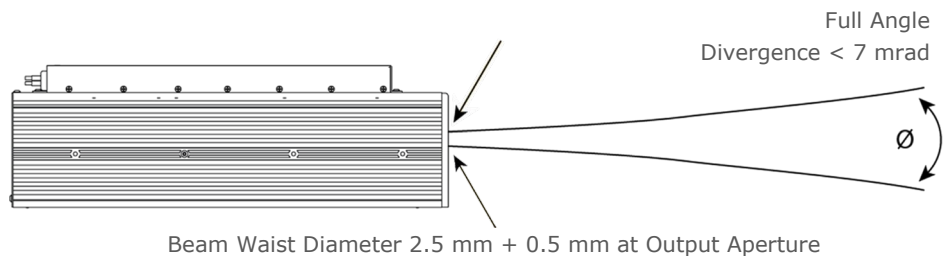
## Optical Resonator

The optical resonator, in conjunction with the electrodes and the gas mixture, generates the laser beam. SYNRAD vi Series optical resonators are comprised of four optical elements: a rear mirror, two turning mirrors, and an output window. All optical elements are aligned and locked into place by factory technicians before the laser is shipped.

The output beam transitions to a Gaussian-like mode in mid and far fields—three meters (9.8 ft.) and beyond. The wave guide structure and optics of the resonator combine to produce a Gaussian-like mode quality ( $M^2$  factor) of  $< 1.2$ . As shown in the figure below, the beam waist diameter is  $2.5 \text{ mm} \pm 0.5 \text{ mm}$  at the output aperture and full angle divergence due to diffraction is less than 7 milliradians (a 7 mrad full angle divergence means that beam diameter increases 7 mm over every one meter distance traveled).



Because of their smaller beam diameter, vi Series lasers have significantly higher power densities than other SYNRAD lasers. This means that any contaminants on the laser's output coupler (or on any beam delivery optic) can absorb enough energy to damage one or more optics in the beam path. Periodically inspect the laser's output coupler and all other beam delivery optics for signs of contaminants, and then carefully clean as required.



## Internal RF Power Supply

SYNRAD vi Series lasers are driven by a compact radio frequency (RF) power source mounted in the laser chassis. The output from the RF supply (nominally at 83.5 MHz) drives the laser directly by exciting carbon dioxide ( $\text{CO}_2$ ) gas in the tube to produce lasing.

## Control Circuit

Sensors built into the OEM vi Series control board monitor the laser for conditions like under/over voltage, over temperature, and other faults that pose a risk of damage to the laser. The vi40 has temperature broadcasting capability. (See Appendix) Additionally, laser operation is controlled by a Laser Enable input.

## Optical Setup

After selecting a laser for a  $\text{CO}_2$  laser processing system, the two most important elements to consider are:

- (1) Beam delivery optics to transmit the beam to the work area
- (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. Because the vi Series laser beam diverges by 7 mm over each meter of distance traveled, the laser should be mounted a distance of 1.0–1.5 m (40–60 in) away from the work area and no closer than 0.75 m (30 in) for optimum performance. Right angle turning mirrors (beam benders) are often used in conjunction with the laser mounting position to obtain this distance.

Expander/collimators are optical devices that reduce laser 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 the best solution to provide the required beam expansion before reaching the focusing optic.

## Focusing Optics

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.



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 being processed.

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 and becomes increasingly important as laser power increases. Dirty or scratched lenses will under-perform, exhibit a vastly shortened lifetime, and may fail catastrophically.

When the application requires air (instead of nitrogen) 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 and dried to ISO 8573-1:2010 Class I, II.

Class I specifications as shown in the following table.

### Assist Gas Purity Specifications

Assist Gas	Typical Purpose	Specification
Air	Cutting/Drilling	Breathing Grade $\geq$ 99.9996% purity; filtered to ISO Class I particulate level

Air	Cutting/Drilling	Compressed; Instrument-grade air filtered and dried to ISO 8573-1:2010 Class I, II, I (< 10 1.0– 5.0 µm particles/m <sup>3</sup> ; < -40 °F dew point; < 0.01 mg/m <sup>3</sup> oil vapor)
Argon	Welding	High Purity Grade > 99.998% purity; filtered to ISO Class I particulate level
Helium	Welding	High Purity Grade > 99.997% purity; filtered to ISO Class I particulate level
Nitrogen	Cutting/Drilling	High Purity Grade > 99.9500% purity; filtered to ISO Class I particulate level
Oxygen	Cutting/Drilling	Ultra Pure Grade > 99.9998% purity; filtered to ISO Class I particulate level

## Cooling

### Introduction

Heat generated by excited CO<sub>2</sub> molecules is transferred to the bore walls and cooling fins by diffusion. For air cooled versions, dual side fans, or rear fan prevent the laser from overheating. Further heat can also be transferred to water through external corrosion-resistant copper alloy tubing to regulate temperature for maximum stability.

Proper cooling is vital to the lifetime and operational stability of SYNRAD CO<sub>2</sub> lasers:



- The laser gain decreases as the gas heats up, resulting in a loss of output power as the overall laser temperature increases. Keeping the laser temperature stable provides the best output power stability.
- The laser gas is driven with Radio Frequency (RF) energy to cause the gas mixture to emit photons and develop the laser beam. The RF electronics also generate heat which must be properly removed to prevent damage to the components.
- Most SYNRAD CO<sub>2</sub> lasers are tuned and optimized for operation at or below 22°C (72°F) and lose about 0.5 to 1.0% output power per degree Celsius at operating temperatures above this point.

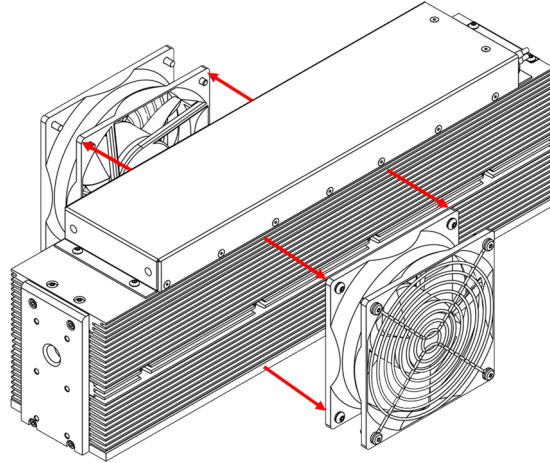
### Fan Cooling

Customers must provide cooling to prevent the laser from overheating. SYNRAD recommends using two cooling fans rated for at least 4.0 m<sup>3</sup>/min (140 CFM) for the vi30+, or 5.4 m<sup>3</sup>/min (190 CFM) for the vi40. The cooling fans should measure 120 × 120 mm (4.7" × 4.7") and have at least 57.2 mm (2.25") of unobstructed clearance between the rear face of the fan housing and any mounting surface or enclosure.

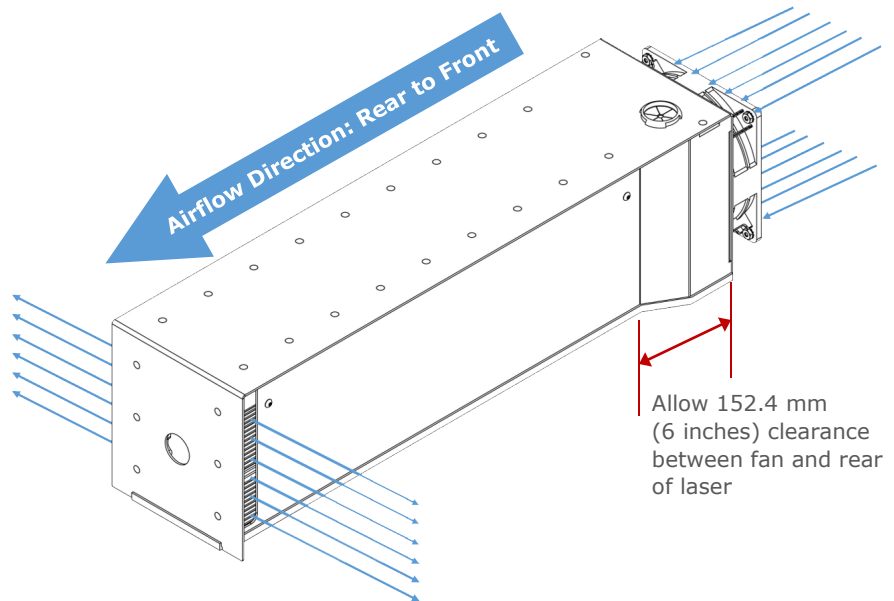
For free-space mounting (no fan shroud), position the fans symmetrically, as shown in the following figure, where they are centered horizontally with the laser chassis and vertically with the heat sink fins. Position both fans so the front face is no more than 76 mm (3.0") from the vi30+ or vi40's heat-sink fins.

Recommended Free Space Example for Cooling:

Gap between fan and laser must be less than 76 mm



Recommended Fan Shroud Example for Rear Cooling:



Airflow must be directed away from output optic



Customer designed fan shroud must enclose both the OEM laser and cooling fan.

When using a tight-fitting fan shroud designed for side cooling, the cooling fans can be positioned within 5–25 mm (0.20–1.0”) of the heat-sink fins as long as the same gap is maintained on either side.

A fan shroud designed for rear cooling can be used to minimize the width of the laser installation as shown in the figure above. The shroud should enclose the full length of the laser and the cooling fan and must fit snugly against the laser’s heat-sink fins. Use a fan rated for at least 8.5 m<sup>3</sup>/min (300 CFM) at a static air pressure of 23.9 mm H<sub>2</sub>O (0.94 in H<sub>2</sub>O) and position it approximately 150 mm (6.0”) from the rear of the laser.

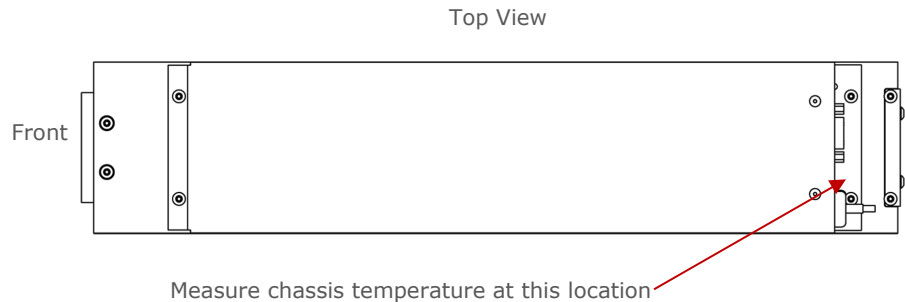
The vi Series lasers do not provide a voltage output sufficient to power cooling fans, so customers must provide an external power source to drive the selected cooling fans. Because of

the heat generated by internal RF circuitry, establishing significant airflow evenly over the entire surface of the combined laser/RF chassis is vitally important to the performance and longevity of the laser.

### Temperature Monitoring

vi30+ Chassis Temperature - the image below shows the recommended location for mounting a customer-supplied external temperature sensor. A reading of approximately 60 °C (140 °F) at this location is the point where over-temperature faults will begin to occur.

OEM vi30+ external temperature monitoring location:



vi40 – includes a temperature broadcast feature that provides real-time temperature measurements of the laser interior. Direct temperature data is transmitted on intervals of 250 ms for real-time feedback on operating conditions. Temperature data can be integrated into machine control systems to trigger system cooling and/or provide advanced warning of potential fault conditions. A reading of 70 °C (158 °F) will start to automatically trigger over-temperature faults. See Temperature Broadcast Feature addendum page XX for complete details.

### Water Cooling - Coolant Flow Rate (for H<sub>2</sub>O cooled versions)

Ensure that coolant flow is 1.0 GPM (3.8 LPM) and the pressure does not exceed 60 PSI (4.1 bar).

### Setting Coolant Temperature (H<sub>2</sub>O cooled versions)

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 set-point 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.

**Guidelines**

- 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.

See dew point temperature table below for a range of air temperature and relative humidity values. Remember that the laser’s coolant temperature must be set above the dew point temperatures shown in the chart, but should not exceed 22 °C (72 °F).

Dew Point Table °F Temperatures

Air Temperature (°F)	Relative Humidity (%)															
	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
60°	-	-	-	32	36	39	41	44	46	48	50	52	54	55	57	58
65°	-	-	33	37	40	43	46	48	51	53	55	57	59	60	62	64
70°	-	33	37	41	45	48	51	53	56	58	60	62	64	65	67	69
75°	-	37	42	46	49	52	55	58	60	62	65	67	68	70	72	73
80°	35	41	46	50	54	57	60	62	65	67	69	71	73	75	77	78
85°	40	45	50	54	58	61	64	67	70	72	74	76	78	80	82	83
90°	44	50	54	59	62	66	69	72	74	77	79	81	83	85	87	88
95°	48	54	59	63	67	70	73	76	79	81	84	86	88	90	92	93
100°	52	58	63	68	71	75	78	81	84	86	88	91	93	95	97	98

Dew Point Table °C Temperatures

Air Temperature (°C)	Relative Humidity (%)															
	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
16°	-	-	-	0	2	4	5	7	8	9	10	11	12	13	14	15
18°	-	-	1	3	4	6	8	9	11	12	13	14	15	16	17	18
21°	-	1	3	5	7	9	11	12	13	14	16	17	18	18	19	21
24°	-	3	6	8	9	11	13	14	16	17	18	19	20	21	22	23
27°	2	5	8	10	12	14	16	17	18	19	21	22	23	24	25	26
29°	4	7	10	12	14	16	18	19	21	22	23	24	26	27	28	28
32°	7	10	12	15	17	19	21	22	23	25	26	27	28	29	31	31

	35°	9	12	15	17	19	21	23	24	26	27	29	30	31	32	33	34
	38°	11	14	17	20	22	24	26	27	29	30	31	33	34	35	36	37

## Controlling Laser Power

### Control Signals

Much of the information provided in this section describes the use of a SYNRAD UC-2000 Universal Laser Controller to provide tickle and PWM Command signals to the vi Series laser. If using an alternate method of laser control, thoroughly review this section, Controlling Laser Power, as well as the following section, DB-9 I/O connections, for an understanding of the signal requirements necessary to control vi Series lasers. For more information about the UC-2000, please consult the UC-2000 Laser Controller Operator's Manual.

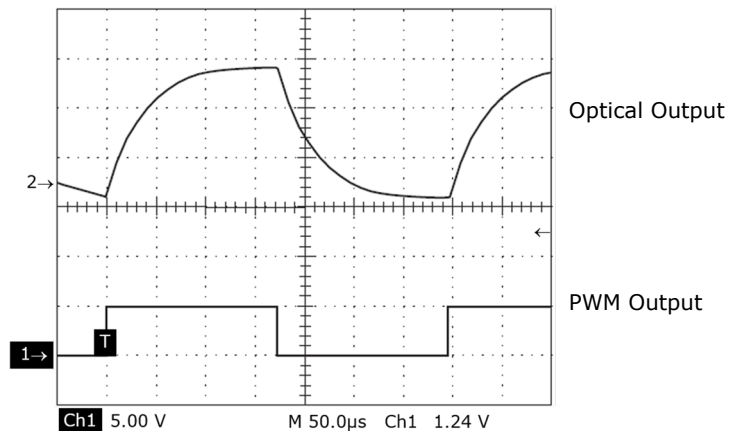
## Operating Modes

### Pulse Width Modulation (PWM)

Pulse Width Modulation, or PWM, controls laser power by varying the duty cycle of the laser's RF amplifiers, which in turn control the time-averaged RF power applied to the laser. Typically, laser output follows the PWM input with a rise and fall time constant of  $\sim 100 \mu\text{s}$ ; however, the laser cannot precisely follow PWM input signals if the "On" pulse is less than  $100 \mu\text{s}$  in duration. At a constant 50% duty cycle, vi30/40 lasers typically reach 90–100% of full optical output when operated at a frequency of 5 kHz and reach 65–80% optical output at 7 kHz. The percentage of optical output increases as duty cycle increases (at a constant PWM frequency) or as PWM frequency decreases (at a constant duty cycle). The following figure shows representative vi Series optical output waveforms at two different PWM frequencies.

OEM vi Series lasers are designed to operate at Command signal base frequencies up to 100 kHz; however, the choice of PWM frequency depends on the user's specific application. In the majority of laser applications, the UC-2000's default Command signal frequency of 5 kHz has proven to work well. For high-speed motion applications that cannot tolerate any ripple in the optical beam response but still need adjustable power levels, we recommend the use of higher PWM frequencies, up to 100 kHz maximum.

Typical optical output pulse (50%) duty cycle at 3kHz:

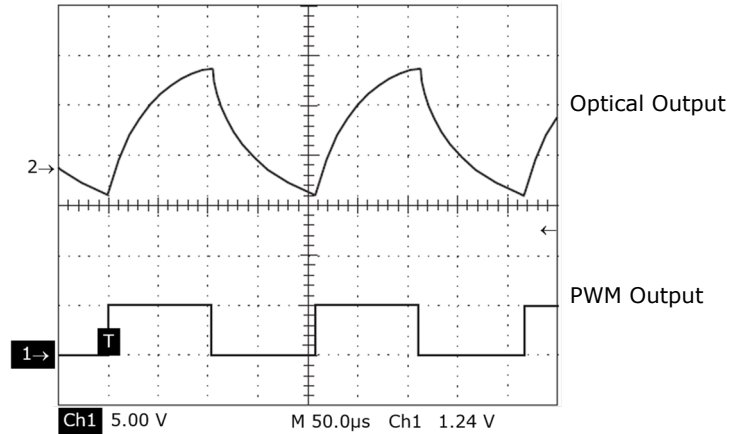




Always use shielded cable when connecting to your PWM Command signal source to PWM Input/PWM Return inputs.

In electrically-noisy environments, long lengths of unshielded wire act like an antenna and may generate enough voltage to trigger un-commanded lasing.

Typical optical output pulse (50%) duty cycle 5kHz:



### Command Signal

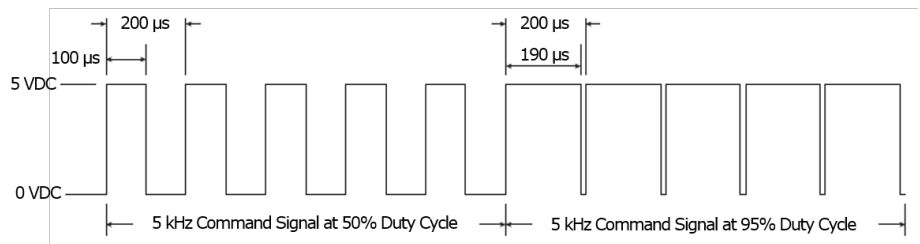
The modulated Command signal applied between Pin 1, PWM Positive, and Pin 6, PWM Negative, of the DB-9 I/O connector on the vi Series laser has three basic parameters: signal amplitude, base frequency, and PWM duty cycle. By changing these parameters, you can command the beam to perform a variety of marking, cutting, welding, or drilling 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.

Base frequency, the second parameter, is the repetition rate of the PWM input signal. The standard base frequency is 5 kHz, which has a period of 200 μs. Maximum PWM frequency is 100 kHz.

The third Command signal parameter, PWM duty cycle, is the percentage of the period that the Command signal is high. 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. The following figure illustrates PWM Command signal parameters while the following table lists PWM signal specifications.

PWM Command Signal Waveform:



The vi30+/40's DB-9 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 DC (0 Hz) to 100 kHz. The following table below provides minimum, maximum, and nominal PWM signal specifications.

PWM Command Signals

Laser State	Minimum	Nominal	Maximum
Laser Off	0.0 VDC	0.0 VDC	+0.8 VDC
Laser On	+3.5 VDC (5 mA)	+5.0 VDC (9 mA)	+6.7 VDC (10 mA), continuous
Frequency Range	0 Hz (DC)	5 kHz	100 kHz
Duty Cycle	0%	--	100%



SYNRAD lasers are designed for maximum performance using a 95% duty cycle. Increasing the maximum PWM percentage beyond 95% greatly increases the laser's heat load with little or no corresponding increase in laser output power.

**Tickle Pulse**



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.

SYNRAD vi Series lasers do not incorporate internal tickle; therefore, users must provide 1µs duration tickle pulses, at a frequency of 5 kHz, between applied PWM Command signals. A tickle pulse must be sent at the end of every 200-µs interval in which a PWM Command signal was not applied.

**External Control**

The two primary elements of laser control are gating, the ability to turn the laser on and off at the appropriate times, and power, the ability to control the laser's output energy. Both gating and power can be handled by a device such as a personal computer, Programmable Logic Controller (PLC), or function generator capable of providing tickle pulses in addition to sending PWM signals at the proper time (gating) and with the proper duty cycle (power).

**Analog Voltage or Current Control**

Although OEM vi Series lasers cannot be controlled directly by analog voltage or current signals, this type of control is possible when using the UC-2000 Controller. The Controller is connected normally to the laser and analog voltage or current signals sent to the UC-2000's ANV/ANC connector then control both laser gating and power.

To generate the correct analog voltage for the UC-2000 Controller from a computer or PLC, a Digital-to-Analog (D/A or DAC) card capable of generating 0 V (laser off) to 10 V (maximum laser power) must be installed. To generate the proper analog current, install a D/A card that

can generate 4 mA (laser off) to 20 mA (maximum power). Software able to control your analog output card is required for either configuration.

### **Continuous Wave (CW)**

In some applications, such as high speed marking or cutting, the time constant of the laser and the PWM modulation causes a series of dots that may be visible on the marking surface instead of a "clean" line. Operating the laser in CW mode will prevent this behavior from occurring.

To operate the laser in CW mode, apply a constant +5 VDC signal to Pin 1, PWM Positive, and Pin 6, PWM Negative, on the DB-9 I/O connector. This constant voltage source forces the internal switching electronics to remain on, providing continuous and uninterrupted laser output power. During CW operation, output power cannot be changed. To adjust output power, refer back to the Pulse Width Modulation (PWM) section for information regarding high frequency operation.

### **Gated Operation with the UC-2000**

In many marking and cutting applications, the laser is required to pulse, or gate, on and off in synchronization with an external control signal (typically from a computer or function generator operating in the range from DC to 1 kHz). To pulse or gate the laser, connect a signal providing +5.0 VDC pulses to the Gate connector on the rear panel of the UC-2000.

The UC-2000's default gate logic is factory set to internal Pull-Up (normally on) mode so that an open (disconnected) Gate input causes the laser to turn on. This functionality allows the user to easily test and verify laser operation prior to integration.

In an integrated system, you should configure the UC-2000's gate input logic to internal Pull-Down (normally off) mode. This pre-vents the beam from being enabled unless a high level (+3.5 V to +5.0 VDC) signal is applied to the Gate input connector. In the Pull-Down (normally off) mode an asserted logic low signal, short circuit to ground, or an open or disconnected Gate input locks the beam off.

Users who intend to use a gating signal should set the UC-2000's gate input logic to internal Pull-Down (normally off) mode. This prevents the beam from being enabled unless a high level (+3.5 V to +5.0 VDC) signal is applied to the Gate input connector. In the pull-down (normally off) mode, an asserted logic low signal, short circuit to ground, or an open or disconnected Gate input locks the beam off.

Many CO<sub>2</sub> lasers operating in applications requiring short gating pulses at repetition rates below 500 Hz will exhibit some leading edge overshoot regardless of the PWM frequency. This occurs because a cool lasing medium (the CO<sub>2</sub> gas) is more efficient than a hot one. The overshoot effect is more pronounced at lower gating frequencies since the gas has a longer time to cool down between Command signal pulses.



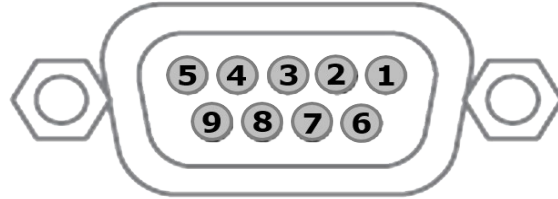
## **DB-9 I/O Connections**

### **User I/O Connection Summary**

The DB-9 I/O connector provides a +5 VDC auxiliary output (DC Out), a PWM input, an enable input, and four status outputs. The user inputs, Laser Enable and PWM Positive/PWM Negative, enable lasing and provide output power control. User outputs

indicate vi30+/40 ready, lase, overtemp, and input voltage status. The OEM vi30+/40's PWM inputs are optoisolated; however, all other inputs and outputs operate using standard 5V logic levels (0V – logic low; 5V – logic high). Both inputs and outputs are ESD protected, but are not optoisolated; all input signals sent to the laser must be clean or conditioned by the user. The figure below illustrates the pin arrangement of the DB-9 I/O (9-pin female D-type subminiature) connector on the OEM vi30+/40's rear panel while the following table provides connection descriptions.

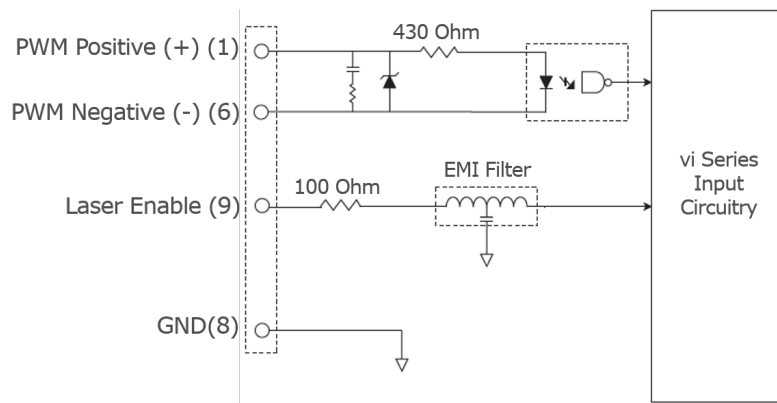
DB-9 I/O Connector Pinouts/DB-9 I/O Pin Descriptions:



Function	Pin #, Description	Signal Specifications
<b>PWM Command</b>	<p><b>Pin 1 = PWM Positive Input</b> Use this optoisolated input (referenced to <b>pin 6</b>) to provide tickle and Pulse Width Modulated signals to the laser. When this input is on, 48 VDC is applied to the RF driver.</p> <p><b>Pin 6 = PWM Return</b> This input is isolated from the other inputs and provides the return side for the PWM Input.</p>	<p>Off state Vmax = 0.8 VDC On state Vmin = 3.5 VDC @ 5 mA On state Vmax 6.7 VDC @ 10 mA Frequency = 0 to 100 kHz</p>
<b>Laser Ready</b>	<p><b>Pin 2 = Laser Ready Output</b> This output is logic high (5V, referenced to <b>pin 8</b>) to indicate the laser is ready to lase, logic low (0V) when the laser is disabled.</p>	<p>Off state Vmax = 0.8 VDC On state Vmin = 4.5 VDC @ 50 mA On state Vmax 5.0 VDC @ 0.5 mA</p>
<b>Laser Active</b>	<p><b>Pin 3 = Laser Active Output</b> This output is logic high (5V, referenced to <b>pin 8</b>) to indicate the laser is firing, logic low (0V) to indicate the laser is inactive.</p>	
<b>Overtemp Fault (vi30+ only)</b>	<p><b>Pin 4 = Overtemp Fault Output</b> This output is logic high (5V, referenced to <b>pin 8</b>) to indicate the laser has had an overtemp fault, logic low (0V) to indicate the laser temperature is within limits.</p>	
<b>Temperature Broadcast (vi40)</b>	<p><b>Pin 4 = Temperature Broadcast Output</b> This output provides a serial data stream that provides the laser temperature data See Appendix TBD for the full details.</p>	

<b>DC Voltage Fault</b>	<b>Pin 7 = DC Voltage Fault Output</b> This output is logic high (5V, referenced to <b>pin 8</b> ) to indicate the laser's supply voltage has gone under or over the specified supply voltage range. The output is logic low (0V) to indicate the supply voltage is within limits.	
<b>Laser Enable</b>	<b>Pin 9 = Laser Enable Input</b> Use this input to enable or disable the laser.	Off state $V_{max} = 0.8$ VDC On state $V_{min} = 2.0$ VDC @ 0.2 mA On state $V_{max} 5.0$ VDC @ 0.5 mA
<b>DC Out</b>	<b>Pin 5 = DC Out</b> This output provides a 5 VDC at 250 mA source for use with the other I/O.	N/A
<b>Ground</b>	<b>Pin 8 = I/O Ground</b> This pin provides the reference ground for all inputs and outputs except the PWM Command input.	N/A

DB-9 I/O Connector – Input Equivalent Schematic:



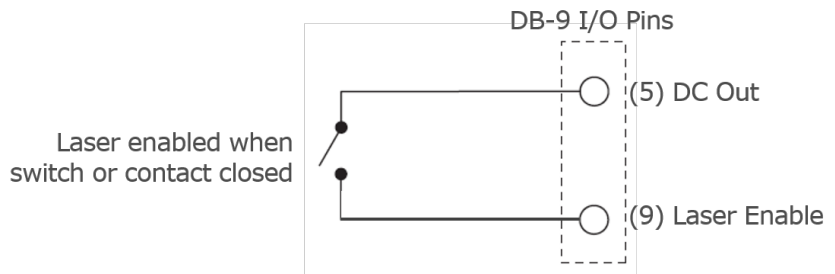
Input Circuit Specifications:

Input Signals	Input Device Type and Specifications
PWM Positive	<ul style="list-style-type: none"> <li>High-speed optoisolator LED</li> <li>On state <math>V_{min} +3.5</math> VDC @ 5 mA</li> <li>On state (continuous) <math>V_{max} +6.7</math> VDC @ 10 mA</li> <li>Frequency, max. 100 kHz</li> </ul>
Laser Enable	<ul style="list-style-type: none"> <li>5V logic input buffer</li> <li>Off state <math>V_{max} +0.8</math> VDC</li> <li>On state <math>V_{min} +2.0</math> VDC @ 0.2 mA</li> <li>On state (continuous) <math>V_{max} +5.0</math> VDC @ 0.5 mA</li> </ul>

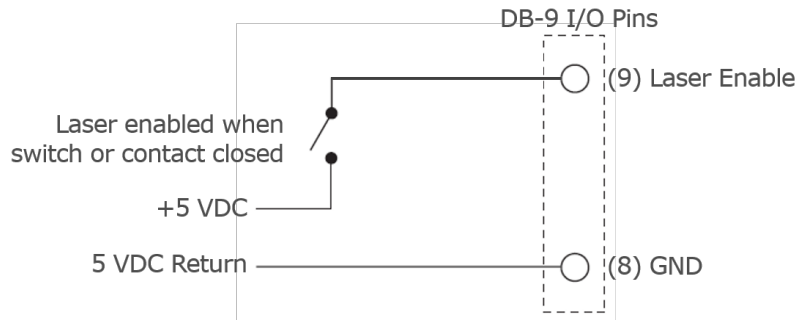
### Sample Input Circuits

The figure below illustrates one method of applying the Laser Enable signal using a customer-supplied limit switch or relay contact powered by the vi Series' DC Out output (+5V, 250 mA).

OEM vi Series Powered Laser Enable Circuit:

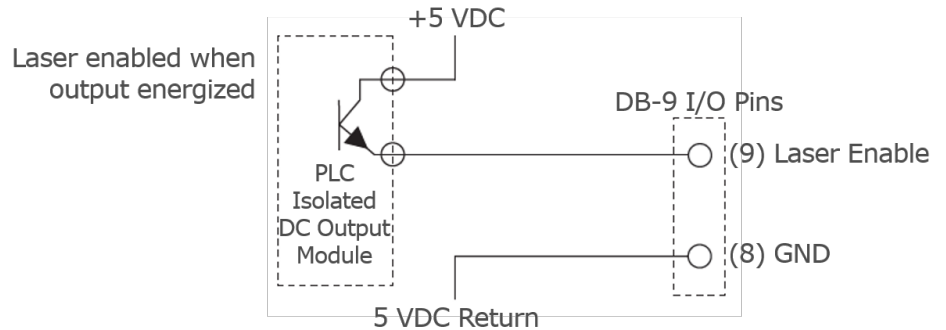


Customer Powered Laser Enable Circuit:



The figure below shows an isolated PLC output module switching the Laser Enable signal from a +5 V source.

PLC Switched Laser Enable Circuit:



**Output Circuitry**

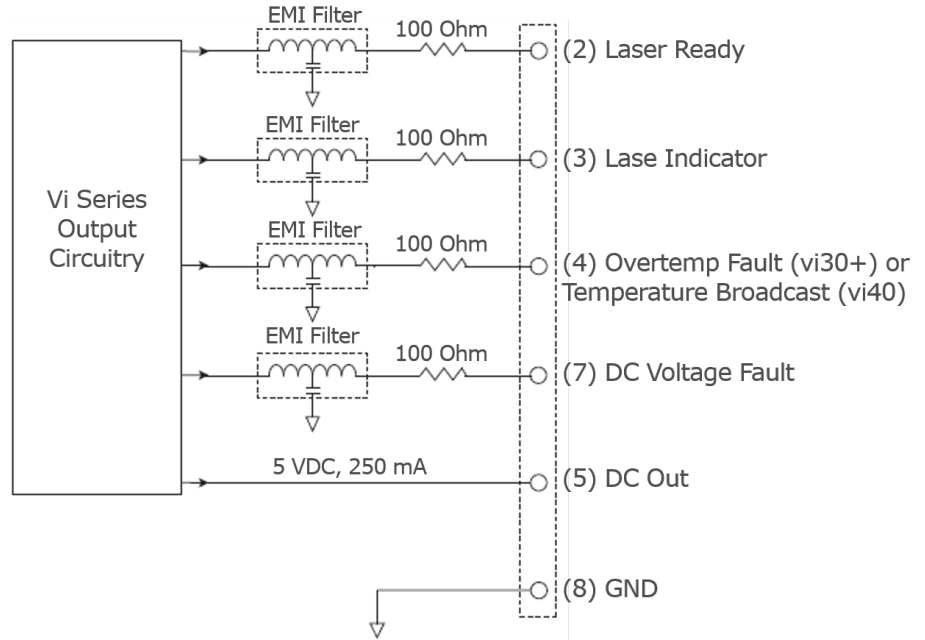
The OEM vi Series has four user outputs that communicate laser status to the user's control system. As described in the following table, the four outputs, Laser Ready, Lase Indicator, Overtemp Fault, and DC Voltage Fault are ESD protected, but are not optoisolated. The Laser Ready output goes high (+5V) when lasing is possible, otherwise the output is low (0V) when the laser is not ready. Lase Indicator goes high when the PWM signal is sufficient to induce laser output and is low when no beam is being emitted. Overtemp Fault goes high when laser temperature rises above its upper thermal limit; otherwise the output is low. DC Voltage Fault goes high when an under/over voltage condition is sensed; otherwise the output is low when the DC supply voltage is within limits.

The vi30+/40 also includes a +5 VDC output voltage source, DC Out. This output can provide a maximum current of 250 mA and is useful for driving the Laser Enable input as described in the Input circuitry subsection.



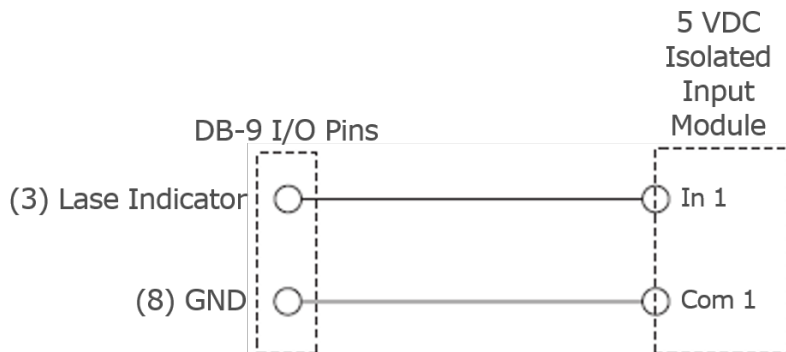
OEM vi Series outputs are voltage sources. Each output can source 50 mA to a ground referenced load (the ground reference, GND, is Pin 8).

Output Equivalent Schematic:



### Sample Output Circuit – Lase Indicator Output to PLC Input

You can monitor OEM vi Series laser status remotely by connecting one or more outputs to an isolated 5 VDC solid state relay or PLC input module. The figure below illustrates the connections required to monitor the vi30+’s Lase Indicator status, or any other vi30+ output, using an isolated 5 VDC input module.



# General Specifications

## vi Series

Output Specifications	vi30+			vi40
	9.3 $\mu\text{m}$	10.2 $\mu\text{m}$	10.6 $\mu\text{m}$	10.6 $\mu\text{m}$
Wavelength Typical ( $\mu\text{m}$ )	9.23 – 9.31	10.2 – 10.3	10.6 $\pm$ 0.03 <sup>9</sup>	
Average Power Output Continuous <sup>1,2</sup> (minimum)	20 W	25 W	30 W	40 W
Power Stability <sup>3</sup> , guaranteed/after 2 min. (typical)	$\pm$ 7%/ $\pm$ 5%	$\pm$ 5%/ $\pm$ 3%		
Mode Quality M <sup>2</sup>	$\leq$ 1.2			
Beam Waist Diameter, mm (at 1/e <sup>2</sup> )	2.5 $\pm$ 0.5			
Beam Divergence, full angle, mrad (at 1/e <sup>2</sup> )	<7.0			
Ellipticity	$\leq$ 1.2			
Polarization	Linear, horizontal			
Rise Time	< 100 $\mu\text{s}$			
Input Specifications	vi30+		vi40	
Power Supply				
Voltage	48 VDC $\pm$ 2.0 VDC			
Maximum Current <sup>5</sup>	10A (11A peak for < 1ms)		15A (17A peak for < 1ms)	
Input Signals	Tickle Signal / PWM Command Signal			
Voltage (5V nominal)	+3.5 to +6.7 VDC / +3.5 to +6.7 VDC			
Current	10 mA @ +6.7 VDC / 10 mA @ +6.7 VDC			
Frequency	5 kHz (1 $\mu\text{s}$ duration) / DC-100kHz			
Cooling Specifications	vi30+		vi40	
Maximum Heat Load	500 Watts		650 Watts	
Maximum Chassis Temperature	$\leq$ 60 $^{\circ}\text{C}$ (158 $^{\circ}\text{F}$ )		$\leq$ 60 $^{\circ}\text{C}$ (158 $^{\circ}\text{F}$ )	
Minimum Flow Rate	140 CFM per fan (two fans required)		190 CFM per fan (two fans required)	
Environmental Specifications	vi30+		vi40	
Operating Ambient Temperature Range <sup>4</sup>	15 $^{\circ}\text{C}$ - 40 $^{\circ}\text{C}$		15 $^{\circ}\text{C}$ - 45 $^{\circ}\text{C}$	
Humidity	0 – 95%, non-condensing			
Physical Specification	vi30+ (Dual)	vi30+ (Air)	vi40 (Air)	
Length	465.7 mm (18.12 in.)	426.7 mm (16.8 in.)		
Width	88.9 mm <sup>8</sup> (3.495 in.)			
Height	138.7 mm <sup>6,7</sup> (5.46 in.)			
Weight	6.8 kg (15.0 lbs.)	6.49 kg (14.3 lbs.)	6.71 kg (14.8 lbs.)	

\* Specifications subject to change without notice.

1 - This power level is guaranteed for 24 months for the vi30+ and 12 months for the vi40, regardless of operating hours.

2 - 48 VDC input voltage to obtain guaranteed output power.

3 - Guaranteed from cold start at 5kHz, 95% duty cycle. Value after 2 minutes typical.

4 - Published specifications guaranteed at a temperature of 22 °C. Some performance degradation may occur in ambient temperatures above 22 °C. For air-cooled lasers, laser power typically decreases 0.5–1% per degree Celsius increase in ambient temperature.

5 - For <1ms @ 100Hz, 50% duty cycle.

6 - Mounting feet will add 1/4 in (0.64 cm) to overall height.

7 - Tall models, add 1/4 in (0.64 cm) to overall height.

8 - Wide models, add the width of the mounting feet for an overall width of 4.58 in (11.633 cm).

9 - Typical. Actual wavelength may vary from 10.2 - 10.8 μm.

## Maintenance Procedures



### Introduction

This section of the Operation Manual explains how to conduct regular maintenance of vi Series lasers. If you cannot attend to the unit using the information described in this manual, contact SYNRAD®, (+.425.349.3500) or an authorized SYNRAD Distributor.



### Disabling a vi Series Laser

Before performing any maintenance on your vi Series laser, be sure to completely disable the laser by disconnecting the DC Power Cables from the DC power supply.



### Periodic Maintenance

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

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.

If you operate the laser in dirty or dusty environments, contact SYNRAD® about the risks of doing so and precautions you can take to increase the longevity for the laser system 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 the Setting coolant temperature section in the Intro, and technical reference chapters for details on preventing condensation.

2. 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.
3. Visually inspect the exterior housing of the laser to ensure that all warning labels are present. Refer to the Laser Safety chapter for vi30/40 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)—Wear 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.

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



Ensure that DC power to the laser is turned off and locked out before inspecting optical components in the beam path.

Invisible CO<sub>2</sub> laser radiation is emitted through the aperture. Corneal damage or blindness may result from exposure to laser radiation.

### 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.

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 Optics 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; always use gloved hands or fingers.
- Hold optics by the outer edge; never touch the coated surface.

- Always place optics lens on a tissue or suitable equivalent material 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

The table below lists the type and grade of materials required to properly clean optical surfaces.

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



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.
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.
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. Use a clean lens wipe on each pass. The wipe will pick up and carry surface contaminants that may scratch optical surfaces or coatings.
6. Carefully examine the optic under suitable lighting. 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.



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.



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.

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

## Troubleshooting Procedures

### Introduction

The Troubleshooting 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 information.

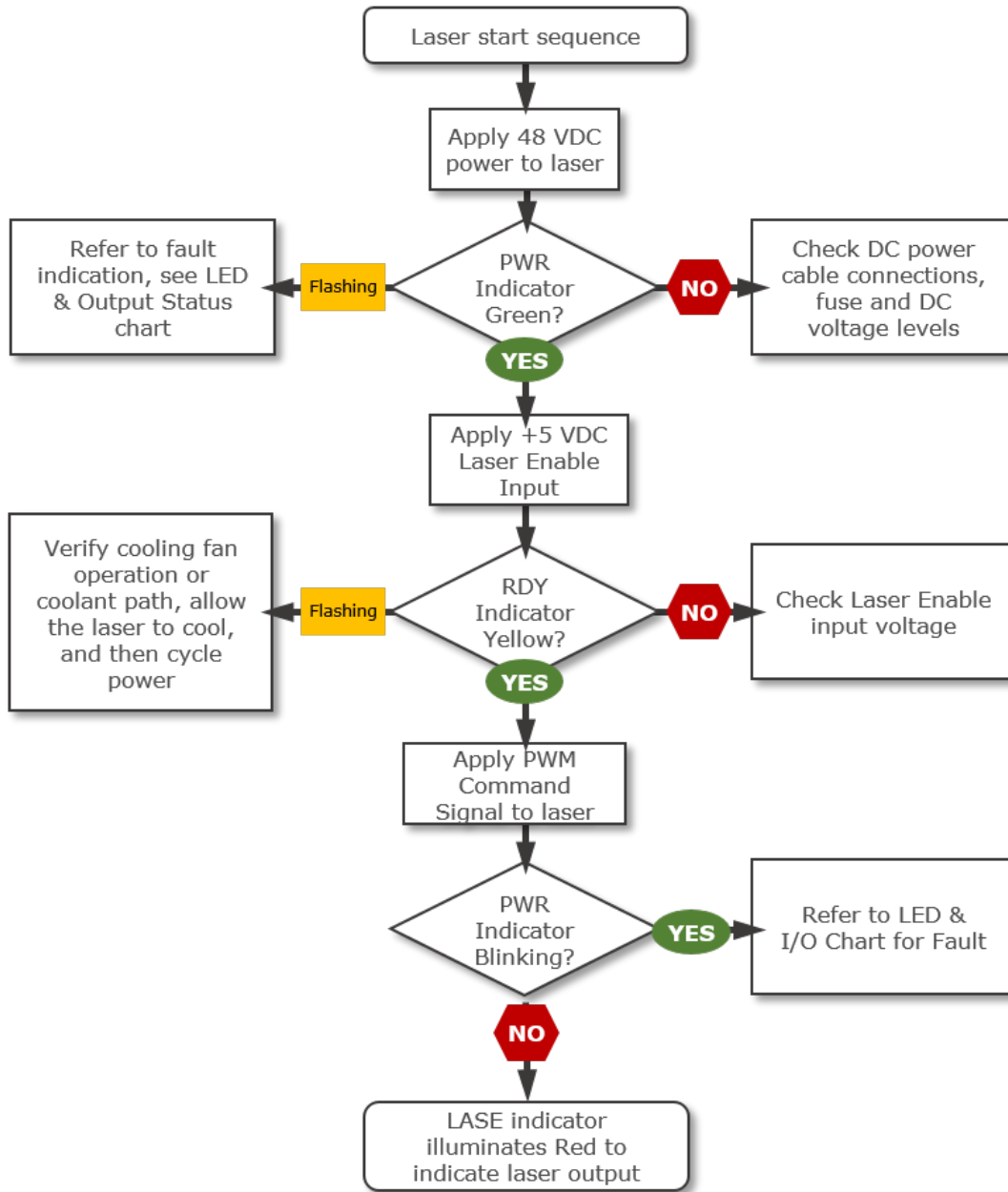
Attempting repair of a SYNRAD laser without the express authorization of SYNRAD, will void the product warranty.

If troubleshooting or service assistance is required, please contact SYNRAD Customer Service.



To troubleshoot vi Series 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 on the following page.

### Operational Flowchart



### Status LEDs

OEM vi Series LED indicators, in conjunction with the DB-9 I/O outputs, provide status information to the user. The table below shows LED indicator and output signal states during normal and fault conditions.

On OEM vi Series lasers, the PWR indicator illuminates green on DC power up. The RDY LED illuminates yellow when a Laser Enable signal is applied customer-supplied tickle signals are passed through to the RF driver. When PWM Command pulses are applied (and are long enough to produce laser output) the LASE LED illuminates red.

### Laser Fault Indications

OEM vi Series lasers have the ability to indicate five specific fault conditions. In the event of certain faults, the RDY LED, PWR LED or both will blink an error code, pause 1/2 second, and then repeat the code. This sequence continues until the fault is corrected and the laser is reset by cycling DC power to the laser.

## vi Series Input I/O Status States

Laser Condition/Fault	Input Status		LED Status			Output Status					Comments
	Laser Enable	PWM				Laser Ready	Overtemp*	Temperature Broadcast**	DC Voltage Fault	Laser Active	
PIN #	9	1 to 6				2	4	4	7	3	Except for PWM, all I/O referenced to Pin 8
DC Power Off	X	X				L	L	L	L	L	No RF to tube
DC Power Applied Laser Not Enabled	0	X				L	L		L	L	No RF to Tube
DC Power Applied Laser Enabled	1	0				H	L		L	L	Tickle applied to tube for 5 seconds, the laser may fire
Laser Firing	1					H	L		L	H	Normal laser operation with PWM active
Over Temperature	1	X				L	H		L	L	Chassis temperature > 60°C
Under Voltage	1	X				L	L		H	L	P/S Voltage >52 VDC
Over Voltage	1	X				L	L		H	L	P/S Voltage > 52 VDC
DC Sense	1	X				L	L		L	L	Laser service required
PWM Drive Fault	1	X				L	L		L	L	Laser service required
Table Key	0 = Input OFF (0.8V max) 1 = Input ON (2.0V min) X = Does not matter		 	<b>Blinking LED</b> # = Blink pattern C = Continuous blink		L = Low (0.8V max) H = High (4.5V min) * = vi30+ only ** = vi40 only					



On vi Series OEM lasers, enable faults are not latched. Clearing the fault condition re-enables the RDY indicator and the laser will fire after the five-second delay provided the SHT indicator is lit and a PWM Command signal is applied. Because exposure to 10.6 μm CO<sub>2</sub> 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.

## Resetting Faults

### Over Temperature Fault

Over temperature faults occur when thermal limits in the laser are exceeded (RDY indicator flashes continuously; PWR LED remains solid green). To reset an over temperature fault, cool laser chassis temperature below 60 °C and then cycle DC power. When the RDY LED illuminated without flashing, lasing is enabled.

### Under Voltage Fault

An under voltage fault occurs when the DC input voltage is at or below 45 VDC. This fault is indicated by the PWR indicator flashing 1 blink at 1/2 second intervals. To reset

an under voltage fault, ensure that 48 VDC is applied to the laser under full-load conditions and then cycle DC power. When PWR and RDY indicators illuminate, lasing is enabled.

Under voltage faults are typically caused by the DC power supply being unable to properly regulate output voltage under full-load or high inrush current conditions. Improper regulation may be caused by an undersized DC supply or insufficient AC line voltage.

### **Over Voltage Fault**

An over voltage fault occurs when the DC input voltage is at or above 52 VDC. This fault is indicated by the PWR indicator flashing 2 blinks at 1/2 second intervals. To reset an over voltage fault, ensure that 48 VDC is applied to the laser under full-load conditions and then cycle DC power. When PWR and RDY indicators illuminate, lasing is enabled.

### **DC Sense Fault**

A DC Sense fault is indicated by the PWR indicator flashing 3 blinks at 1/2 second intervals. If this fault occurs, the laser requires service, contact SYNRAD or a SYNRAD Authorized Distributor.

### **PWM Sense/Control Board Fault**

A PWM Sense or control board fault is indicated by both RDY and PWR indicators flashing continuously. If this fault occurs, the laser requires service, contact SYNRAD or a SYNRAD® Authorized Distributor.

### **No Power LED Fault**

The power supply is connected and the voltage is correct, but the PWR LED is not on. The in line fuse on the red power wire has blown. Replace the fuse.

### **Beam Delivery Optics**

The laser appears to lose power over time; laser output power must be increased to maintain previous performance.

Beam delivery optics are coated by vapor residue or debris. Check the condition of the optics and clean or replace as needed.

# Addendum

## vi40 Temperature Broadcast

### Overview

The vi40 is equipped with a Temperature Broadcast Feature, which provides users the ability to monitor the laser's internal temperature status.

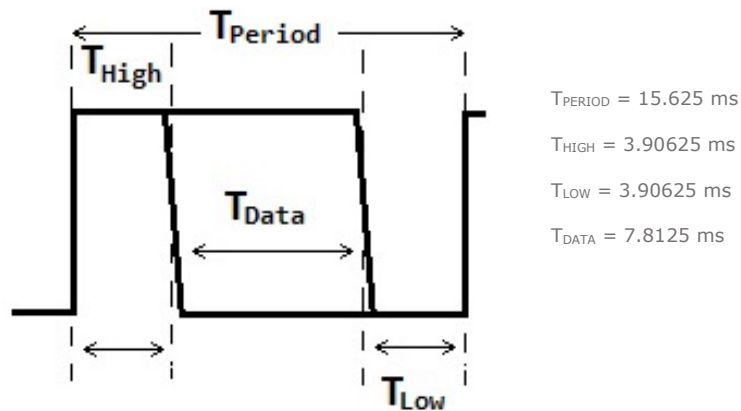
The temperature data is:

- Indicated in degrees Celsius (°C)
- Transmitted as 13 bit serial data packets through pin 4 (referenced to pin 8) of the laser's DB-9 I/O connector
- Transmitted as values ranging from 0 to 125°C and a resolution of 0.0625°C per bit

### 1-Wire Synchronous Data Transmission:

Data transmission on the Vi40 temperature output line is synchronous and follows a set of rules:

- 1) The start of the data bit must always be high for 3.90625 ms
- 2) The end of the data bit must always be low for 3.90625 ms
- 3) One data bit period is 15.625ms (64 Hz)
- 4) The end of each data packet must always be low for a rest period of 250 ms

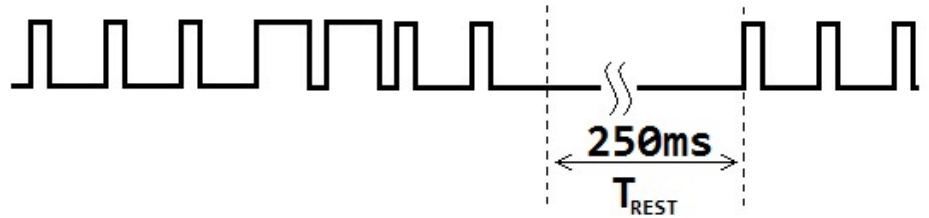


Synchronous Transmission of a Single BIT

The figure above shows the protocol for the synchronous transmission of a single bit. The rising edge of the output signal indicates the start of a data bit and the level must remain high for the time indicated by  $T_{HIGH}$ . Data is transmitted next and this value can either be logic high or low. The time provided for the data value to be read is indicated by  $T_{DATA}$ . After the data bit, the signal is pulled low (if data is high) or stays low to indicate the end of bit. The signal must remain low for the duration of the time indicated by  $T_{LOW}$ . The signal is repeated for the next bit to be transmitted. At the end of the data stream, there is a rest period to indicate the end of a transmission packet.

The duration of the rest period is indicated by  $T_{REST}$ (figure below). A rising edge signal after the rest period indicates a start of a new data packet and the data bit transmission method is repeated.

Rest Period:



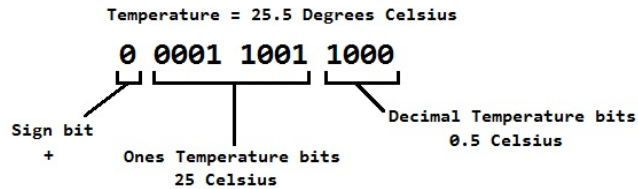
**Temperature Reading:**

The temperature output on the Vi40 control board is indicated in degrees Celsius ( $^{\circ}C$ ). The temperature data consists of a 13-bit two’s complement data where the 13<sup>th</sup> bit is the signed bit plus 12 data bits. The temperature measurement has a resolution of 0.0625 $^{\circ}C$  per bit and has a range from 0 to +125 $^{\circ}C$ .

For example:

Temperature ( $^{\circ}C$ )	Data (12:0)
+125	0 0111 1101 0000
+25	0 0001 1001 0000
+0.0625	0 0000 0000 0001
0	0 0000 0000 0000

The first bit of transmission is the signed bit for negative temperatures. (The initial release of the vi40 limits the temperature readings to above 0 $^{\circ}C$ , but this bit has been added to allow for future expansion if needed.) The next 8 bits of data represents the binary temperature value in 1 $^{\circ}C$  increments. The last 4 bits of data represents the binary temperature value in 0.0625 $^{\circ}C$  increments. The figure below shows a typical temperature output transmission a customer can expect to see:



The figure below shows an example output of 25.5  $^{\circ}C$ :

