

f201 Operator's Manual



SYNRAD®

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f201 Operator's Manual

Version 3.4

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table of contents

Laser Safety 1

Warranty information	vii
Sales and Applications	viii
Customer Service	viii
Technical Support	viii
Reference materials	viii
Hazard Information	11
Terms	11
General hazards	12
Other hazards	14
Disposal	14
Additional laser safety information	14
Agency compliance	18
Center for Devices and Radiological Health (CDRH) requirements	18
OEM model	18
Federal Communications Commission (FCC)	19
Requirements	19
European Union (EU) requirements	20
Introduction	26
Firestar nomenclature	26
Unpacking	26

Getting Started 2

Introduction	26
Firestar nomenclature	26
Unpacking	27
Incoming inspection	27
Packaging guidelines	27
Removing the lifting handles	29
Inventory	30
f201 lasers	30
Connecting	34
Cooling connections	34
PS-96 power supply connections	38
PS-96 AC input section	39
Control connections	42
Other connections	43

table of contents

Getting Started 2

Incoming inspection	27
Packaging guidelines	27
Unpacking	27
Unpacking the laser	27

Operation 3

Unpacking	28
Removing the lifting handles	29
Inventory	29
f100/f201 lasers	30
Inventory	30
Mounting	32
f100/f201 mounting	32

Technical Reference 4

Mounting	33
Mounting	33
f201 mounting	33
Mounting	35
Cooling connections	36
PS-96 power supply connections	41
Other connections	50
Controls and indicators	53
f201 lasers	53
Initial start-up	55
With a UC-2000 Controller	55
Initial start-up	57
Without a UC-2000 Controller	57
Initial start-up	58
Technical overview	64
Laser tube	64
Optical resonator	64
Technical overview	65

table of contents

Maintenance/Troubleshooting 5

Internal RF power supply	65
Optical setup	66
Technical overview	67
Controlling laser power	68
Control signals	68
Operating modes	70
User I/O connections	73
Input/output signals	74
DC Power cables	86
Integrating Firestar safety features	87
OEM lasers	87
Integrating Firestar safety features	88
Remote interlock functions	88
f201 general specifications	90
Maintenance	94
Disabling f201 lasers	94
Daily inspections	94
Storage/shipping	95
Cleaning optical components	95
Troubleshooting	98
Introduction	98
Troubleshooting	99
Operational flowchart	99
Troubleshooting	100
Functional block diagram	100
Troubleshooting	101
Status LEDs	101
Troubleshooting	102
Laser fault indications	104
Resetting faults	104
Troubleshooting	105
Other laser faults	106
Troubleshooting	107
Beam delivery optics	109
Troubleshooting	110

table of contents

List of Figures

Figure 1-1 Labeling terms and definitions.	12
Figure 1-2 Safety goggles.	14
Figure 1-5 F 201 hazard label locations.	18
Table 1-1 Class 4 safety features.	22
Table 1-2 European Union Directives.	23
Figure 1-7 F201 declaration of conformity.	25
Figure 2-1 Unpacking the laser.	29
Figure 2-2 Removing lifting handles.	30
Figure 2-3 F201 shipping box contents.	31
Table 2-1 f100/f201 ship kit contents.	32
Figure 2-5 Fastening f100/f201 from above.	33
Figure 2-7 Improper mounting method.	34
Figure 2-8 Detail of fastening into mounting surface	35
Figure 2-8 Fastening f201 from above.	35
Figure 2-10 Fastening f201 from below.	36
Figure 2-11 Detail of fastening into laser.	36
Table 2-3 Dew point temperatures.	39
Figure 2-12 F100/f201 cooling connections	40
Figure 2-13 F201 cooling connections.	41
Figure 2-14 PS-96 rear view.	43
Table 2-4 Three-phase AC electrical recommendations.	44
Table 2-5 Single-phase AC electrical recommendations.	45
Table 2-6 Purge gas specifications.	49
Figure 3-1 F201 controls and indicators (front).	51
Figure 3-2 F201 controls and indicators (rear).	52
Figure 4-1 beam characteristics.	59
Figure 4-2 "Flying optics" beam path.	60
Table 4-1 Assist gas purity specifications.	61
Figure 4-3 Typical Firestar f201 waveforms.	63
Figure 4-4 PWM Command signal waveform.	64
Table 4-2 PWM Command signal specifications.	64
Table 4-3 User I/O pin descriptions.	67
Table 4-4 Input circuit specifications.	72
Table 4-5 Output circuit specifications.	74

table of contents

List of Figures (cont.)

Figure 4-5	User I/O connector pinouts.	69
Figure 4-6	Auxiliary power supply wiring.	70
Figure 4-8	Input equivalent schematic.	72
Figure 4-7	Quick Start Plug wiring diagram.	73
Figure 4-10	Customer-supplied interlock.	75
Figure 4-11	Customer-supplied interlock, negative voltage.	75
Figure 4-12	PLC driven interlock signal.	76
Figure 4-13	Multiple PLC driven inputs.	76
Figure 4-14	Firestar output driving warning lamp.	77
Figure 4-15	Firestar output driving relay.	77
Figure 4-16	Firestar output driving PLC input module.	78
Figure 4-17	Wiring Set 1 and Set 2 to power external circuits.	79
Table 4-7	f201/f400 DC Power connector pinouts.	80
Table 4-10	Firestar f201 general specifications.	84
Table 5-1	Required cleaning materials.	90
Figure 5-1	Operational flowchart.	93
Figure 5-2	f-Series functional block diagram.	94
Table 5-2	Status signals.	95
Table 5-3	Normal operating condition.	96
Table 5-4	Quick Start Plug or interlock/shutter inputs not connected.	96
Table 5-5	Interlock open condition.	96
Table 5-6	Over Temperature fault.	97
Table 5-7	Shutter closed condition.	97
Table 5-8	VSWR fault.	97
Table 5-9	Laser error codes.	98

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Warranty information

This is to certify that Firestar® f-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. 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 f-Series 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 f-Series 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 f-Series 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 Buyer by SYNRAD, or the use thereof, infringes upon any Patent, foreign or domestic.

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Sales and Applications

SYNRAD Regional Sales Managers work with customers to identify and develop the best CO₂ 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.

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 customercare@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 the SYNRAD web site at <http://www.synrad.com>.

EU headquarters

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getting started

2

Use information in this chapter to prepare your Firestar f201 laser for operation. The order of information presented in this chapter is the same as the order of tasks that you will need to perform. The best way to get your laser ready for operation is to start at Unpacking and work your way through Connecting.

This chapter contains the following information:

Introduction – introduces the f201 laser, lists important features, and describes Firestar nomenclature.

Unpacking – provides important information about unpacking your f201 laser.

Inventory – displays and describes all components shipped with your f201 laser.

Mounting – describes how to attach your f201 laser to a mounting surface.

Connecting – explains how to connect cooling tubing, power, and control cabling.

Caution
possible
equipment
damage

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

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getting started

Introduction

F201 lasers are part of a smaller-footprint lasers from SYNRAD featuring high power and excellent beam quality. The circular beam provides more accurate cutting and faster processing speeds than competing technologies. With an integrated RF power supply, meaning no external RF cables, the compact laser housing mounts easily to flatbed cutters, robotic arms, or gantry systems making integration into your production line simple and fast.

f201 features include:

Compact resonator design	Color-coded LEDs mirror user outputs
Integrated RF power supply	"Industrial-strength" ± 5 V to 24 VDC I/O
Built-in "tickle" generator	Keypad and OEM models available

Firestar nomenclature

Firestar f201 lasers are available only as OEM lasers; they do not include either a keypad or manual shutter assembly. SYNRAD's OEM lasers are primarily designed as components for integration into larger processing systems by the Original Equipment Manufacturer (OEM) or System Integrator who bears the responsibility for meeting the appropriate laser safety requirements for Class 4 laser systems.

Single tube

Firestar f201 lasers contain a single tube (optical resonator) within the laser chassis. These lasers incorporate a single set of controls and indicators as well as a single set of cooling ports.

Model numbers

The last three characters in the Firestar model number serve to designate the functional category, cooling method, and model version. The functional category is indicated by an "S" (Switch-less) for OEM models. The next letter indicates the cooling method: "W" for water-cooled units, "W" is omitted on f201 lasers since they are all water-cooled). The last letter in the model number indicates the current model version beginning with "B". For example, the model number. FSF201SC indicates a "C" version OEM water-cooled f201 laser.

Important Note: All Firestar f201 lasers are water-cooled because of the integrated RF section's heat removal requirements. F201 lasers cannot be fan-cooled. Damage to your laser will void your warranty.

getting started

Unpacking

The Unpacking section includes subsections:

- Incoming inspection
- Packaging guidelines
- Unpacking the laser
- Removing the lifting handles

Incoming inspection

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

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

Packaging guidelines

Warning possible personal injury

Lifting or moving f201 lasers poses a potential for injury. Use appropriate lifting techniques and/or equipment to prevent a risk of injury. In some cases, you may require assistance from additional personnel to safely unpack and move this equipment.

To prevent equipment damage or loss of small components, use care when removing packaging materials.

After unpacking, review the Inventory section and verify that all components are on hand.

Do not lift or support the laser using the cooling fittings; lift the laser by the mounting feet or baseplate only.

Save all shipping containers and packaging materials, including covers and plugs. Use these specialized packing materials when shipping the laser to another location.

When packing a laser for shipment, be sure to remove all accessory items not originally attached to the laser including beam delivery components, cooling tubing, etc.

Refer to Packaging instructions drawings in the Technical Reference chapter for details on packaging f201 lasers using SYNRAD-supplied shipping materials.

When shipping water-cooled lasers, remember to drain all cooling water from the laser and then cap the open fittings to prevent debris from entering the coolant path.

F201 lasers and power supplies are heavy and awkward to move. Use appropriate lifting techniques, additional personnel, and/or hoisting equipment to prevent a risk of injury when rigging this equipment.

getting started

Unpacking

Unpacking the laser

To unbox the laser, refer to the figure below and perform the following steps:

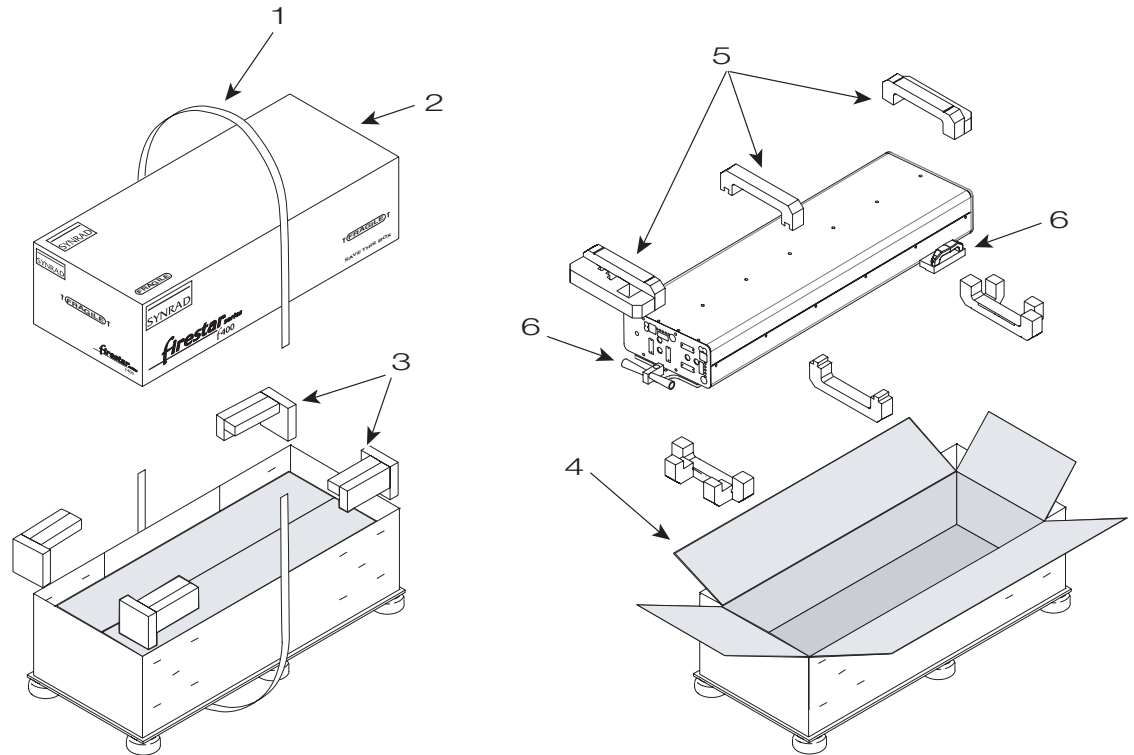


Figure 2-1 Unpacking the laser.

- 1 Carefully cut the shipping strap wrapped around the container. This strap secures the upper lid to the shipping crate.
- 2 Remove the upper lid and set it aside.
- 3 Remove the four polyurethane foam blocks that center the inner box within the outer crate.
- 4 Open the four flaps of the inner box.
- 5 Remove the three foam blocks cradling the top of the laser. To remove the center block, first slide it forward several inches and then lift.
- 6 The laser is shipped with three lifting handles bolted to the mounting feet. Use these handle grips to hoist or lift the laser from its shipping container. To prevent injury to personnel or damage to the laser, always use a minimum of three people to handle the laser.

Note: Do not lift or support the laser using the cooling fittings. Lift the laser using the lifting handles, mounting feet or baseplate only.

- 7 After removing the laser, pull out all the accessory items packaged with the laser.

getting started

Unpacking

Removing the lifting handles

Once you have placed the laser in its final mounting location, refer to the figure below and perform the following steps to remove the lifting attachments.

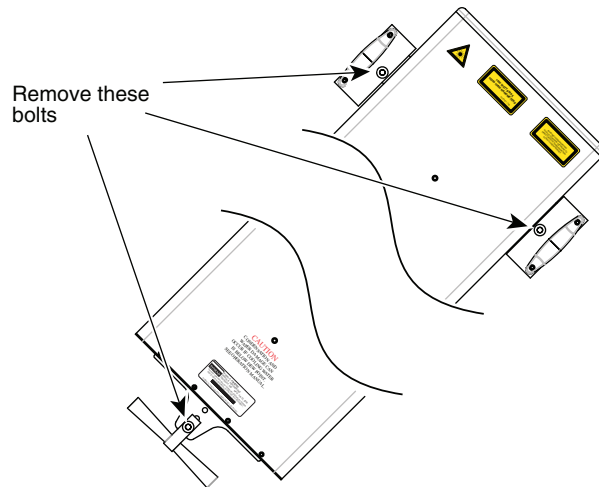


Figure 2-2 Removing lifting handles.

- 1 Locate the 8 mm hex wrench included with the accessory items.
- 2 Remove the M10 × 1.5 metric capscrews from the three locations shown in the above figure.
- 3 Retain the three M10 × 1.5 capscrews. Use these bolts for mounting if metric fasteners are required.
- 4 Store the lifting attachments so that they can be reinstalled if the laser is moved to another location.

getting started

Inventory f201 lasers

SYNRAD CO₂
Welcome flier



Quick Start Plug



Chiller Fittings and
Mounting Bolts



Cooling Tubing



DC Power Cable



Firestar f-Series Laser
(f100 shown)

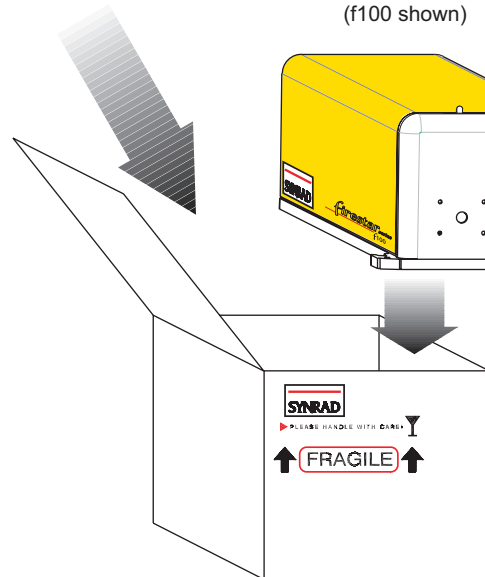
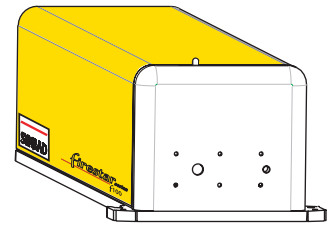


Figure 2-3 F201 shipping box contents.

getting started

Inventory

Table 2-1 f201 ship kit contents.

Shipping Box Contents	Qty	Shipping Box Contents	Qty
DC Power Cable	1	Spare 20 Ampere Fuses (not shown)	1/2
Quick Start Plug	1	Chiller Fittings	2
BNC Control Cable (f201 only)	1	Spherical Washer Sets (f201 only)	3
Cooling Tubing.....	1	Cooling Kit	1
Mounting Bolts	3/6	Final Test Report (not shown)	1
SYNRAD CO ₂ Welcome Flier	1		

f201 contents description

Each item listed in the table above is described below:

DC Power Cable – carries DC power from the DC power supply to your Firestar laser.

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

BNC Control Cable (f201 only) – Coaxial cable carries the PWM Command signal from the UC-2000 Controller to the laser’s Quick Start Plug.

Cooling Tubing – Carries cooling water from the chiller to the laser and back. This black polyethylene tubing is 1/2-inch O.D. by 30 feet and must be cut to length.

Mounting Bolts –Fasten our laser to your mounting surface. Firestar f201 lasers include three metric (M8 × 1.25 × 30 mm) and three standard (5/16–18 × 1.25" UNC) capscrews.

SYNRAD CO₂ Welcome Flier – Contains an f201 customer welcome that provides where to find, operation, and maintenance information for your f201 single-tube laser on our website.

Spare 20 Ampere Fuses (not shown) – fast-blow fuses protects Firestar’s internal circuitry.

Chiller Fittings – Adapt 1/2-inch O.D. tubing to 3/8" NPT threads for connection to a chiller. The chiller’s inlet and outlet ports must be equipped with, or be adapted to, 3/8" NPT female threads.

Spherical Washer Sets (not shown) – used in conjunction with Firestar f201 mounting bolts to align the laser to your mounting surface. Shipped with f201 lasers only.

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

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

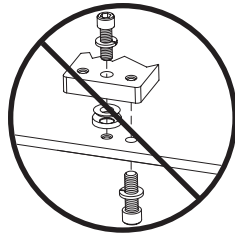
getting started

Mounting

f201 mounting

F201 mounting brackets are threaded to accept either metric or standard fasteners.

Important Note: As shown in the figure below, **DO NOT** use more than one fastener per mounting location. Using two or more fasteners per mounting tab will cause damage to the laser; use only one fastener per location to mount your f201 laser.



Do not use more than one fastener per mounting foot. Doing so will damage the laser

Fastening f201 lasers from above

To fasten your f201 laser to a mounting surface from above, perform the following steps:

- 1 Refer to the appropriate outline and mounting drawing for dimensions and then drill and tap three mounting holes into your mounting surface. For SAE installations, drill and tap three 5/16–18 (f201).

These hole locations (referenced by Note 2 on the O & M drawings) should correspond to the thru holes labeled "A" as shown in the figure below.

- 2 Assemble three spherical washer sets as detailed in the Outline and Mounting drawing.
- 3 Place the spherical washer sets over the threaded holes in your mounting surface.
- 4 Carefully position the laser so that each thru hole in the baseplate aligns with a spherical washer and threaded mounting hole.
- 5 Insert the appropriate metric or standard capscrews, included in the laser's ship kit, through the baseplate, through the spherical washers, and into the threaded holes of the mounting surface (see figure below). Turn the screws by hand until the threads engage.
- 6 Evenly tighten all three capscrews. For M8 capscrews, torque to 12 N m; for M10 screws, torque to 24 N m. When using 5/16" screws, torque to 13 ft lb; for 3/8" capscrews, tighten to 23 ft lb.

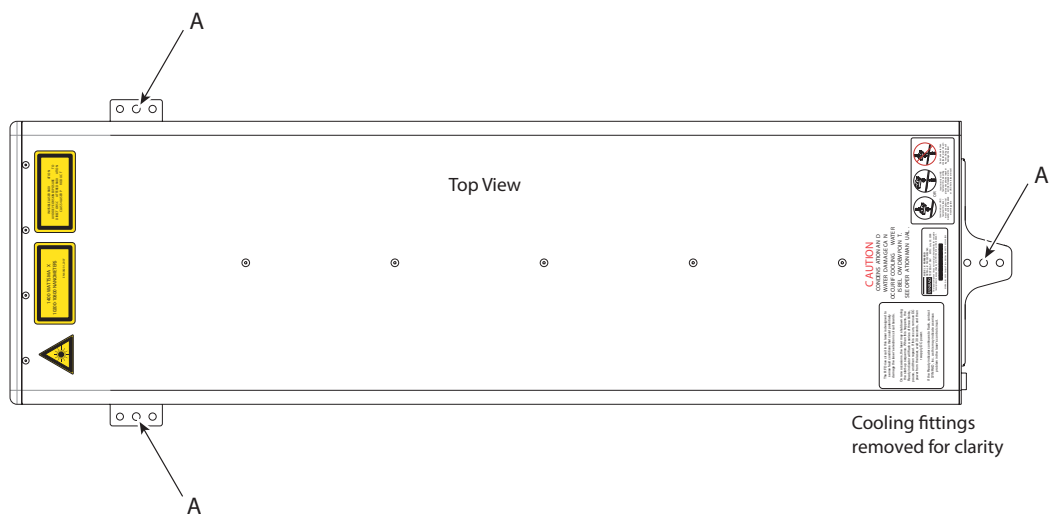
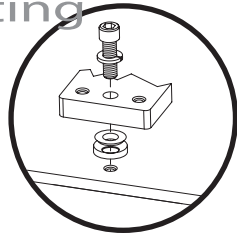


Figure 2-4 Fastening the f201 from below.

getting started

Mounting

f201 mounting



Insert metric or SAE fastener thru laser mount and spherical washer set into threaded mounting plate

Figure 2-5 Detail of fastening into mounting surface.

Fastening f201 lasers from below

To fasten your f201 laser to a mounting surface from below, perform the following steps:

- 1 Refer to the appropriate outline and mounting drawing for dimensions and then drill three 8.5 mm (f201) holes into your mounting surface. For SAE installations, drill three 0.332" (f201) holes into your mounting surface.

These hole locations (referenced by Note 1 or Note 3 on the O & M drawings) should correspond to the threaded holes labeled "M", for metric, or "S", for standard, as shown in the following figure.

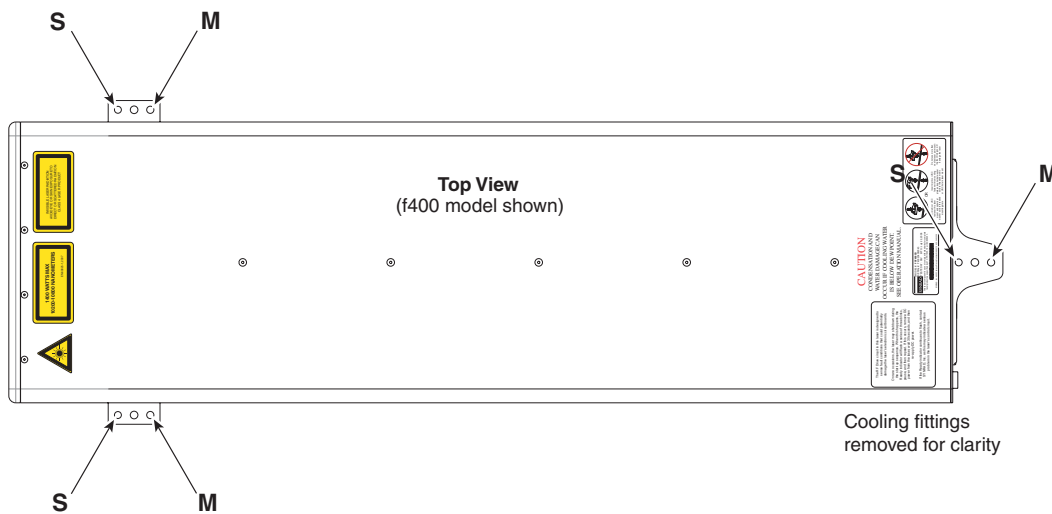


Figure 2-6 Fastening f201 from below.

- 2 Assemble three spherical washer sets as detailed in the outline and mounting drawing.
- 3 Place the spherical washer sets over the thru holes in your mounting surface.
- 4 Carefully position the laser so that each threaded hole in the baseplate (labeled "M" or "S" in the prior figure) aligns with a spherical washer and thru hole in the mounting surface.
- 5 Insert the appropriate metric or standard capscrews, included in the laser's ship kit, through the mounting surface and spherical washers into the threaded holes of Firestar's baseplate (see Figure 1-11). Turn the screws by hand until the threads engage.
- 6 Evenly tighten all three capscrews. For M8 capscrews, torque to 12 N m; for M10 capscrews, tighten to 24 N m. When using 5/16" capscrews, torque to a value of 13 ft lb; for 3/8" capscrews, tighten to 23 ft lb.

getting started

Connecting

The Connecting section includes subsections:

- Cooling connections
- PS-96 power supply connections
- Control connections
- Other connections

Cooling connections

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

Guidelines for cutting and installing tubing

- Cut tubing lengths generously to allow for trimming.
- Cut tubing squarely; diagonal cuts may not seal properly. Trim away burrs if the cut is “ragged”.
- Avoid excessive stress on fittings; create gentle bends when routing tubing close to connectors. Excessive stress from sharp bends will compromise the sealing properties of the fitting.
- Never allow the tubing to kink, since kinking severely restricts coolant flow.
- Push tubing completely into the fitting, then pull the tubing to verify that it is locked into place. Tubing extends into the fitting approximately 7/8 of an inch.
- If tubing must be disconnected from a fitting, first push and hold the tubing slightly into the fitting. Next push the white fitting ring evenly towards the fitting, and then pull the tubing free.
- After disconnecting tubing from a fitting, trim 12.7 mm (1/2") from its end before reconnecting. Trimming the end of the tubing before reconnecting the fitting provides an undisturbed sealing surface.

Laser cooling fittings

If your integrated laser application uses metric cooling tubing, we recommend the installation of tubing adaptors to convert the laser's existing WATER IN/WATER OUT fittings from 1/2-inch standard to 12-mm metric tubing. The ship kit sent with your f201 laser includes a cooling kit containing two each 1/2-inch male to 1/2-inch female 90° adaptors and two each 1/2-inch male to 12-mm female 90° adaptors. If required, many tubing and fitting manufacturers can supply 1/2-inch to 12-mm straight fittings.

Caution possible equipment damage

Firestar f201 lasers incorporate special fittings that accept only standard 1/2" O.D. cooling tubing.

DO NOT REMOVE OR ADJUST THESE FITTINGS!

Each laser is shipped with a cooling kit that includes 90° push-on tubing connectors to adapt the brass fittings to your choice of standard (1/2-inch) or metric (12-mm) cooling tubing.

getting started

Mounting

Chiller preparation guidelines

The ship kit includes chiller fittings with 3/8" NPT male threads. If these fittings will not connect to your chiller then you must provide fittings that will adapt the laser's 1/2" O.D. polyethylene cooling tubing to your chiller's Inlet and Outlet ports.

Because Firestar's cooling tubing is supplied in inch sizes, do not use metric tubing fittings unless you have installed the appropriate inch-to-metric tubing adaptors. The use of metric fittings on inch size tubing will lead to coolant leaks or may allow the pressurized tubing to blow off the fitting.

Coolants

SYNRAD recommends the laser's cooling fluid contain at least 90% distilled water by volume. In closed-loop systems, use a corrosion inhibitor/algaecide such as Optishield® Plus or equivalent as required. Avoid glycol-based additives because they reduce the coolant's heat capacity and high concentrations may affect power stability. For SYNRAD lasers, the minimum coolant setpoint is 18 °C (64 °F) so glycol is not necessary unless the chiller is subjected to freezing temperatures. If tap water is used, chloride levels should not exceed a concentration of 25 parts per million (PPM) and total hardness should be below 100 PPM. Install a filter on the chiller's return line and inspect frequently. f201 lasers use the following wetted materials in the coolant path—aluminum, brass, copper, Delrin®, PBT, polyethylene, stainless steel, and Viton®.

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

Setting coolant temperature

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

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

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

Use the Gas Purge port (f201) to introduce nitrogen or dry, filtered air into the laser housing.

Air-condition or dehumidify the room or the enclosure containing the laser.

Increase coolant flow by an additional 3.8 lpm (1.0 GPM). Do not exceed a coolant pressure of 414 kPa (60 PSI).

Note: To reduce problems associated with condensation, Firestar f201 lasers can operate up to 28 °C. However, these elevated cooling temperatures may result in decreased laser performance and/or reduced laser lifetime.

getting started

The following table provides dew point temperatures 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 given in the chart; however, for best results and performance, use a coolant temperature in the range of 18–22 °C (64–72 °F) when possible.

Connecting

Table 2-3 Dew point temperatures.

Dew Point Temperature Chart °F (°C)

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

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

getting started

Connecting f201 cooling tubing connections

To connect cooling tubing to your f201 laser, refer to the figure below and perform the following steps. The numbered items that follow correspond to the step numbers in the following procedure.

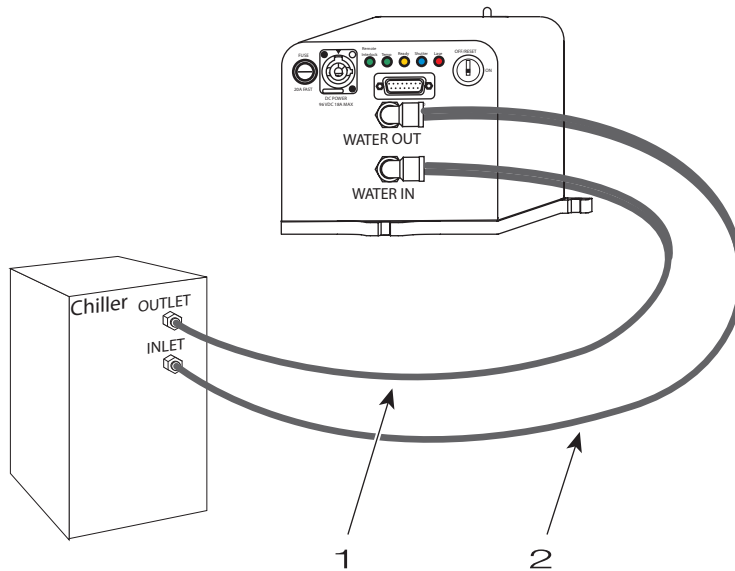


Figure 2-7 F201 ooling connections.

- 1 Cut and connect a length of cooling tubing to fit between the chiller's Outlet port and the WATER IN port on the rear of your f201 laser.
 - 2 Cut and connect a length of cooling tubing to fit between the WATER OUT port on the rear of the laser and the chiller's Inlet port.
 - 3 Turn on the chiller and adjust the temperature setpoint to 18 °C to 22 °C. Regulate coolant flow to 9.5 lpm (2.5 GPM) for f201 lasers at less than 414 kPa (60 PSI) of pressure.
 - 4 Closely examine all cooling connections and verify that there are no leaks.
-
- 1 Locate the 1/2-inch O.D. cooling tubing in the Ship Kit and cut four lengths (12–18 inches long) to fit partway between your chiller and the rear of the laser.
 - 2 Select two lengths of tubing and connect one end of each piece to the laser's WATER IN ports.
 - 3 Connect the other end of each length of tubing to the "Y" fitting (included in the Ship Kit).

Caution possible equipment damage

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

getting started

- 4 Cut and connect a length of tubing to fit between the chiller's Outlet port and the center of the "Y" fitting.
- 5 Select the other two lengths of previously cut 1/2-inch cooling tubing and connect one end of each piece to the laser's WATER OUT ports.
- 6 Connect the other end of each length of tubing to the other "Y" fitting.
- 7 Cut and connect a length of tubing to fit between the chiller Inlet and the center of the "Y" fitting.
- 8 Turn on the chiller and adjust the temperature setpoint to 18 °C to 22 °C. Regulate coolant flow to 15.1 lpm (4.0 GPM) of pressure.
- 9 Closely examine all cooling connections, assure there are no leaks.

Connecting

PS-96 power supply connections

The following procedures describe how to connect the PS-96 DC power supply to your f201 laser.

When connecting other types of DC power sources, remember to follow proper Lockout/Tagout procedures to ensure that AC power is de-energized, and then connect input AC power per the manufacturer's instructions. Firestar f201 lasers require a DC power source capable of supplying 96 VDC.

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



Warning
serious
personal
injury

Hazardous DC voltages exist on DC power supply output terminals when the power supply is energized. Contacting energized terminals may result in serious personal injury or death. Protect all 96 VDC connections from incidental contact in accordance with National, State, and Local requirements for electrical insulation and labeling.

Caution
possible
equipment
damage

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

Caution
possible
equipment
damage

Do not plug and unplug the DC Power cable on the rear of the laser to switch DC power to the laser. Switching power under load causes arcing that will damage the connector and control board. To properly cycle power to the laser, switch the AC power source controlling the PS-96 DC power supply.

getting started

DC Power cable

To connect the DC Power cable to your f201 laser, refer to the following figure and perform the steps described below.

DC Power cable—f201 lasers

- 1 Verify that input AC voltage to the DC power supply is physically locked out or disconnected.
- 2 Locate the f201 DC Power cable. The DC Power cable is 5 meters (16 feet) long with a plug on one end and five (5) connection lugs on the other. This cable has a minimum bend radius of 87.4 mm (3.44").
- 3 Carefully remove the plastic terminal guard from the output terminal block.

Important Note: Always re-install the terminal guard to protect users against inadvertent contact with hazardous DC voltages on the connection lugs and DC output terminals.

- 4 On the lug end of the cable, attach the two black wires with the "0 VDC" marker to the negative (-) 96 VDC output terminal on the DC power supply. Tighten the terminal nut to a maximum torque of 4.0 N m (35 in lb).

PS-96 AC input section

Three-phase operation (recommended)

SYNRAD's PS-96 DC power supply is capable of supplying 96 VDC at 47 amperes maximum. Three-phase AC input power requirements for the PS-96 supply are 105–264 VAC, 3Ø (three phase with ground phase to phase), 23 A maximum per phase, 47–63 Hz. The following table provides recommendations for three-phase input wiring and fusing.

 **Caution**
possible
personal
injury

All AC input wiring and fusing to the DC power supply must be sized and connected in accordance with applicable local, state, and national requirements.

Local, state, and national code requirements (like NEC, CSA, and IEC 60364) supersede any recommendations provided in this manual.

Table 2-4 Three-phase AC electrical recommendations.

Parameter	Recommendation
Input voltage	105–264 VAC, 3Ø
Input current, max.	23 Amperes (per phase)
Wire gauge	10 AWG
Fuse/circuit breaker	30 Amps

To connect three-phase AC input power to the PS-96 power supply, refer back to the prior figure and perform the following steps:

getting started

Connecting

Caution
possible
equipment
damage

Do not plug and unplug the DC Power cable on the rear of the laser to switch DC power to the laser. Switching power under load causes arcing that will damage the connector and control board. To properly cycle power to the laser, switch the AC power source controlling the PS-96 DC power supply.

⚠ Caution
possible
personal
injury

All AC input wiring and fusing to the DC power supply must be sized and connected in accordance with applicable local, state, and national requirements.

Local, state, and national code requirements (like NEC, CSA, and IEC 60364) supersede any recommendations provided in this manual.

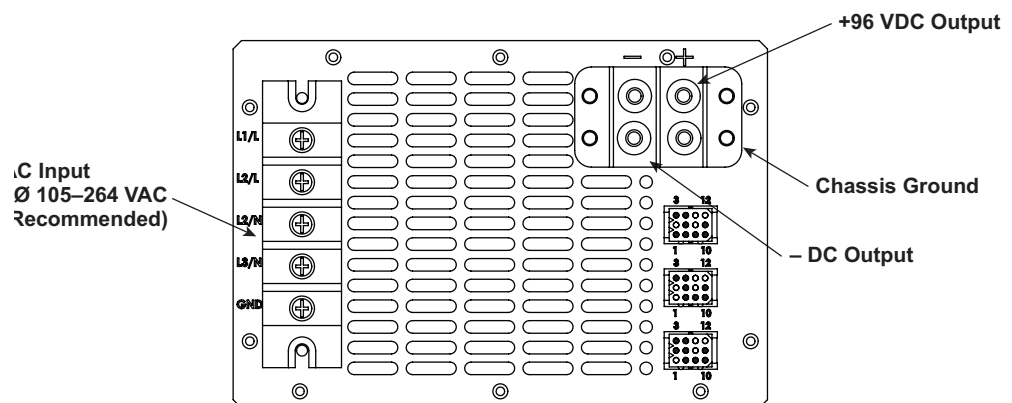


Figure 2-8 PS-96 interface.

Note: Because AC input connections and requirements vary from facility to facility, customers must provide the AC power cable or wiring.

- 1 Follow your facility's Lockout/Tagout procedures and verify that input AC power to the DC power supply is physically locked out or disconnected.
- 2 Connect the safety ground (earth) wire, typically green, to the input terminal labeled "GND".
- 3 Connect the first AC three-phase hot wire, typically black, to the input terminal labeled "L1/L".
- 4 Connect the second three-phase hot wire, typically red, to the input terminal labeled "L2/L".
- 5 Connect a jumper wire (the same wire gauge as the other AC wires) between the terminals labeled "L2/L" and "L2/N".
- 6 Connect the third AC hot wire, typically blue, to the input terminal labeled "L3/N".

Single-phase input power requirements for SYNRAD PS-96 DC power supply are 208–264 VAC, 1Ø (single phase), 20 A maximum, 47–63 Hz. Table below provides recommendations for single-phase input wiring and fusing.

getting started

Connecting

Single-phase operation

Table 2-5 Single-phase AC electrical recommendations.

Parameter	Recommendation
Input voltage	208–264 VAC, 1Ø
Input current, max.	20 Amperes
Wire gauge	10 AWG
Fuse/circuit breaker	30 Amps

There are two possible circuit configurations for single-phase connections: (1) one circuit where the voltage between hot conductors measures 208–264 VAC (recommended), or (2) an alternate case using two individual circuits where the voltage between the hot and neutral conductors from each individual circuit measures 120–264 VAC. To connect single-phase AC input power to the PS-96 power supply, refer back to prior figures and perform the following steps:

Note: Because AC input connections and requirements vary from facility to facility, customers must provide the AC power cable or wiring.

One single-phase circuit (208–264 VAC)

- 1 Follow your facility's Lockout/Tagout procedures and verify that input AC power to the DC power supply is physically locked out or disconnected.
- 2 Connect the safety ground (earth) wire, typically green, to the input terminal labeled "GND".
- 3 Connect one AC hot wire, typically black, to the input terminal labeled "L1/L".
- 4 Connect a jumper wire (the same wire gauge as the other AC wires) between the terminals labeled "L1/L" and "L2/L".
- 5 Connect the other hot wire, typically black, to the input terminal labeled "L2/N".
- 6 Connect a jumper wire (the same wire gauge as the other AC wires) between the terminals labeled "L2/N" and "L3/N".

Note: The neutral white, typically white, is not used in this wiring scheme.

Two individual single-phase circuits (120–264 VAC)

- 1 Follow your facility's Lockout/Tagout procedures and verify that input AC power to the DC power supply is physically locked out or disconnected.
- 2 Connect the safety ground (earth) wires from both circuit 1 and circuit 2, typically green, to the input terminal labeled "GND".
- 3 Connect the AC hot wire from circuit 1, typically black, to the input terminal labeled "L1/L".
- 4 Connect the return (neutral) wire from circuit 1, typically white, to the input terminal labeled "L2/N".
- 5 Connect the hot wire from circuit 2, typically black, to the input terminal labeled "L2/L".
- 6 Connect the return (neutral) wire from circuit 2, typically white, to the input terminal labeled "L3/N".

getting started

Control connections

All control connections to Firestar f201 lasers are made through the 15-pin User I/O connector on the rear panel. The User I/O port receives power commands from SYNRAD's UC-2000 Universal Laser Controller or FH Series Marking Head and also serves as the connection point for auxiliary signals between the laser and any parts handling, automation, or monitoring equipment.

UC-2000 Universal Laser Controller

SYNRAD recommends the use of a UC-2000 Universal Laser Controller to generate pulse width modulated (PWM) Command signals that control the laser's output power. To connect a UC-2000 Controller (available separately), perform the steps described in the appropriate f201 laser section below:

Note: F-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 User I/O connections, also in the Technical Reference chapter, for signal specifications and connection details.

f201 lasers

- 1 Disconnect DC power from the laser.
- 2 Locate the Quick Start Plug in the ship kit.
- 3 Connect the Quick Start Plug to the User I/O connector on the rear of the f201 laser.
- 4 Attach the BNC connector on the end of the UC-2000's Power/Control cable to the BNC connector on the rear of the Quick Start Plug.
- 5 Connect the miniature DC power plug on the UC-2000's Power/Control cable to the miniature connector on the cable from the UC-2000's wall plug transformer.
- 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.

Connecting Quick Start Plug

In order for your f201 laser to properly operate, several input signals must be applied to the DB-15 User I/O connector before lasing is enabled. Voltage must be applied to Remote Interlock (Pin 3) and Shutter Open Request (Pin 10) inputs before the laser will fire. In applications where Firestar is integrated into an automated system and safety interlocks are required, these input signals must be provided by the customer's control system. The Quick Start Plug included in the ship kit has factory-installed shorting jumpers wired into it to enable these inputs. Connect the Quick Start Plug to the User I/O connector when performing initial start-up and testing of your Firestar laser.

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

getting started

Connecting

Other connections

Warning
serious
personal
injury

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

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

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

Caution
possible
equipment
damage

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

Gas Purge connector

A gas purge is highly recommended when operating the laser in dirty or dusty environments. Purging the laser creates a positive pressure inside the laser housing that prevents dirt and debris from accumulating on optical surfaces including beam combiner, telescope, and turning optics. In condensing atmospheres, a gas purge helps to reduce the potential for condensation damage.

To connect the f201 gas purge port, perform the steps described below:

- 1 Connect nitrogen or breathing-grade air to the Gas Purge connector using 1/4-inch plastic tubing.
- 2 Push the tubing completely into the fitting and then pull the tubing lightly to ensure that it is locked into place.

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

- 3 Set a purge pressure between 13.8–34.5 kPa (2–5 PSI). This provides just enough positive airflow to prevent dust from entering the laser. If a flowmeter is available, set a flow rate of 0.85–1.7 m³/hr (30–60 SCFH, Standard Cubic Feet per Hour) at a pressure not to exceed 34.5 kPa (5 PSI).

The Gas Purge connector on your f201 laser must be connected to a source of nitrogen or clean, dry air only; do not use any other gases for purging. Purge gas specifications are listed in the table below.

getting started

Gas Purge connector

Table 2-6 Purge gas specifications.

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

Caution
possible
equipment
damage

Do not exceed a gas purge pressure of 34.5 kPa (5 PSI). Excessive pressure may damage the purge assembly or other internal laser components.

Do not use argon as a purge gas. Use only nitrogen or clean, dry air as described in Table 1-6, Purge gas specifications.

Laser Safety

1

This chapter contains safety information that you will need to know prior to getting started.

- Hazard Information – includes equipment label terms and hazards, please familiarize yourself with all definitions and their significance.
- General & Other Hazards – provides important information about the hazards and unsafe practices that could result in death, severe injury, or product damage.
- Disposal – information on your f201 laser parts and/or components as they pertain to disposal.
- Additional Safety Information – describes how to find additional information about your f201 laser.
- Compliance – explains in the subsections therein applicable and appropriate regulation information.

Note: Read the entire safety section. This will ensure you are familiar with the hazards and warnings prior to starting.

Warning Serious personal injury



is Class 4 CO₂ laser product emits invisible infrared laser radiation in the 9.3–10.6 μm wavelength band.

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!

This product emits an invisible laser beam that is capable of seriously burning human tissue.

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

Laser Safety

Hazard Information

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

Terms

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










Parameter	Description
 	<p>WARNING: Potential & Imminent hazards which, if not avoided, could result in death or serious injury.</p> <p>Alerts operator of serious dangers, hazardous radiation, hazardous voltages, vapor hazard, & reflective dangers.</p>
	<p>DANGER: Hazards which, if not avoided, could result in minor or moderate injury.</p> <p>Alerts operator of lifting dangers.</p>
	<p>CAUTION: Potential hazards or unsafe practices which, if not avoided, may result in product damage.</p> <p>Alerts operator of equipment dangers.</p>
  	<p>IMPORTANT NOTES & TIPS:</p> <p>Content specific information and/or recommendations.</p>

Figure 1-1 Labeling terms and definitions.

Warning
Serious personal injury

For laser systems being used or sold within the U.S.A., customers should refer to and follow the laser safety precautions described American National Standards Institute (ANSI) document Z136.1-2014, Safe Use of Lasers.

 For laser systems being used or sold outside the U.S.A., customers should refer to and follow the laser safety precautions described in European Normative and International Electrotechnical Commission documents IEC/TR 60825-14:2014, Safety of Laser Products – §14: A User's Guide.



Laser Safety

General hazards

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

Danger Serious personal injury



Do not allow laser radiation to enter the eye by viewing direct or reflected laser energy.

CO₂ laser radiation can be reflected from metallic objects even though the surface is darkened. Direct or diffuse laser radiation can inflict severe corneal injuries leading to permanent eye damage or blindness. All personnel must wear eye protection suitable for CO₂ radiation, e.g. 9.3–10.6 μm when in the same area as an exposed laser beam.

Eye wear protects against scattered energy but is not intended to protect against direct viewing of the beam—never look directly into the laser output aperture or view scattered laser reflections from metallic surfaces.

Enclose the beam path whenever possible. Exposure to direct or diffuse CO₂ laser radiation can seriously burn human or ani-

mal 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. Material Safety Data Sheets (MSDS) for materials being processed should be thoroughly evaluated and the adequacy of provisions for fume extraction, filtering, and venting should be carefully considered. Review the following references for further information on exposure criteria:

ANSI Z136.1-2014, 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 CO₂ laser systems because difluoroethane persists for long time periods over wide areas.

Laser Safety

General hazards

F201 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 Z136.1-2014, 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, lasers can be reflected, refracted, diffracted or scattered.



Figure 1-2 Always wear safety glasses or protective goggles with side shields to reduce the risk of damage to the eyes when operating the laser.

A CO₂ 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.

Warning
Serious personal injury

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



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.

Laser Safety

Other hazards

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

Disposal

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

Additional laser safety information

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

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

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

Laser Safety

F201 label locations

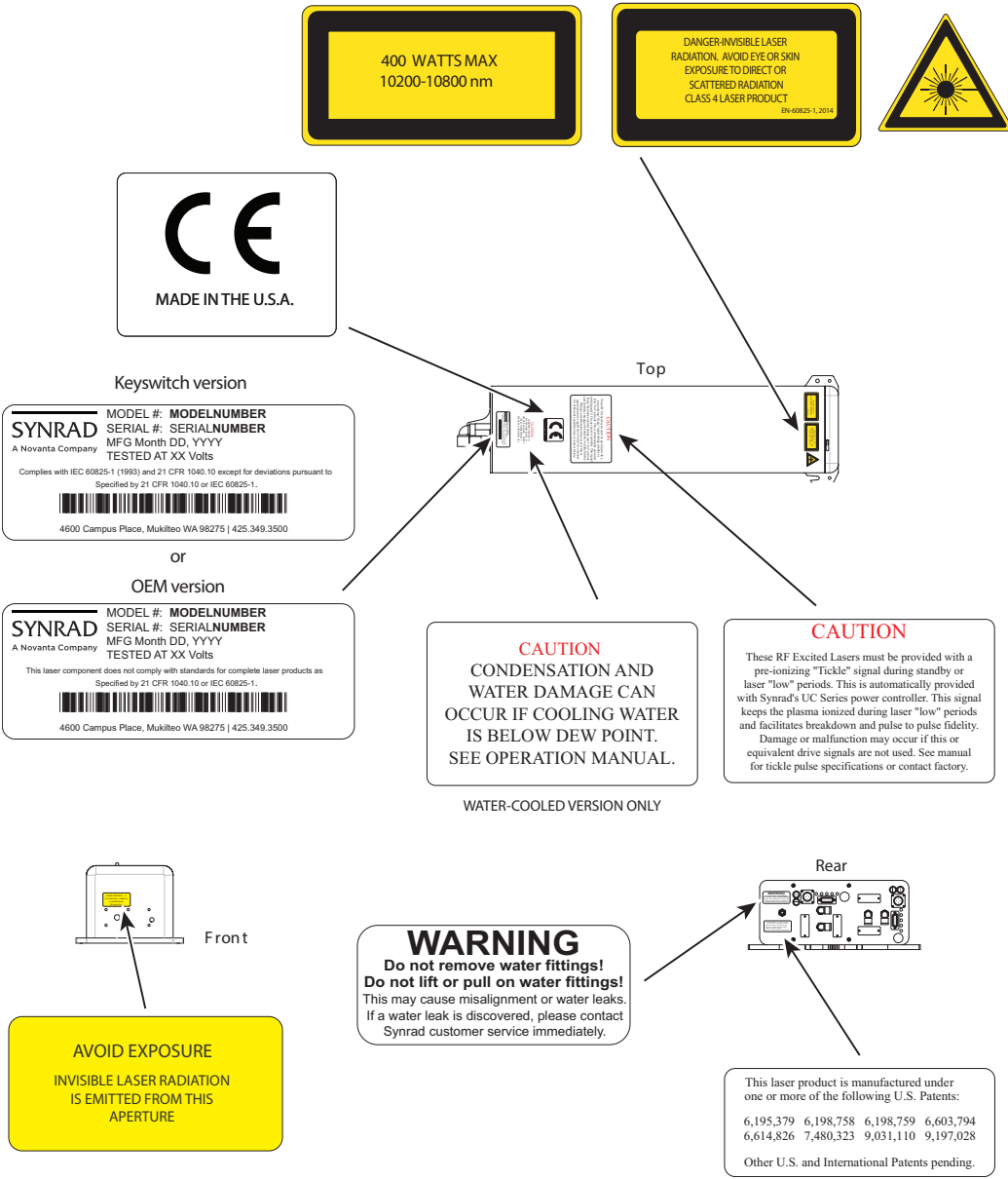


Figure 1-3 F 100 hazard label locations.

Laser Safety

F201 label locations (continued)

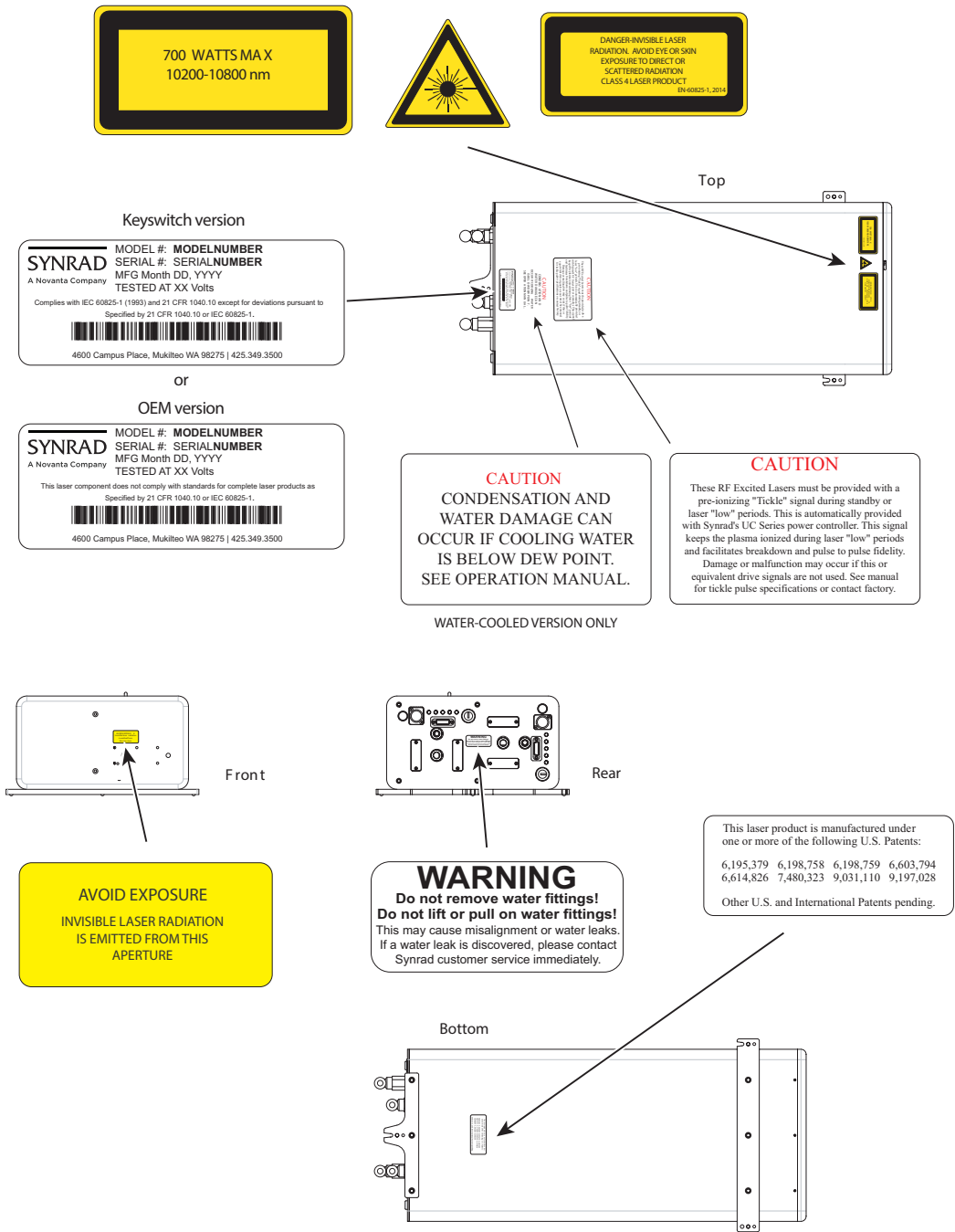


Figure 1-4 F 200 hazard label locations.

Laser Safety

F201 label locations (continued)

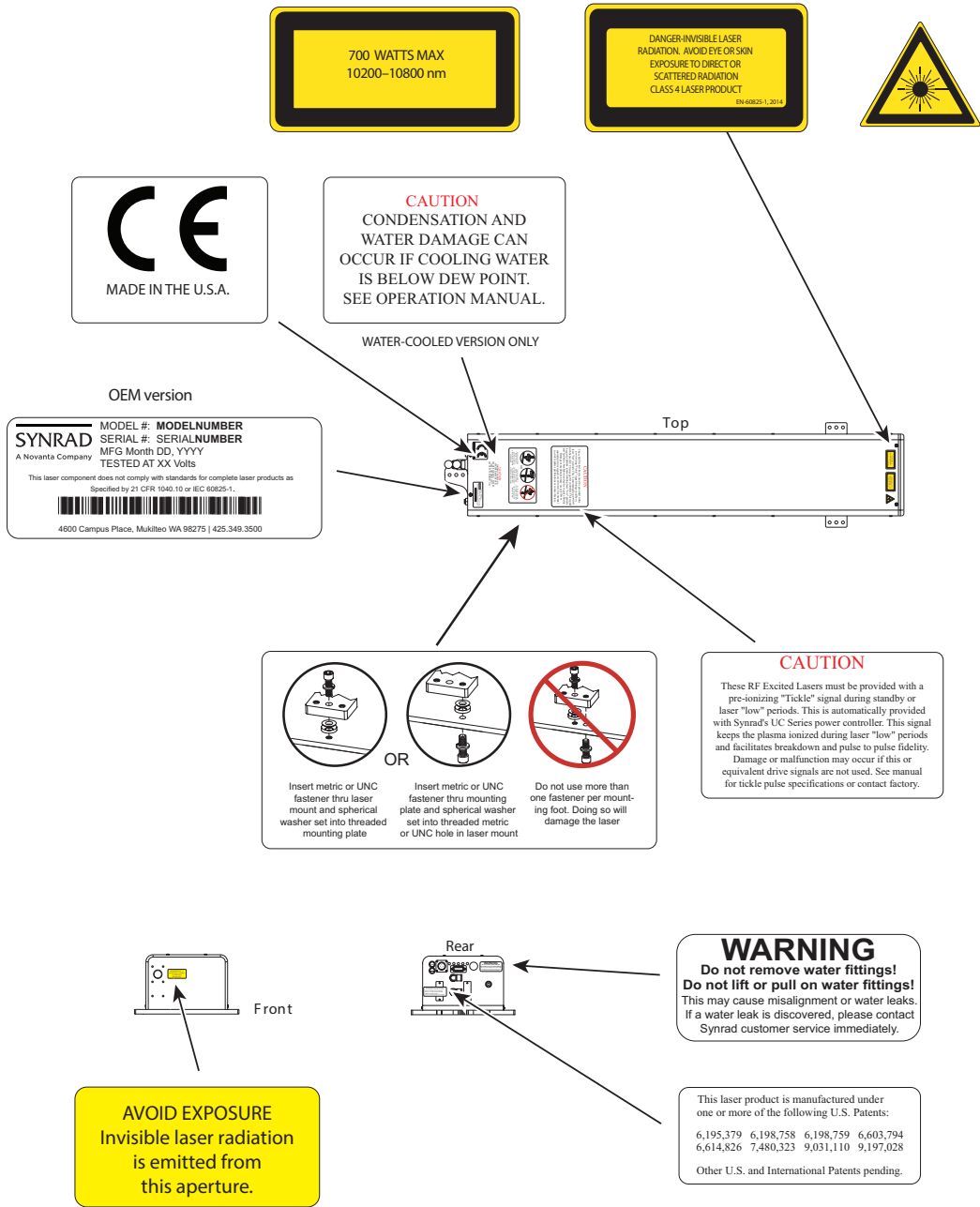


Figure 1-5 F 201 hazard label locations.

Laser Safety

Agency compliance

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

SYNRAD lasers are designed, tested, and certified to comply with certain United States (U.S.) and European Union (EU) regulations. These regulations impose product performance requirements related to electromagnetic compatibility (EMC) and product safety characteristics for industrial, scientific, and medical (ISM) equipment. The specific provisions to which systems containing f201 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. 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 f201 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 laser and laser ready indicators, remote interlock for power on/off, a laser aperture shutter switch, and a five-second delay between power on and lasing. Incorporation of certain features is dependent on the laser version (Keyswitch or OEM). Table 1, Class 4 safety features, indicates which features are available on f201 lasers, the type and description of the feature, and if the feature is required by CDRH regulations.

OEM models

F201 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

Laser Safety

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, §5C.

SYNRAD f201 lasers have been tested and found to comply by demonstrating performance characteristics that have met or exceeded the requirements of 47 CFR, §18, §5C for Radiated and Conducted Emissions.

FCC information to the user

Interference Potential

Note: The following FCC information to the user is provided to comply with the requirements of 47 CFR, §18, §5C Information to the user.

In our testing, SYNRAD has not discovered any significant electrical interference traceable to f201 lasers.

System Maintenance

Ensure that all exterior covers are properly fastened in position.

Measures to Correct Interference

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

- 1 Use shielded cables to and from the equipment that is experiencing interference problems.
- 2 Ensure that the 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.

Laser Safety

European Union (EU) requirements

RoHS compliance

SYNRAD f201 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 60825-1:2014 (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

F201 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 EN 60825-1 without additional safeguards. European Union Directives state that "OEM laser products which are sold to other manufacturers for use as components of any system for subsequent sale are not subject to this Standard, since the final product will itself be subject to the Standard." This means that Buyers of OEM laser components are solely responsible for the assurance that the laser processing system sold to an end-user complies with all laser safety requirements before the actual sale of the system. Note that when an OEM laser component is incorporated into another device or system, the entire machinery installation may be required to conform to EN 60825-1:2004, 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. Table 1, Class 4 safety features, summarizes f201 product features, indicating the type and description of features and whether those features are required by European Union regulations.

Electromagnetic interference standards

SYNRAD f201 lasers have demonstrated performance characteristics that have met or exceeded the requirements of EMC Directive 2014/30/EU.

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 f201 lasers, EN 61000-6-4:2018 defines radiated and conducted RF emission limits while EN 61000-6-2:2016 defines immunity standards for industrial environments.

SYNRAD f201 Operator's Manual Version 3.4

Laser Safety

Table 1-1 Class 4 safety features.

Feature	Location / Description	Required by:		Available on: OEM f201
		CDRH	EN60825-1	
Keyswitch¹	Rear panel control On/Off/Reset Keyswitch controls power to laser electronics. Key cannot be removed from switch in the "On" position.	Yes	Yes	No
Shutter function	Laser control Functions as a beam attenuator to disable RF driver/ laser output when closed.	Yes	Yes	Yes
Shutter indicator	Rear panel indicator (Blue) Illuminates blue to indicate shutter is open.	No	No	Yes
Ready indicator	Rear panel indicator (Yellow) Indicates that laser has power applied and is capable of lasing.	Yes	Yes	Yes
Lase indicator	Rear panel indicator (Red) 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	Circuit element Disables RF driver/laser output for five seconds after Keyswitch is turned to "On" or remote reset/start pulse is applied when Keyswitch is in "On" position.	Yes	No	Yes
Power fail lockout¹	Circuit element Disables RF driver/laser output if input power is removed then later reapplied (AC power failure or remote interlock actuation) while Keyswitch is in "On" position.	Yes	Yes	No
Remote Interlock	Rear panel connection Disables RF driver/laser output when a remote interlock switch on an equipment door or panel is opened.	Yes	Yes	Yes
Remote Interlock Indicator	Rear panel indicator (Green/Red) Illuminates green when Remote Interlock circuitry is closed. Illuminates red when interlock circuitry is open.	No	No	Yes
Over temperature protection	Circuit element Temperature shutdown occurs if temperature of the laser tube rises above safe operating limits.	No	No	Yes
Temp indicator	Rear panel indicator (Green/Red) Illuminates green when laser temperature is within operating limits, changing to red when thermal limits are exceeded.	No	No	Yes
Warning labels	Laser exterior Labels attached to various external housing locations to warn personnel of potential laser hazards.	Yes	Yes	Yes

¹ Not available on f201 OEM lasers

Laser Safety

When integrating SYNRAD f201 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 f201 lasers comply with the relevant requirements of 2014/30/EU, the Electromagnetic Compatibility Directive, as summarized in the table below.

Table 1-2 European Union Directives.

Applicable Standards / Norms

2014/30/EU	Electromagnetic Compatibility Directive
2014/35/EU	Low Voltage Directive
2015/863/EU	RoHS Directive
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 Electromagnetic Field Immunity
EN 61000-6-2:2005	Electrical Fast Transient/Burst Immunity
EN 61000-6-2:2005	Conducted RF Disturbances Immunity

After a laser or laser processing system has met the requirements of all applicable EU Directives, the product can bear the official compliance mark of the European Union as a Declaration of Conformity.

Laser Safety

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™ f201 Laser

Model Number: FSF201SD (*OEM)

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

Applicable Directive(s):


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: 7/22/19

CE
MADE IN THE U.S.A.
900-20976-14 Rev C

Figure 1-6 Declaration of conformity.

Laser Safety

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™ f201 Laser

Model Number: FSf201SD (*OEM)

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

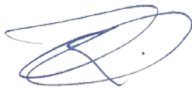
Applicable Directive(s):	2014/30/EU	Electromagnetic Compatibility Directive
	2014/35/EU	Low Voltage Directive
	2015/863/EU	RoHS Directive

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: 7/19/19



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Figure 1-7 F201 declaration of conformity.

3

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

This chapter contains the following information:

Controls and indicators – displays and describes exterior controls and indicators on f201 lasers.

Initial start-up – explains how to start your f201 laser while verifying proper operation.

 **Danger**
serious
personal
injury

This Class 4 laser product emits invisible infrared laser radiation in the 10.6 μm CO₂ wavelength band. Since direct or diffuse laser radiation can inflict severe corneal injuries, always wear eye protection when in the same area as an exposed laser beam. Do not allow the laser beam to contact a person. This product emits an invisible laser beam that is capable of seriously burning human tissue.

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

 **Warning**
serious
personal
injury

On Firestar f201 OEM lasers, remote interlock faults are not latched. Clearing the fault condition re-enables the Ready indicator and the laser will fire after the five-second delay provided that the Shutter indicator is lit and a PWM Command signal is applied. Because exposure to 10.6 μm CO₂ laser radiation can inflict severe corneal injuries and seriously burn human tissue, the OEM or System Integrator must ensure that appropriate safeguards are in place to prevent unintended lasing.

 **Warning**
serious
personal
injury

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

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

operation

Controls and indicators

The Controls and indicators section includes subsections:

f201 lasers

f201 lasers

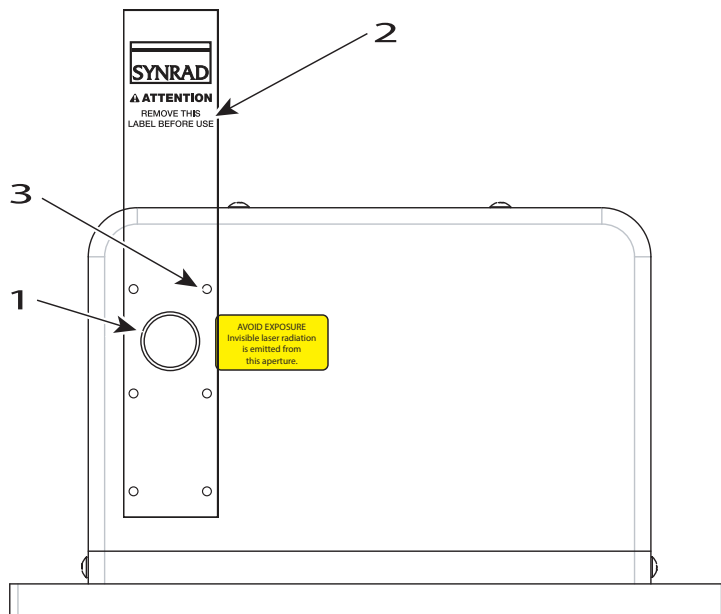


Figure 3-1 F201 controls and indicators (front).

- 1 Laser Aperture – provides an opening in Firestar’s front panel from which the beam exits.
- 2 Aperture Seal – prevents dust from damaging the output coupler during shipping. Remove the red self-adhesive label before applying power to the laser.
- 3 Optical Accessories Mounting – provides six threaded holes (8–32 UNC) for mounting optional beam delivery components available from SYNRAD. Because excessive weight may damage the laser, consult SYNRAD before mounting components not specifically designed as Firestar options. Refer to Firestar package outline drawings in the Technical Reference chapter for mounting dimensions.

Note: When mounting optical components to f201 lasers, the 8–32 UNC fasteners must extend no further than 4.8 mm (0.19") into the laser’s faceplate.

operation

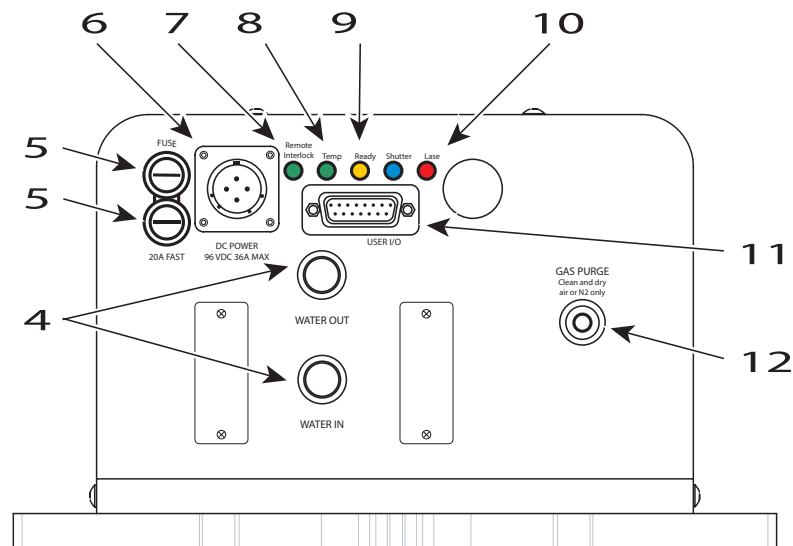


Figure 3-2 F201 controls and indicators (rear).

- 4 WATER OUT and WATER IN Ports – provides connection points for Firestar’s cooling system using non-removable straight 1/2-inch fittings. A cooling kit contains 90° tubing adaptors for both 1/2-inch and 12-mm cooling tubing.
- 5 FUSE Holder – protects laser circuitry with a 20 A, 125 V fast-acting fuse.
- 6 DC POWER Connector – receives 96 VDC from the DC power supply through the DC Power cables.
- 7 Remote Interlock Indicator – illuminates green to indicate that a remote interlock circuit is closed and that lasing may be enabled. The Remote Interlock indicator is red and lasing is disabled if the interlock input is open.
- 8 Temp Indicator – illuminates green to indicate that coolant temperature and flow is within limits and that lasing may be enabled. The Temp indicator is red and lasing is disabled if the coolant temperature rises above safe operating limits.
- 9 Ready Indicator – illuminates yellow when the laser is enabled, indicating that, after a five-second delay, lasing will begin when a PWM Command signal is applied.
- 10 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.
- 11 User I/O Connector – provides a connection point for auxiliary output power, as well as input and output signals. Refer to User I/O connections in the Technical Reference chapter for pinouts and signal descriptions.
- 12 Gas Purge Connector (f201 only) – provides a low pressure nitrogen (or pure air) purge gas connection to prevent dust and debris from entering the laser housing and damaging electronic or optical components.

operation

Initial start-up

The Initial start-up section includes subsections:

With a UC-2000 Controller

Without a UC-2000 Controller

With a UC-2000 Controller

Before your 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.

Note: When performing the initial start-up sequence, you must first connect the Quick Start Plug or you must provide the required Remote Interlock and Shutter Open Request signals to the User I/O connector. See User I/O connections in the Technical Reference chapter for User I/O 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 beam block 61 cm (24 in) from the laser aperture to prevent the beam from traveling beyond the work area.
- 4 Turn on the chiller and set the temperature setpoint between 18 °C–22 °C. Verify that the chiller is delivering the recommended flow rate for your laser at less than 414 kPa (60 PSI) of pressure. Examine all cooling connections carefully and ensure that they do not leak.
- 5 Start purge gas flow at a rate of 0.85–1.7 m³/hr (30–60 SCFH, Standard Cubic Feet per Hour) at a pressure not to exceed 34.5 kPa (5 PSI). If a flowmeter is not available, set a purge pressure between 13.8–34.5 kPa (2–5 PSI).

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

- 6 Set the UC-2000 to MANUAL mode, and then set the PWM Adj Knob to provide zero percent output (0.0%). The UC-2000's Lase indicator should be Off.
- 7 Verify that the laser's Keyswitch (if equipped) is in the OFF/RESET position.
- 8 Turn on the +96 VDC power supply.

If the factory-wired Quick Start Plug is installed, the Remote Interlock indicator will illuminate green and the Shutter indicator will illuminate blue—if the manual Shutter Switch is Open. The Temp indicator will illuminate green if laser temperature is within safe operating limits.

operation

Starting your f201 laser

Note: Ready LEDs denote separate control functions. Although the Ready lamp may light, no power is applied to the RF boards until both Ready and Shutter indicators are illuminated.

- 1 If the laser has a Diode Pointer installed, remove its aperture dust cover.

Note: Assure the red self-adhesive aperture seal is removed from the laser faceplate.

- 2 Press the UC-2000's Lase On/Off button. The Lase indicator on the UC-2000 should illuminate.
- 3 Use the PWM Adj Knob on the UC-2000 to slowly increase power. The Lase LED turns red when PWM Command pulses are long enough to produce laser output (typically 7–10 μ s at 5 kHz). The spot where the beam hits the beam block increases in brightness to indicate increased power output.
- 4 Press the UC-2000's Lase On/Off button to stop lasing. Lase indicators on the UC-2000 and the laser should both turn off.
- 5 Shut off the chiller or otherwise stop coolant flow through the laser.
- 6 Shut off gas purge flow to the laser. In dirty or dusty environments; however, it may be necessary to purge the laser continuously to prevent contamination of internal optics.

 **Warning**
serious
personal
injury

Because of phase differences, external tickle pulses may combine with the internally-generated tickle signal causing the Lase LED to flicker during the transition from tickle to lasing. Laser output may occur if the Lase LED flickers.

If your f201 laser fails to lase, refer to Troubleshooting in the Maintenance/Troubleshooting chapter for troubleshooting information.

Without a UC-2000 Controller

If you are not using a UC-2000 to control the laser, follow the procedure below to verify laser operation. Although a tickle signal is not required, you will need to provide PWM Command signals to User I/O connector. Refer to User I/O connections in the Technical Reference chapter for connector pinouts and refer to Controlling laser power in the Technical Reference chapter for Command signal descriptions.

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

Caution
possible
equipment
damage

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

operation

Initial start-up

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 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 Input (Pin 9) on the laser's User I/O connector and connect the ground or return of the controller to PWM Return (Pin 1). On f200 lasers, parallel this PWM signal between both User I/O connectors.
- 5 Turn on the chiller and set the temperature setpoint between 18 °C–22 °C. Verify that the chiller is delivering the recommended flow rate for your laser at less than 414 kPa (60 PSI) of pressure. Examine all cooling connections carefully and ensure that they do not leak.
- 6 Start purge gas flow at a rate of 0.85–1.7 m³/hr (30–60 SCFH, Standard Cubic Feet per Hour) at a pressure not to exceed 34.5 kPa (5 PSI). If a flowmeter is not available, set a purge pressure between 13.8–34.5 kPa (2–5 PSI).

Caution possible equipment damage

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

- 7 Verify that the laser's Keyswitch (if equipped) is in the OFF/RESET position.
- 8 Turn on the +96 VDC power supply.

Note: If the factory-wired Quick Start Plug is installed, the Remote Interlock indicator will illuminate green and the Shutter indicator will illuminate blue—if the manual Shutter Switch is open. The Temp indicator will illuminate green if laser temperature is within safe operating limits.

Caution possible equipment damage

Do not exceed a gas purge pressure of 34.5 kPa (5 PSI). Excessive pressure may damage the purge assembly or other internal laser components.

Do not use argon as a purge gas. Use only nitrogen or clean, dry air as described in the following table, Purge gas specifications.

operation

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technical reference

4

Use information in this chapter as a technical reference for your Firestar f201 laser.

This chapter contains the following information:

Technical overview – briefly describes Firestar’s technology and basic optical setup.

Controlling laser power – explains various aspects of Firestar control signals.

User I/O (Input/Output) connections – describes signals and specifications for the 15-pin User I/O connector.

DC Power cables – provides information about f201 power cables including connectors and pinouts.

Integrating Firestar safety features – describes how to integrate Firestar f201 safety features into your automated control system.

f201 general specifications – provides specifications for the Firestar f201 laser.

Firestar f201 package outline drawing – illustrates laser package outline and mounting dimensions for f201 lasers.

Packaging instructions – illustrates how to package Firestar f201 lasers for shipment.

technical reference

Technical overview

The Technical overview section includes subsections:

- Laser tube
- Optical resonator
- Internal RF power supply
- Optical setup

Laser tube

Firestar® f201 lasers were developed using new technology patented by SYNRAD. Firestar's patented "f" technology, based on an unstable free-space resonator design, enables SYNRAD to economically produce a symmetrical laser beam from a small but powerful laser capable of operating for many years with virtually no maintenance. Firestar's unique extruded aluminum envelope offers excellent heat transfer, long gas life, and low operating costs in contrast to other laser tube technologies. Besides 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.

Duo-Lase® operation

Firestar lasers consist of two standard, sealed tubes (f201 tubes respectively) that are combined using SYNRAD's Duo-Lase® technology to provide a single diffraction-limited beam at twice the output power. All power and control functions between the two laser sections are totally independent, essentially achieving fail-safe operation for applications that can be served with the power of a single laser tube. Any one electronic or laser tube failure will affect only that section, leaving the second section unaffected and available for temporary use.

The Duo-Lase optical combining technique is based on the fact that each tube is linearly polarized, which allows the use of a polarization-sensitive beam combiner to achieve a 98 percent efficiency in combining the two beams. Both components of the resulting output beam are spatially parallel and collinear. The normal temporal and spatial variations inherent in a single tube laser are reduced by combining the output of two lasers.

Cooling

Heat generated by excited CO₂ molecules is transferred to the bore walls by diffusion. Collected heat is transferred to the water in the cooling tubes by conduction of the electrodes and aluminum envelope. The coolant path is directed through corrosion-resistant copper alloy tubing to regulate laser temperature for maximum stability.

Optical resonator

The optical resonator, in conjunction with the electrodes and the gas mixture, generates the laser beam. Firestar f201 optical resonators are comprised of three optical elements: a front mirror, a rear mirror, and an output window. These optical elements are fastened to the tube's exterior and are exposed to its interior through holes in the end caps. O-rings are sandwiched between optical elements and the end cap to form a gas seal and to provide a flexible cushion that allows the slight movement necessary for alignment. All optical elements are aligned and locked into place by factory technicians before the laser is shipped.

technical reference

Technical overview

Caution possible equipment damage

Because of their smaller beam diameter, Firestar lasers have significantly higher power densities than previous SYNRAD lasers. This means that any contamination 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. In dirty environments, purge laser optics using filtered air or nitrogen to prevent vapor and debris from accumulating on optical surfaces.

On f201 lasers, a small telescope just before the output coupler corrects a slight ellipticity in the beam generated by the resonator. The output beam, roughly square as it exits the telescope, transitions to Gaussian-like in mid and far fields three meters and beyond. The internal structure and optics of the resonator combine to produce a Gaussian-like mode quality (M^2 factor) of 1.2 ± 0.1 . As shown in the figure below, beam diameter (beam waist) is 3.5 mm at the output aperture and full angle divergence due to diffraction is 4 milliradians (a 4 mrad full angle divergence means that beam diameter increases 4 mm over every one meter distance traveled).

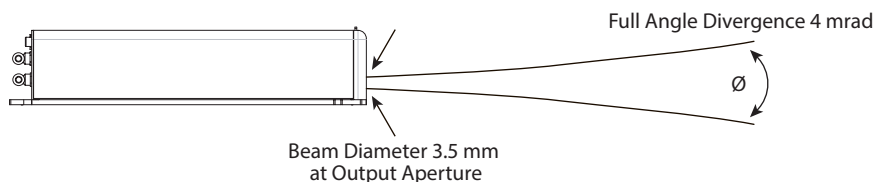


Figure 4-1 beam characteristics.

On f201 lasers, the beam waist is located one meter before the output aperture due to the addition of internal beam conditioning optics that improve beam quality and strip any side lobes present to produce a Gaussian-like mode quality (M^2 factor) of 1.2 ± 0.1 . Beam diameter at the output aperture is 4.5 mm with a full angle divergence of 4 milliradians.

Internal RF power supply

The compact, self-contained RF power supply converts 96 VDC input power into a high-power radio frequency (RF) signal. The 40.68 MHz RF output from the RF power supply is then routed to the electrode structure in the laser tube where it excites carbon dioxide (CO_2) gas in the tube to produce lasing.

Control circuit

Switches and sensors built into the f201 control board monitor the laser for various conditions like under/over voltage, over temperature, and VSWR faults that pose a risk of damage to the laser. Additionally, laser operation is controlled by the following: a manual Shutter Switch; a Keyswitch (on Keyswitch-equipped lasers); the Shutter Open Request input; the Remote Interlock input; and the Remote Reset/Start Request input.

technical reference

Technical overview

Optical setup

After selecting a laser for a CO₂ laser processing system, the two most important elements to consider are: (1) beam delivery optics to transmit the beam to the work area; and (2) focusing optics to focus the beam onto the part or material to be processed. Each element is crucial in the development of a laser-based material processing system and each element should be approached with the same careful attention to detail.

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 laser beam diverges slowly, increasing by two or three diameters over several meters, Firestar lasers should be mounted a distance of 1.3–1.8 meters (50–70 inches) away from the work area and no closer than one meter (40 inches) for optimum performance. Right angle turning mirrors are often used in conjunction with the laser mounting position to obtain this distance. Figure below shows how right angle turning mirrors in a “flying optics” setup help create this longer beam path.

Firestar f201 lasers, with their internal one-meter beam path and conditioning optics, can be mounted right at the work area.

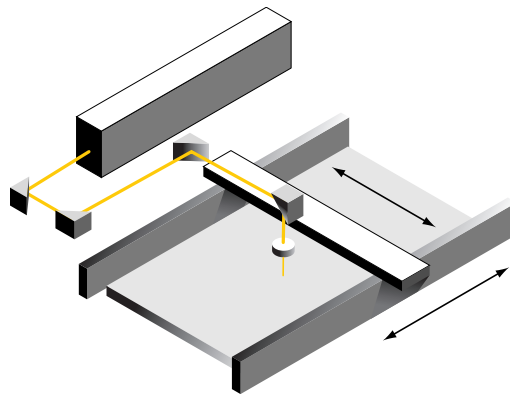


Figure 4-2 “Flying optics” beam path.

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

Expander/collimators are optical devices that reduce beam divergence while at the same time increasing beam diameter by a selectable magnification factor. Adding an expander/collimator to the “flying optics” setup shown above would substantially reduce beam divergence and any variance in beam diameter caused by the changing optical path length. In fixed-length delivery systems where the laser is positioned only one meter away from the focusing optic and a small spot size is required, an expander/collimator is again the best solution to provide the required beam expansion before reaching the focusing optic.

technical reference

Technical overview

Focusing optics

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

Caution possible equipment damage

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

Optics are fragile and must be handled carefully, preferably by the mounting ring only. Be careful to select optics that are thick enough to withstand the maximum assist gas pressure available for the process. This is especially important in metal cutting applications using high-pressure assist gases. Cleanliness is another important issue affecting performance 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 laser application requires air as an assist gas, use only breathing quality air available in cylinders from a welding supply company. Compressed shop air contains minute particles of oil and other contaminants that will damage optical surfaces. If compressed shop air is the only choice available, it must be filtered to the specifications shown in the following table.

Table 4-1 Assist gas purity specifications.

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

technical reference

Controlling laser power

The Controlling laser power section includes subsections:

Control signals

Operating modes

Control signals

Much of the information provided in this section describes the use of a SYNRAD UC-2000 Universal Laser Controller to provide PWM Command signals to the f201 laser. If using an alternate method of laser control, thoroughly review this section, Controlling laser power, as well as the following section, User I/O connections, for an understanding of the signal requirements necessary to control Firestar lasers. For more information about the UC-2000, please consult the UC-2000 Laser Controller Operator's Manual.

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. All Firestar f201 lasers incorporate a built-in tickle generator, freeing customers from the need to supply tickle pulses between lasing commands.

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

 **Warning**
serious
personal
injury

Because of phase differences, external tickle pulses may combine with the internally-generated tickle signal causing the Lase LED to flicker during the transition from tickle to lasing. Laser output may occur if the Lase LED flickers.

Pulse Width Modulation (PWM)

Pulse Width Modulation, or PWM, controls laser power by varying the duty cycle of Firestar'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 $\sim 150 \mu\text{s}$; however, the laser cannot precisely follow PWM input signals if the "On" pulse is less than $150 \mu\text{s}$ in duration. At a constant 50% duty cycle, f201 lasers typically reach 90–100% of full optical output when operated at a frequency of 3 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). Figure on the following page shows representative f201 optical output waveforms at two different duty cycles and frequencies.

technical reference

Controlling laser power

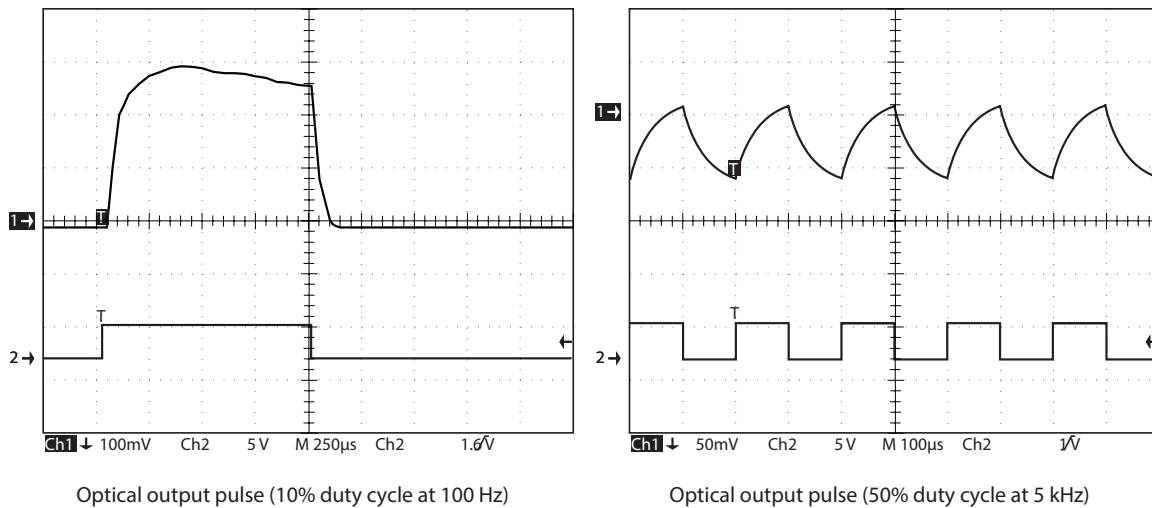


Figure 4-3 Typical Firestar f201 waveforms.

Firestar f201 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. When considering Command frequencies at 5 kHz or below, please review Marking/engraving operation later in this section. 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. At 100 kHz, the laser's optical beam response no longer follows the Command input and is very nearly a DC value with just a small amount of ripple present.

Command signal

The modulated Command signal applied between Pin 9, PWM Input, and Pin 1, PWM Return, of the User

Warning serious personal injury

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

I/O connector on the Firestar f201 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 μ s. Maximum PWM frequency is 100 kHz.

technical reference

Controlling laser power

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 μ s and low for 100 μ s, it has a 50% duty cycle; if the amplitude is high for 190 μ s and low for 10 μ s, it has a 95% duty cycle. Figure below illustrates PWM Command signal parameters while the table below lists PWM signal specifications.

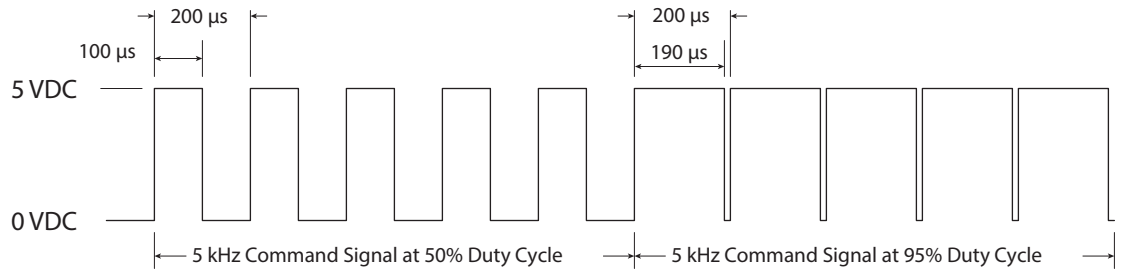


Figure 4-4 PWM Command signal waveform.

Firestar's User I/O PWM input consists of a high-speed optoisolator LED with a forward voltage drop (V_f) of 1.5 VDC. The PWM input frequency can range from DC (0 Hz) to 100 kHz. Table below provides minimum, maximum, and nominal PWM signal specifications.

Table 4-2 PWM Command signal specifications.

Laser State	Minimum	Nominal	Maximum
Laser Off	0.0 VDC	0.0 VDC	+0.8 VDC
Laser On	+3.5 VDC (3 mA)	+5.0 VDC (6 mA)	+6.7 VDC (10 mA), continuous
Frequency Range	0 Hz (DC)	5 kHz	100 kHz
Duty Cycle	0%	— —	100%

Operating modes

External control

In addition to controlling the Firestar laser using a UC-2000 Controller, control of Firestar externally, without a UC-2000, is also possible. 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 sending PWM pulses at the proper time (gating) and with the proper duty cycle (power).

Analog voltage or current control

Although Firestar f201 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/C connector then control both laser gating and power.

technical reference

Controlling laser power

To generate the correct analog voltage 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 9, PWM Input, and Pin 1, PWM Return, on the User 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.

Note: 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. Continuous operation at 99% duty cycle may lead to thermal instability and optical degradation.

Gated operation

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.

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 state, short circuit to ground, or an open or disconnected Gate input locks the beam off.

Warning serious personal injury

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 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 CO₂ 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 cooler lasing medium (the CO₂ gas) is more efficient than a hotter one. This overshoot effect is more pronounced at lower gating frequencies since the gas has a longer time to cool down between Command signal pulses.

technical reference

Controlling laser power

Marking/engraving operation

When the delay between the end of one PWM Command signal pulse and the beginning of the next PWM pulse exceeds 200 microseconds (less than or equal to 5 kHz), Firestar's on-board tickle generator sends a tickle pulse to maintain plasma ionization in the tube. Because the on-board tickle generator can not anticipate when the next PWM Command pulse will arrive; the tickle pulse (which typically lasts for 2–6 μ s depending on the laser) can effectively merge with a PWM signal that follows closely afterwards. When the PWM pulse that follows is short, causing the tickle pulse to become a significant fraction of the PWM pulse duration, then the tickle pulse effectively substantially increases the length of the PWM pulse it has merged with. For subtle marking applications on sensitive, low threshold materials this lengthened PWM pulse may affect mark quality.

While this situation can occur when using PWM Command signal frequencies of 5 kHz and less, it is important to note that it isn't the Command signal frequency itself that is the determining factor but rather this behavior happens only when the off time between PWM pulses exceeds 200 microseconds.

technical reference

User I/O connections

The User I/O connections section includes subsections:

User I/O connection summary

Input/output signals

Sample I/O circuits

I/O connections

User I/O connection summary

Table below provides a quick reference summary to Firestar f201 User I/O connections.

Table 4-3 User I/O pin descriptions.

Pin	Function	Description
1	PWM Return	Use this input pin as the return side of the PWM Command signal.
2	Remote Reset/Start Request input	Apply a positive or negative voltage (± 5 –24 VDC) with respect to Pin 11, Input Common, to reset or remote keyswitch the laser. The laser remains disabled while voltage is applied. Removing voltage from the Remote Reset/Start Request input causes the laser's Ready indicator to illuminate and begins a five-second countdown after which lasing is enabled.
3	Remote Interlock input	Apply a positive or negative voltage (± 5 –24 VDC) with respect to Pin 11, Input Common, to enable lasing. If your system does not use a remote interlock, this input must be connected to a voltage source in the range of ± 5 –24 VDC. Refer to Figure 3-7 for a diagram showing how the Remote Interlock input is factory-jumpered on the Quick Start Plug.
4	+ 5 VDC Auxiliary Power	This connection provides +5 VDC for driving external inputs or outputs. The +5 VDC Auxiliary Power output can source up to 0.5 A and is protected by a 0.5 A self-resetting fuse. The return (ground) path must be through Pin 12, Auxiliary DC Power Ground.
5	+ 24 VDC Auxiliary Power	This connection provides +24 VDC for driving external inputs or outputs. The +24 VDC Auxiliary Power output can source up to 0.5 A and is protected by a 0.5 A self-resetting fuse. The return (ground) path must be through Pin 12, Auxiliary DC Power Ground.
6	Laser Active output	This bi-directional switched output is internally connected to Pin 13, Output Common, when the laser is actively lasing (Lase indicator illuminated red). This output is open (high impedance) when no beam is being emitted (Lase indicator Off).
7	Over Temperature output	This bi-directional switched output is internally connected to Pin 13, Output Common, when laser temperature is above safe operating limits (Temp LED illuminated red). The output is open (high impedance) when laser temperature is within limits (Temp LED green).

technical reference

User I/O connections

Table 4-3 User I/O pin descriptions (continued).

Pin	Function	Description
8	Laser Ready output	This bi-directional switched output is internally connected to Pin 13, Output Common, when the laser is enabled (Ready LED illuminated yellow), indicating that lasing will occur when a PWM Command signal is applied to Pin 9 and Pin 1. When this output is initially switched closed, there is a five-second delay during which lasing is inhibited. This output is open (high impedance) when the laser is disabled (Ready LED Off).
9	PWM Input	Connect your PWM Command signal (+5 VDC, 5 kHz nominal, 100 kHz max, pulse width modulated) to this input pin to control laser output power. Refer back to Controlling laser power for further information on laser control signals.
11	Input Common	Use this input pin to connect return lines for Remote Interlock, Shutter Open Request, and Remote Reset/Start Request lines.
12	Auxiliary DC Power Ground	This connection provides a ground (earth) connection for +5 and +24 VDC auxiliary power outputs. This pin is the only User I/O pin that is connected to chassis ground. Do not use this pin for grounding if DC power to external I/O circuits is supplied from an external customer-supplied DC power source.
13	Output Common	Use this pin to complete the return path for output connections (Pin 6, 7, 8, 14, or 15). The Output Common line is protected by a 0.25 A self-resetting fuse.
15	Interlock Open output	This bi-directional switched output is internally connected to Pin 13, Output Common, when remote interlock circuitry is open (Remote Interlock indicator illuminated red), indicating that lasing is disabled. The output is open (high impedance) when lasing is enabled (Remote Interlock indicator green).

Input/output signals

Firestar's input/output signals are divided into three categories: auxiliary DC power, input signals, and output signals. Signals in each category are fully described in the sections below. Following figure illustrates the pin arrangement of the User I/O (15 pin female D-type subminiature) connector on Firestar's rear panel.

technical reference

User I/O connections

Auxiliary DC power

Firestar's User I/O connector provides auxiliary DC power for driving external inputs or outputs connected to the User I/O port. Pin 4, +5 VDC Auxiliary Power, and Pin 5, +24 VDC Auxiliary Power, are protected by self-resetting fuses rated at 0.5 A. Pin 12, Auxiliary DC Power Ground, is connected to chassis ground while all other User I/O pins are floating with respect to chassis ground. Figure 3-6 illustrates Firestar's internal DC supply wiring.

Caution

possible
equipment
damage

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

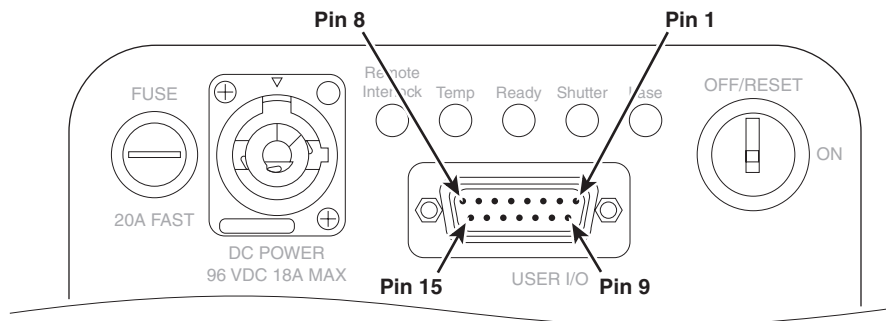


Figure 4-5 User I/O connector pinouts.

Pin 4 + 5 VDC Auxiliary Power

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

Pin 5 + 24 VDC Auxiliary Power

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

Pin 12 Auxiliary DC Power Ground

technical reference

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

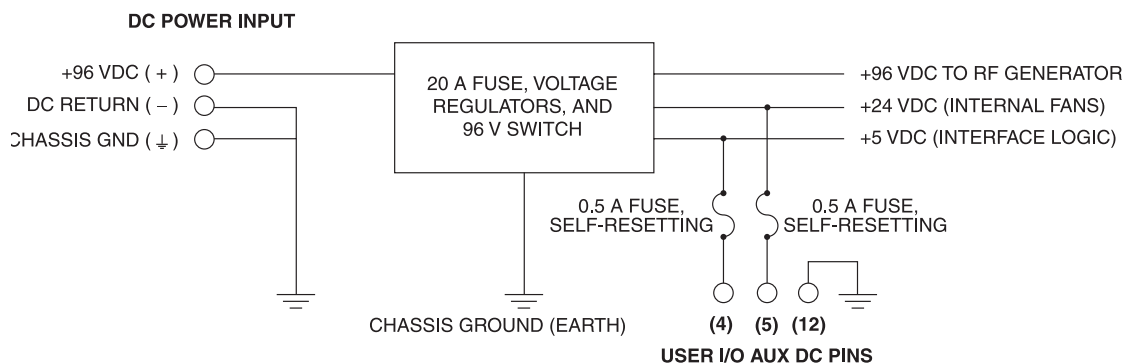


Figure 4-6 Auxiliary power supply wiring.

Input signals

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

Pin 1 PWM Return

Connect the return side of your PWM Command signal to this pin. Refer to Table 4-4 for input circuit specifications.

Pin 2 Remote Reset/Start Request

Apply a positive or negative voltage (± 5 –24 VDC) with respect to Pin 11, Input Common, to reset or remote keyswitch the laser. The laser remains disabled while voltage is applied to this input. Removing voltage from the Remote Reset/Start Request input causes the laser's Ready lamp to illuminate and begins a five-second countdown after which lasing is enabled. Because all DC power is removed from the laser's RF driver when this input is active, no lasing can occur until voltage is removed from Pin 2. Refer to Table 3-4 for input circuit specifications.

For Keyswitch-equipped lasers in automated systems, the Remote Reset/Start Request input can operate as a remote keyswitch. To use this "remote keyswitch" functionality, first place the Keyswitch in the ON position. Then after each DC power-up cycle (or to reset a fault condition), apply a momentary voltage pulse in the range of ± 5 –24 VDC to Pin 2. This reset action initiates a five-second delay after which lasing is enabled. To prevent operator injury when using Keyswitch-equipped lasers, the Remote Reset/Start Request signal is ignored when the Keyswitch is set to the OFF/RESET position. The manually-operated Keyswitch must be set to the ON position before the laser can be reset from a remote location.

technical reference

User I/O connections

Pin 3 Remote Interlock

Apply a positive or negative voltage (± 5 –24 VDC) with respect to Pin 11, Input Common, to enable lasing. If your system does not use a remote interlock, this input must be connected to a voltage source in the range of ± 5 –24 VDC. Refer to following figure for a diagram showing how the Remote Interlock input is factory-jumpered on the Quick Start Plug. Because all DC power is removed from the laser's RF driver when this input is inactive, no lasing can occur until voltage is applied to Pin 3. Refer to Table 4-4 for input circuit specifications.

After voltage is removed and then re-applied to the Remote Interlock input on Keyswitch-equipped lasers, the Keyswitch or the Remote Reset/Start Request input must be toggled to restart the laser. This action initiates a five-second delay during which lasing is inhibited.

On OEM lasers, the Remote Interlock input is not latched. Re-applying a voltage to Pin 3 enables the Ready indicator and lasing is possible after the five-second delay, provided that the Shutter Open Request signal is also present (Shutter indicator illuminated).

Pin 9 PWM Input

Connect your PWM Command signal (+5 VDC, 5 kHz nominal, 100 kHz max) to Pin 9. This pulse width modulated Command signal controls laser output so that a duty cycle of 50% corresponds to a laser output of approximately one-half rated output power and a duty cycle of 95% corresponds to approximately full output power. Refer to Controlling laser power in this chapter for further information on laser control signals. Connect the PWM signal source return to Pin 1, PWM Return. See following table for input circuit specifications.

Pin 10 Shutter Open Request

Apply a positive or negative voltage (± 5 –24 VDC) with respect to Pin 11, Input Common, to enable lasing, in conjunction with the manual Shutter Switch (if equipped). If your system does not supply a Shutter Open Request signal, this input must be connected to a voltage source in the range of ± 5 –24 VDC. Refer to Figure 3-7 for a diagram showing how the Shutter Open Request input is factory-jumpered on the Quick Start Plug. When a voltage is initially applied to this input, there is a five-second delay during which lasing is inhibited. Because all DC power is removed from the laser's RF driver when this input is inactive, no lasing can occur until voltage is applied to Pin 10. See Table 3-4 for input circuit specifications.

To enable Keyswitch-equipped lasers, you must apply a voltage (in the range of ± 5 –24 VDC) to the Shutter Open Request input and move the manual Shutter Switch (if equipped) to the Open position. Lasing is inhibited when voltage is removed from Pin 10 or the Shutter Switch is Closed.

Note: To ensure optimum performance, a five-second delay is imposed from the time a Shutter Open Request input occurs to the time that PWM Command signals are accepted.

Pin 11 Input Common

Use this pin to connect return lines for Remote Interlock, Shutter Open Request, and Remote Reset/Start Request lines. Refer to the following table for input circuit specifications.

Figure below illustrates how Remote Interlock inputs are factory-jumpered on the Quick Start Plug to enable lasing for initial testing and troubleshooting purposes.

technical reference

User I/O connections

Figure below illustrates the input circuit's equivalent internal schematic while following table provides Firestar f201 input circuit specifications.

Table 4-4 Input circuit specifications.

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

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

Warning
serious
personal
injury

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

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

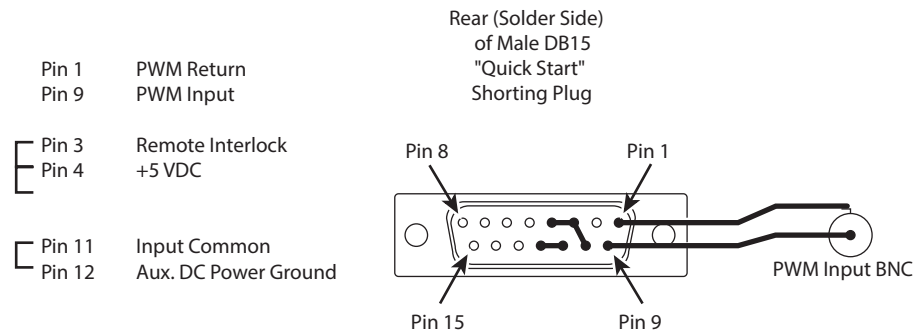


Figure 4-8 Input equivalent schematic.

technical reference

User I/O connections

Output signals

Firestar's five user outputs correspond to the status functions described below. Outputs are optoisolated, bi-directional analog switches that allow for high-side or low-side switching. The shared connection, Output Common, is separate from the laser's chassis ground to allow high-side or low-side switching and to isolate control signals for optimum EMI performance.

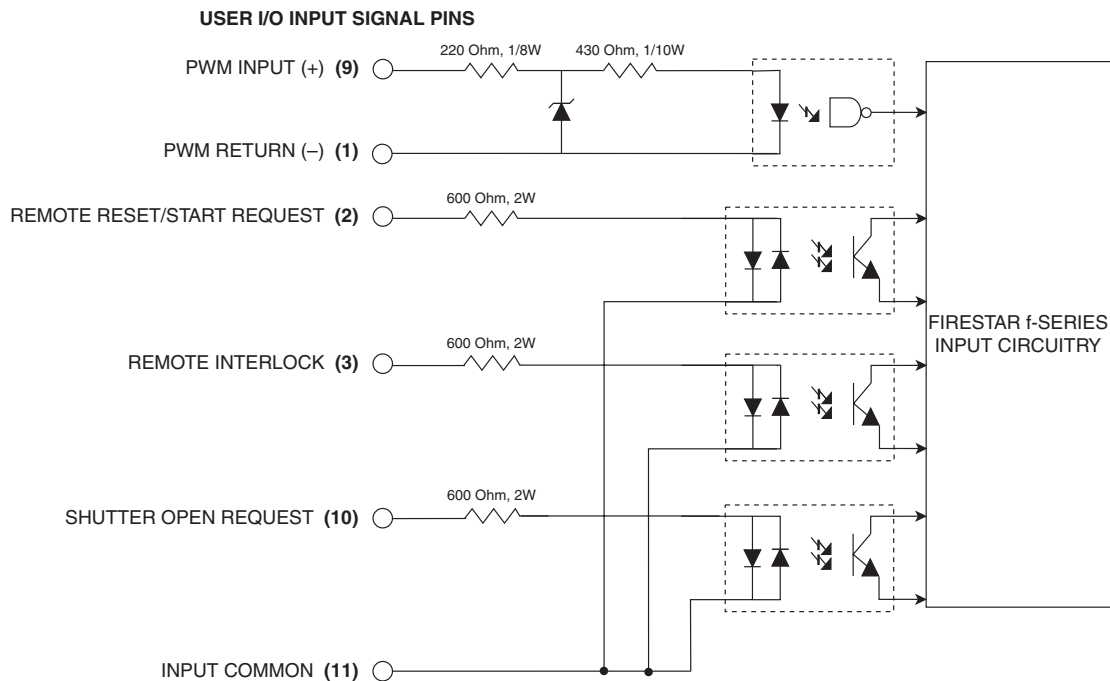


Figure 4-7 Quick Start Plug wiring diagram.

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

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

Pin 6 Laser Active

This bi-directional switched output is internally connected to Pin 13, Output Common, when the laser is actively lasing (Lase indicator red). This output is open (high impedance) when no beam is being emitted (Lase indicator Off). Refer to the following table for output circuit specifications.

Pin 7 Over Temperature

This bi-directional switched output is internally connected to Pin 13, Output Common, when laser temperature is above safe operating limits (Temp indicator red). The output is open (high impedance) when laser temperature is within operating limits (Temp LED green). After an over temperature fault occurs, cool the laser and then cycle DC power to reset the laser. Refer to the following table for output circuit specifications.

technical reference

User I/O connections

Pin 8 Laser Ready

This bi-directional switched output is internally connected to Pin 13, Output Common, when the laser is enabled (Ready indicator On), indicating that lasing will occur when a PWM Command signal is applied to Pin 9 and Pin 1. When this output is initially switched closed, there is a five-second delay during which lasing is inhibited. This output is open (high impedance) when the laser is disabled (Ready LED Off). Refer to Table below for output circuit specifications.

Pin 13 Output Common

Use this pin to complete the return (ground) path for any output connection (Pin 6, 7, 8, 14, or 15). The Output Common line is protected by a 0.25 A self-resetting fuse.

Pin 14 Shutter Open

This bi-directional switched output is internally connected to Pin 13, Output Common, when the Shutter Switch is Open and a Shutter Open Request signal is present (Shutter LED blue), indicating that lasing may be enabled if other operating conditions are met. The output is open (high impedance) when the Shutter Switch is Closed or the Shutter Open Request signal is removed. When Shutter Open output closes (Shutter LED Off), there is a five-second delay until PWM inputs are recognized. Refer to the below table for output circuit specifications.

Pin 15 Interlock Open

This bi-directional switched output is internally connected to Pin 13, Output Common, when remote interlock input circuitry is open (Remote Interlock LED red), indicating that lasing is disabled. This output is open (high impedance) when the laser is enabled (Remote Interlock indicator green). When this output is initially switched open, there is a five-second delay during which lasing is inhibited. See the following tables for output circuit specifications.

Following figure illustrates the output circuit's equivalent internal schematic and the following provides Firestar f201 output circuit specifications.

Table 4-5 Output circuit specifications.

Output Device	Specifications
Bi-directional MOSFET	2.5 Ohms R _{dson} 10 MOhms Off Voltage ± 24 VDC, max. Current 50 mA, max.

technical reference

User I/O connections

Sample I/O circuits

Sample inputs

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

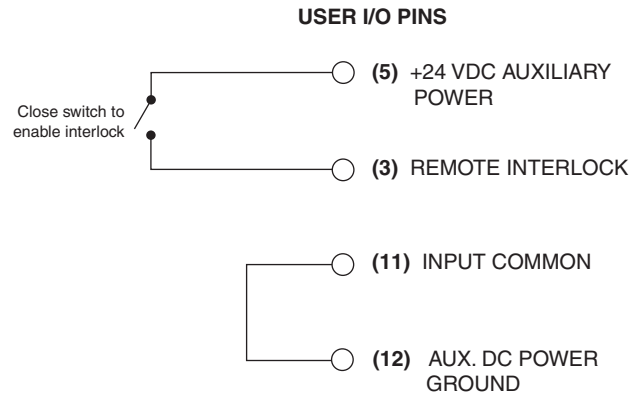


Figure 4-10 Customer-supplied interlock.

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

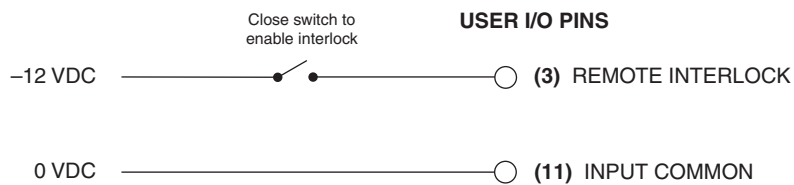


Figure 4-11 Customer-supplied interlock, negative voltage.

technical reference

User I/O connections

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

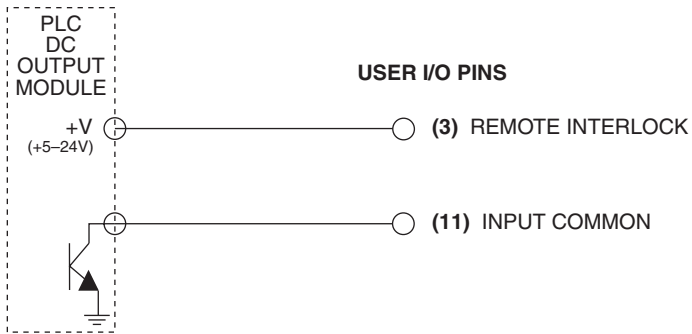


Figure 4-12 PLC driven interlock signal.

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

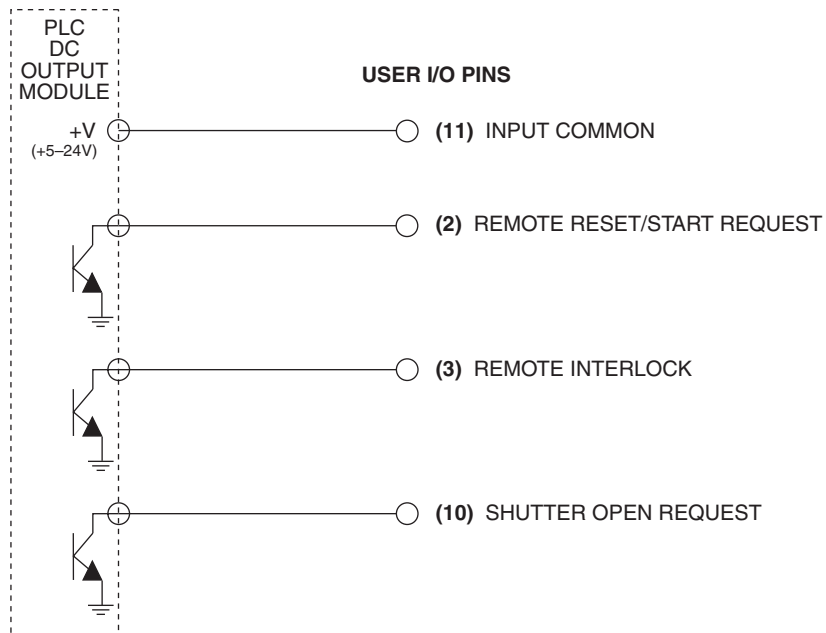


Figure 4-13 Multiple PLC driven inputs.

technical reference

User I/O connections

Sample outputs

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

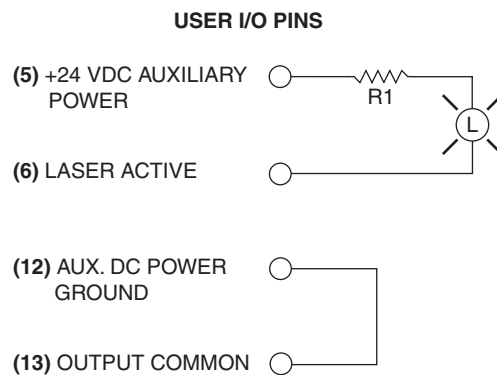


Figure 4-14 Firestar output driving warning lamp.

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

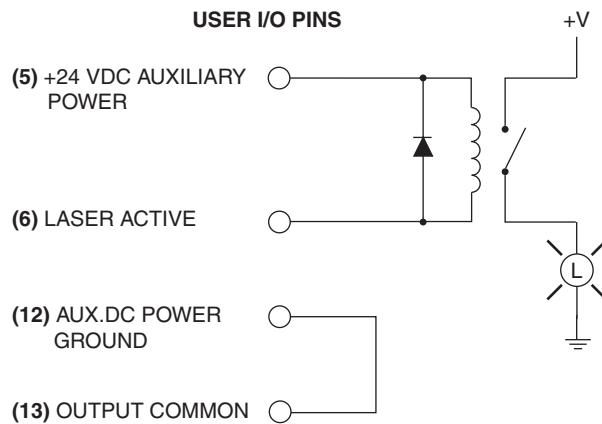


Figure 4-15 Firestar output driving relay.

technical reference

User I/O connections

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

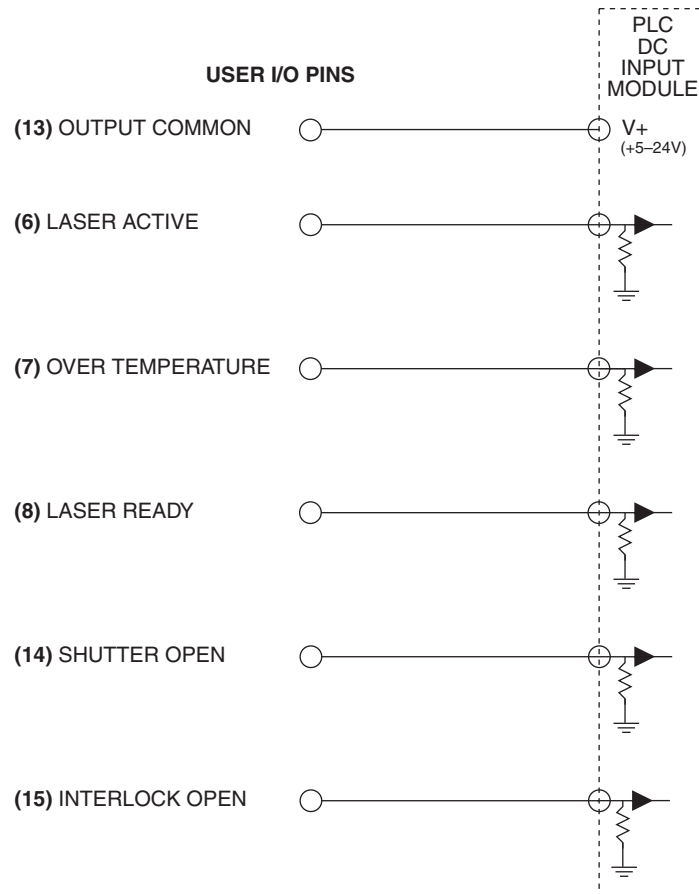


Figure 4-16 Firestar output driving PLC input module.

technical reference

DC Power cables

The DC Power cables section includes subsections:

f201 DC Power cables

Note: If you lengthen the DC Power cable, you must calculate and measure the additional voltage drop to ensure that 96 VDC is available at the laser's DC POWER connector under full-load conditions. Depending on the additional length required, you may need to use larger gauge wire.

f201 DC Power cables

DC Power cables for f201 lasers are manufactured with #12 AWG wire; however, DC input current is split between two positive (+) and two negative (-) conductors. Firestar f201 DC Power cables are available in 5 meter (16.4 ft) and 7 m (23 ft) lengths. The standard length is 5 meters. The minimum bend radius for f201 DC Power cables must be greater than 124.5 mm (4.9 in).

F201 DC Power cables are wired into a Canon-type ME3476L14-4S plug that connects with a matching receptacle on the laser's rear panel. Table below provides pinout information for f201 DC Power cable connectors.

Table 4-7 f201 DC Power connector pinouts.

Function	Wire Color Code	Terminal Designation
+96 VDC	Red	A
- VDC	Black	B
+96 VDC	Red	C
- VDC	Black	D
Ground	Green	Shell

technical reference

Integrating Firestar safety features

The Integrating Firestar safety features section includes subsections:

Remote Interlock functions

Firestar's DB-15 User I/O connector allows system integrators or end-users to integrate Firestar safety features into their control system. Firestar's keyswitch, shutter, and remote interlock functions serve to enable or disable DC power to Firestar's RF drive. Without DC power, the RF driver cannot supply RF energy to the resonator, causing the CO₂ gas to remain in a zero-energy state. Firestar status indicators provide users with a quick visual indication of the laser's operational status. All power to the laser's RF board is removed whenever Ready or Shutter indicators are Off (Laser Ready or Shutter Open outputs open).

OEM lasers

On OEM lasers, the Ready LED illuminates on DC power-up (provided that Shutter Open Request and Remote Interlock inputs are enabled) and five seconds later, DC power is applied to the RF driver. Over temperature faults are reset by removing and then re-applying DC power after the laser has cooled. Remote interlock faults are not latched; the Ready LED illuminates yellow as soon as the interlock circuit is closed (when the Remote Interlock LED turns from red to green) and five seconds later lasing is enabled.

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

Your control system can monitor the laser's ready status on the User I/O connector by connecting your system's input between Pin 8, Laser Ready, and Pin 13, Output Common (see Figure 4-16).

technical reference

Integrating Firestar safety features

The Laser Ready output closes when the laser is enabled (Ready LED illuminated yellow), indicating that lasing is possible. The output is open (Ready LED off) when lasing is disabled.

Note: After the Laser Ready output closes, a five-second delay occurs before lasing is enabled.

Remote interlock functions

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

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

To use Firestar's remote interlock feature, apply a voltage in the range of ± 5 –24 VDC to Pin 3, Remote Interlock. Applying an interlock signal causes the Remote Interlock LED to illuminate green and sends DC power to the RF driver, which enables lasing after a five-second delay (provided that the Ready LED is yellow and the Shutter LED is blue). Removing the interlock signal removes DC power from the RF driver, causing the Remote Interlock LED to turn red and the Ready LED to turn off. Lasing remains disabled until a Remote Interlock signal is reapplied to Pin 3.

Your control system can monitor the laser's remote interlock status on the User I/O connector by connecting your system's input to Pin 15, Interlock Open, and Pin 13, Output Common (see Figure 3-16). This output is closed when remote interlock circuitry is open (Remote Interlock LED illuminated red). The output is open (in a high-impedance state) and the Remote Interlock LED is green when interlock circuitry is closed.

technical reference

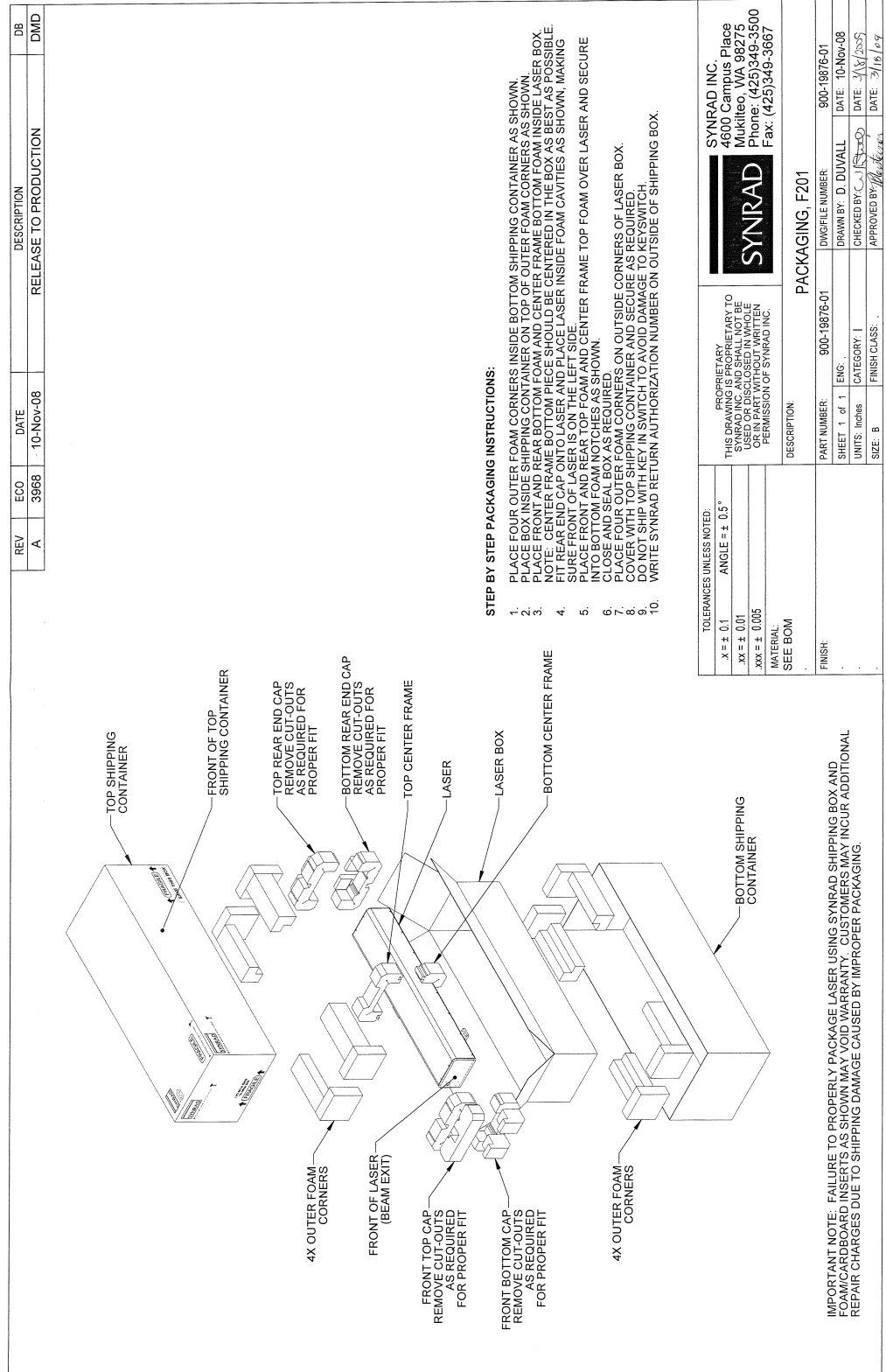


Figure 4-16 F201 packaging diagram.

technical reference

f201 general specifications

Table 4-10 Firestar f201 general specifications.

Parameter	Firestar f201
Output Specifications	
Wavelength	10.2; 10.6 microns
Power Output^{1,2}	
Continuous	200 Watts
Pulsed ³	250 Watts
Power Stability ⁴	± 7%
Power Stability ⁵	± 5%
Mode Quality	$M^2 = 1.2 \pm 0.1$
Beam Waist Diameter (at $1/e^2$) ⁶	4.5 ± 0.1 mm
Beam Divergence, full angle, (at $1/e^2$)	4.0 ± 0.2 mrad
Ellipticity	< 1.3
Polarization	Linear, horizontal
Extinction Ratio.....	> 100:1
Rise Time	< 150 μ s
<hr/>	
Input Specifications	
Power Supply	
Voltage	96 ± 2.0 VDC
Maximum Current	36 A
Command Input Signal	
Voltage	+3.5 to +6.7 VDC
Current (max., continuous)	10 mA @ +6.7 VDC
Frequency ⁷	DC–100 kHz
Duty Cycle	0–100%
Logic Low State (V_{min} – V_{max})	0.0 to +0.8 VDC
Logic High State (V_{min} – V_{max})	+3.5 to +6.7 VDC

* Specifications subject to change without notice.

- 1 This power level is guaranteed for 12 months regardless of operating hours.
- 2 Minimum 96 VDC input voltage to obtain guaranteed output power.
- 3 100 Hz, 10% duty cycle, average power as read by laser power meter, then multiplied by 10.
- 4 From cold start (guaranteed) at 95% duty cycle.
- 5 After two minutes (typical) at 95% duty cycle.
- 6 Measured at laser output.
- 7 FCC and CE tested at 5 kHz.

technical reference

f201 general specifications

Table 4-10 Firestar f201 general specifications (continued).

Parameter	Firestar f201
Cooling Specifications	
Maximum Heat Load	4000 Watts (13.7 kBtu/hr)
Flow Rate (minimum)	2.0 GPM at < 60 PSI (7.6 lpm at < 414 kPa)
(recommended)	2.5 GPM at < 60 PSI (9.5 lpm at < 414 kPa)
Pressure Drop	1 PSI at 2 GPM (6.9 kPa at 7.6 lpm)
Coolant Temperature ⁸	18 °C to 22 °C
Environmental Specifications	
Operating Temperature ⁹	15 °C to 40 °C
Humidity	0–95%, non-condensing
Physical Specifications	
Length	48.4 in (122.9 cm)
Width	11.0 in (27.9 cm)
Height	6.48 in (16.5 cm)
Weight	96 lbs (43.5 kg)

* Specifications subject to change without notice.

8 Firestar f201 lasers can be operated at coolant temperatures up to 28 °C (82 °F) in order to reduce problems associated with condensation; however, this may result in decreased laser performance and/or reduced laser lifetime.

9 Published specifications guaranteed at a cooling temperature of 22 °C.

technical reference

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maintenance/ troubleshooting

5

Use information in this chapter to perform maintenance or troubleshoot your f201 laser.

This chapter contains the following information:

Maintenance – describes typical f201 maintenance procedures.

Troubleshooting – explains how to troubleshoot common f201 problems.

maintenance/ troubleshooting

Maintenance

The Maintenance section includes subsections:

Disabling f201 lasers

Daily inspections

Storage/shipping

Cleaning optical components

Disabling f201 lasers

Before performing any maintenance on your Firestar® f201 laser, be sure to completely disable the laser by disconnecting the DC Power cable (or cables) from the rear of the laser.

Daily inspections

Perform the following steps daily to keep your Firestar f201 laser in optimum operating condition. Except for the procedures described below, no other service is required or should be attempted.

Caution
possible
equipment
damage

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

Warning
serious
personal
injury

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

- 1 Inspect all cooling tubing connections for signs of leakage. Check for signs of condensation that may indicate the cooling water temperature has been set below the dew point temperature. Condensation will damage electrical and optical components inside the laser. See Setting coolant temperature in the Getting Started chapter for details on preventing condensation.
- 2 When using compressed air as a purge gas on your f201 laser, empty water traps and oil separators on each filter and/or dryer between the laser and your compressed air source. Compressed air purity must meet the purge gas specifications shown in Table 1-6 in the Getting Started chapter.

maintenance/ troubleshooting

Maintenance

- 3 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.
- 4 Visually inspect the exterior housing of the laser to ensure that all warning labels are present. Refer to the Laser Safety chapter for f201 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 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.

Important Note: 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.

Cleaning optical components

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

Caution possible equipment damage

Because of their smaller beam diameter, Firestar lasers have significantly higher power densities than previous SYNRAD lasers. This means that any contamination 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. In dirty environments, purge laser optics using filtered air or nitrogen to prevent vapor and debris from accumulating on optical surfaces.

Important – Firestar f201 and lasers do not have output windows located inside the faceplate. NEVER disassemble the laser housing to inspect f201 optics. Instead, always connect nitrogen or filtered air to the laser's Gas Purge port to prevent vapor and debris from contaminating internal optical surfaces.

maintenance/ troubleshooting

Maintenance

⚠ Danger
serious
personal
injury

Ensure that DC power to the laser is turned off and locked out before inspecting optical components in the beam path. Invisible CO₂ laser radiation is emitted through the aperture. Corneal damage or blindness may result from exposure to laser radiation.

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

Cleaning guidelines

Wear latex gloves or finger cots (powder-free) to prevent contamination of optical surfaces by dirt and skin oils.

Never handle optics with tools; always use gloved hands or fingers.

Hold optics by the outer edge; never touch the coated surface.

Always place optics on lens tissue for protection; never place optics on hard or rough surfaces.

It may be necessary to use a cotton ball or fluffed cotton swab instead of a lens wipe to uniformly clean the entire surface of small-diameter mounted optics.

Before using any cleaning agents, read Material Safety Data Sheets (MSDS) and observe all necessary safety precautions.

Required cleaning materials

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

Table 5-1 Required cleaning materials.

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

maintenance/ troubleshooting

Maintenance

Cleaning optics

- 1 Shut off and lock out all power to the laser. You must verify that the laser is OFF (in a zero-energy state) before continuing with the optical inspection!
- 2 Visually inspect all optical surfaces in the beam path, including the laser's output coupler, for contaminants.

Caution possible lens damage

Do not allow the nozzle of the air bulb to touch the optical surface. Any contact may damage the optic by scratching coatings on the optical surface.

Do not use compressed shop air to blow contamination from the optic. Compressed air contains significant amounts of water and oil that form adsorbing films on the optical surface.

Do not exert pressure on the surface of the optic during cleaning. Optical surfaces and coatings are easily scratched by dislodged contaminants.

Use a new lens wipe on each pass as contaminants picked up by the wipe may scratch the optical surface.

- 3 Remove loose contaminants from the optic by holding a clean air bulb at an angle to the optic and blow a stream of air at a glancing angle across the lens surface. Repeat as necessary.
- 4 Dampen a lens wipe with the selected cleaning agent. Alcohol (least aggressive) is best for initial surface cleaning. Acetone (moderately aggressive) is best for oily residue or minor baked-on vapors and debris.

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

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

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

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

- 6 Carefully examine the optic under a good light. Certain contaminants or damage such as pitting cannot be removed. In these cases the optic must be replaced to prevent catastrophic failure.
- 7 Repeat Steps 4 through 6 as required, removing all traces of contaminants and deposits.

maintenance/ troubleshooting

Troubleshooting

The Troubleshooting section includes subsections:

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

Introduction

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

To troubleshoot Firestar f201 lasers, it is necessary to understand the sequence of events that must happen before the laser can operate. Before attempting any service, we advise you to read the entire troubleshooting guide and review both the operational flowchart and the functional block diagram.

 **Danger**
serious
personal
injury

This Class 4 laser product emits invisible infrared laser radiation in the 10.6 μm CO₂ wavelength band. Because exposure to direct or diffuse laser radiation can inflict severe corneal injuries, always wear eye protection when in the same area as an exposed laser beam. Do not allow the laser beam to contact a person. This product emits an invisible laser beam that is capable of seriously burning human tissue.

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

Caution
possible
equipment
damage

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

maintenance/ troubleshooting

Troubleshooting

Operational flowchart

The flowchart in the figure below illustrates Firestar's start-up sequence.

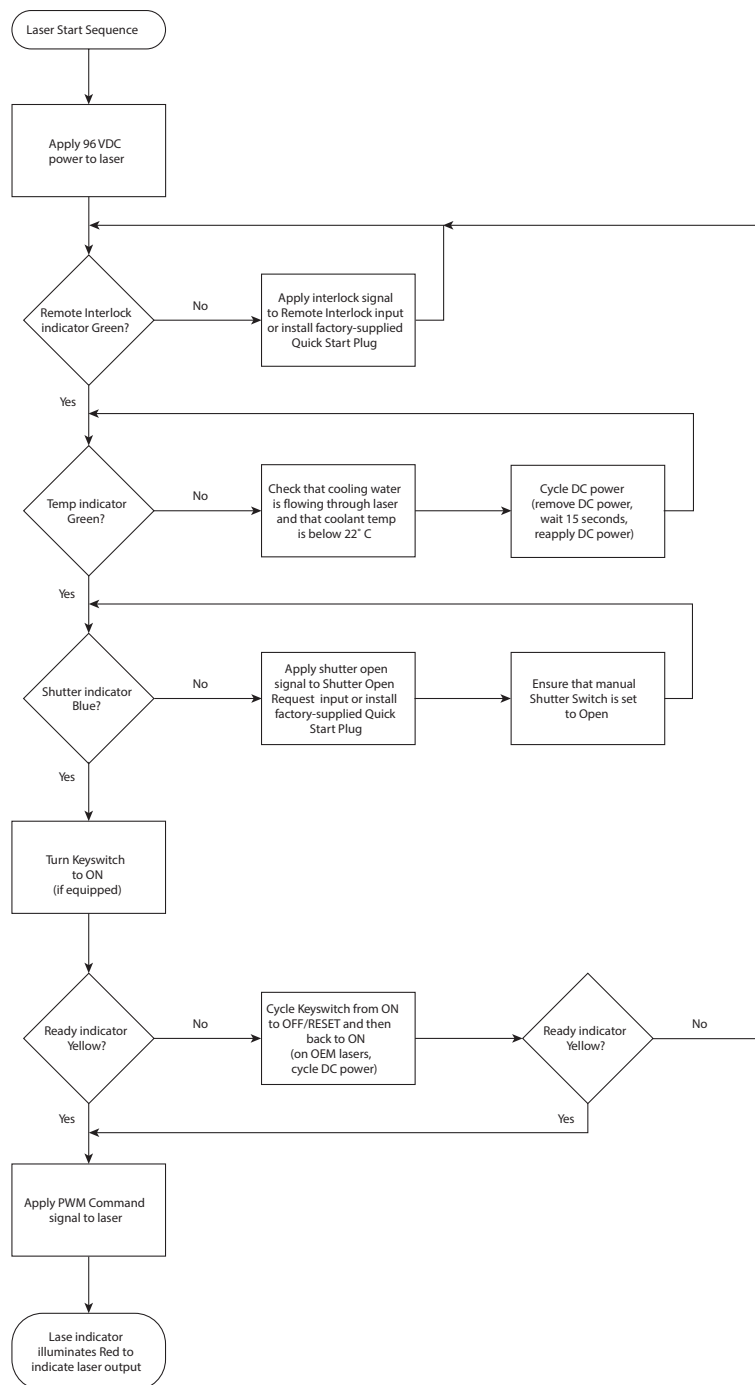


Figure 5-1 Operational flowchart.

maintenance/ troubleshooting

Troubleshooting

Functional block diagram

Figure below is a functional block diagram illustrating the f201's control architecture.

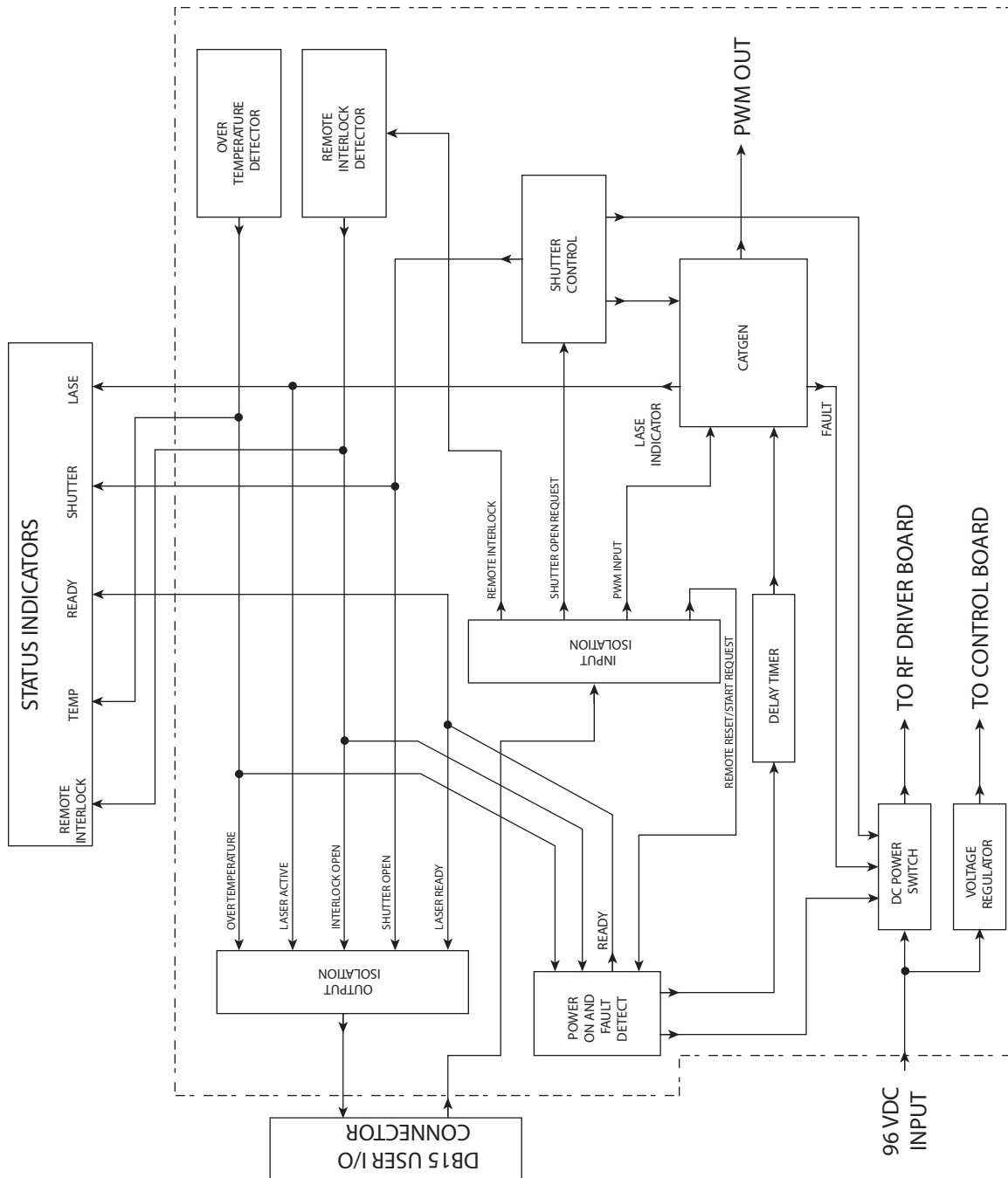


Figure 5-2 f201 functional block diagram.

maintenance/ troubleshooting

Troubleshooting

Status LEDs

Firestar f201 LED indicators, also mirrored as output signals on the User I/O connector, provide status information to the user. Table below shows Firestar output signal and LED indicator states during normal and fault conditions. User I/O outputs are Closed when the state indicated by the signal name is True.

Table 5-2 Status signals.

LED Indicator	LED Status		Output Signal Name	User I/O Signal Status	
	Normal	Fault		Normal	Fault
Remote Interlock	Green	--	Interlock Open	Open	--
	--	Red		--	Closed
Temp	Green	--	Over Temperature	Open	--
	-- Red			--	Closed
Ready	Yellow	--	Laser Ready	Closed	--
	-- Off			--	Open
Shutter	Blue	--	Shutter Open	Closed	--
	-- Off			--	Open
Lase	Red	--	Laser Active	Closed	--
	-- Off			--	Open

When PWM Command pulses are applied (and are long enough to produce laser output) the Lase LED illuminates red.

On OEM lasers, the Ready lamp illuminates on DC power-up when Remote Interlock and Temp indicators illuminate green. After the Ready indicator illuminates, a five-second delay occurs before Firestar is permitted to lase.

Note: Firestar Ready and Shutter indicators (as well as Laser Ready and Shutter Open outputs) denote separate control functions. Although the Ready lamp may light while the Shutter LED is Off (Shutter Switch Closed or Shutter Open Request signal missing), no power is applied to the RF boards until both Ready and Shutter indicators are illuminated.

maintenance/ troubleshooting

Troubleshooting

Tables below show how 201 signal status changes when remote interlock, over-temperature, or shutter closed conditions occur (fault conditions are shown in bold type).

Table 5-3 Normal operating condition.

LED Indicator	LED Status	Output Signal	Output Status
Remote Interlock	Green	Interlock Open	Open
Temp	Green	Over Temperature	Open
Ready	Yellow	Laser Ready	Closed
Lase (tickle active)	Off	Laser Active	Open
Lase (if PWM applied)	Red	Laser Active	Closed

Table 5-4 Quick Start Plug or interlock/shutter inputs not connected.

LED Indicator	LED Status	Output Signal	Output Status
Remote Interlock	Red	Interlock Open	Closed
Temp	Green	Over Temperature	Open
Ready	Off	Laser Ready	Open
Lase (tickle inactive)	Off	Laser Active	Open
Lase (if PWM applied)	Off	Laser Active	Open

Table 5-5 Interlock open condition.

LED Indicator	LED Status	Output Signal	Output Status
Remote Interlock	Red	Interlock Open	Closed
Temp	Green	Over Temperature	Open
Ready	Off	Laser Ready	Open
Lase (tickle inactive)	Off	Laser Active	Open
Lase (if PWM applied)	Off	Laser Active	Open

maintenance/ troubleshooting

Troubleshooting

Table 5-6 Over Temperature fault.

LED Indicator	LED Status	Output Signal	Output Status
Remote Interlock	Green	Interlock Open	Open
Temp	Red	Over Temperature	Closed
Ready	Off	Laser Ready	Open
Lase (tickle inactive)	Off	Laser Active	Open
Lase (if PWM applied)	Off	Laser Active	Open

Table 5-7 Shutter closed condition.

LED Indicator	LED Status	Output Signal	Output Status
Remote Interlock	Green	Interlock Open	Open
Temp	Green	Over Temperature	Open
Ready	Yellow	Laser Ready	Closed
Lase (tickle inactive)	Off	Laser Active	Open
Lase (if PWM applied)	Off	Laser Active	Open

Table 5-8 VSWR fault.

LED Indicator	LED Status	Output Signal	Output Status
Remote Interlock	Green	Interlock Open	Open
Temp	Green	Over Temperature	Open
Ready	Yellow	Laser Ready	Closed
Shutter	Blue (Flashing)	Shutter Open	Closed
Lase (tickle active)	Off	Laser Active	Open
Lase (if PWM applied)*	Red	Laser Active	Closed

* A continuously flashing Shutter LED indicates a VSWR fault and the laser is limited to a maximum pulse length of 12 μ s (approximately 6% duty cycle at 5 kHz) until the fault clears.

maintenance/ troubleshooting

Troubleshooting

Laser fault indications

On f201 lasers manufactured after November 2007, Ready (RDY) and Shutter (SHT) LED's flash to annunciate one of four laser faults. The following table lists error codes, the corresponding fault, and describes basic corrective action. See the following section, Resetting faults, for detailed corrective actions.

Table 5-9 Laser error codes.

LED	# of Blinks	Fault Condition	Corrective Action
RDY	1 blink	Under Voltage Fault	Verify 96 VDC (measured under load)/cycle power
RDY	2 blinks	Over Voltage Fault	Verify 96 VDC (measured under load)/cycle power
RDY	3 blinks	RF Drive Switch Fault	Remove DC power to the laser, wait 30 seconds, and then reapply DC power

Resetting faults

Remote interlock condition

A remote interlock condition occurs when the Remote Interlock input opens (the Remote Interlock LED changes from green to red).

To reset a remote interlock condition on Keyswitch-equipped lasers, re-establish the Remote Interlock signal input (Remote Interlock LED changes from red to green) and cycle the Keyswitch from OFF/RESET to ON (or apply a ± 5 –24 VDC Remote Reset/Start Request pulse with the Keyswitch set to ON). When the Ready indicator illuminates, lasing is enabled after a five-second delay.

 **Warning**
serious
personal
injury

On Firestar f201 OEM lasers, remote interlock faults are not latched. Clearing the fault condition re-enables the Ready indicator and the laser will fire after the five-second delay provided that the Shutter indicator is lit and a PWM Command signal is applied. Because exposure to 10.6 μm CO₂ 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.

maintenance/ troubleshooting

Troubleshooting

On OEM lasers, remote interlock conditions are not latched. Re-establish the Remote Interlock signal input (Remote Interlock LED changes from red to green) to enable the Ready indicator and begin lasing after the five-second delay.

Over temperature fault

Over temperature faults occur when thermal limits in the laser are exceeded (the Temp LED changes from green to red).

To reset an over-temperature fault on Keyswitch-equipped lasers, lower coolant temperature below $^{\circ}\text{C}$ (f201), cycle DC power to the laser, and then cycle the Keyswitch from OFF/RESET to ON (or apply a $\pm 5\text{--}24$ VDC Remote Reset/Start Request pulse with the Keyswitch set to ON). When the Ready indicator illuminates, lasing is enabled after a five-second delay.

Note: Because of the over-temperature latch circuit, the Temp indicator remains red prior to cycling power even after the laser has cooled sufficiently to begin operation. If the Temp indicator remains red after cycling power, the laser is not sufficiently cooled—cool the laser for several more minutes, cycle power, and then cycle the Keyswitch.

Over-temperature faults are now latched. To reset an over-temperature fault, lower coolant temperature below 28°C (f201) to cool the laser and then cycle DC power to the laser. Once the Temp indicator is green and the Ready lamp is lit, lasing is possible after the five-second delay.

Under voltage fault

An under voltage fault occurs when the DC input voltage falls below preset limits. This fault is indicated by the Ready LED flashing 1 blink. To reset an under voltage fault, first correct the voltage problem and ensure that 96 VDC is measured at the laser under full-load conditions. Next, cycle DC power off and then on again. On Keyswitch-equipped lasers, you must also toggle the Keyswitch from OFF/RESET to ON (or apply a $\pm 5\text{--}24$ VDC Remote Reset/Start Request pulse with the Keyswitch set to ON). When the Ready LED illuminates, lasing is enabled after a five-second delay.

Over voltage fault

An over voltage fault occurs when the DC input voltage rises above preset limits. This fault is indicated by the Ready LED flashing 2 blinks. To reset an over voltage fault, first correct the voltage problem and ensure that 96 VDC is measured at the laser under full-load conditions. Next, cycle DC power off and then on again. On Keyswitch-equipped lasers, you must also toggle the Keyswitch from OFF/RESET to ON (or apply a $\pm 5\text{--}24$ VDC Remote Reset/Start Request pulse with the Keyswitch set to ON). When the Ready LED illuminates, lasing is enabled after a five-second delay.

maintenance/ troubleshooting

Troubleshooting

RF Drive Switch fault

An RF Drive DC fault occurs on power-up when the tube fails to breakdown or a fault occurs in the RF Driver's 96-volt switching circuitry. In this case, the Ready LED flashes 3 blinks. If an RF Drive DC fault occurs, reset the laser by removing DC power to the laser, wait 30 seconds, and then reapply power. On Keyswitch-equipped lasers, you must also toggle the Keyswitch from OFF/RESET to ON (or apply a ± 5 -24 VDC Remote Reset/Start Request pulse with the Keyswitch set to ON) When the Ready LED illuminates, lasing is enabled after a five-second delay. If the RF Drive DC fault reappears, contact SYNRAD or a SYNRAD Authorized Distributor.

PWM Drive/RF Oscillation faults

New circuitry on the f201 RF board has eliminated PWM Drive and RF Oscillation faults. The 4-blink fault indication no longer exists.

VSWR fault

A VSWR fault indicates an impedance mismatch between the tube and RF Driver and occurs when a PWM Command signal is first applied. This fault is annunciated by the Shutter LED flashing continuously until the fault disappears. If a VSWR fault occurs, the VSWR circuit limits the maximum PWM pulse length to 12 microseconds (μ s). This equates to a 6% maximum duty cycle at a 5 kHz frequency or a 24% maximum duty cycle at a 20 kHz PWM frequency. When the VSWR fault clears, the laser resumes normal operation without cycling DC power. If the VSWR fault fails to clear or reappears, contact SYNRAD or a SYNRAD Authorized Distributor.

The leading causes of VSWR failures are environmental conditions, like cold overnight temperatures while the laser is off. In cases like this, it may take as long as 60 seconds for tickle to breakdown the tube and begin normal daily operation.

Other laser faults

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

Symptom:

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

Remote Interlock LED	– Red	Interlock Open output	– Closed
Temp LED	– Green	Over Temperature output	– Open
Ready LED	– Off	Laser Ready output	– Open
Lase LED	– Off	Laser Active output	– Open

maintenance/ troubleshooting

Troubleshooting

Possible Causes:

No voltage is applied to Pin 3 (Remote Interlock) of the User I/O connector.

 **Warning**
serious
personal
injury

On Firestar f201 OEM lasers, remote interlock faults are not latched. Clearing the fault condition re-enables the Ready indicator and the laser will fire after the five-second delay provided that the Shutter indicator is lit and a PWM Command signal is applied. Because exposure to 10.6 μm CO₂ 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.

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

Symptom:

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

Remote Interlock LED	– Green	Interlock Open output	– Open
Temp LED	– Red	Over Temperature output	– Closed
Ready LED	– Off	Laser Ready output	– Open
Lase LED	– Off	Laser Active output	– Open

Possible Causes:

Coolant temperature is above 28 °C (f201) or there is inadequate coolant flow through the laser.

Check that your chiller is maintaining a water temperature between 18 °C–28 °C (64 °F–82 °F) at a flow rate of 9.5 lpm (2.5 GPM) for f201.

If water temperature is OK, check the flow rate. The simplest way to do this, if a flow meter is not available, is to disconnect the cooling tubing from the chiller inlet (or the drain) and run the cooling water for one minute into a five-gallon bucket; you should have close to the number of gallons listed above. If there is much less than the recommend flow, check the cooling path for kinked or pinched cooling tubes or check the chiller for a clogged or dirty filter.

maintenance/ troubleshooting

Troubleshooting

On f201 lasers, the over-temperature fault (indicated by the Temp indicator turning red) is latched. This means that if an over-temperature condition occurs the Temp indicator will turn red, the Over Temperature output will Close, the Ready light goes out, and lasing is disabled. Because of its latched condition, the Temp indicator will remain red even after the laser has cooled sufficiently to begin operation.

To reset an over-temperature fault, lower coolant temperature below 28 °C (f201) and then cycle DC power (remove DC power, wait 30 seconds, reapply DC power). On Keyswitch-equipped f100/f200 lasers you must also cycle the Keyswitch from OFF/RESET to ON (or with the Keyswitch ON, apply a positive or negative voltage in the range of ± 5 –24 VDC to Pin 2, Remote Reset/Start Request) after re-applying DC power. When the Ready indicator illuminates, lasing is enabled after the five-second delay. If the Temp indicator remains red after cycling power, continue to flow cooling water through the laser for a few more minutes and then cycle DC power again.

Symptom:

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

Remote Interlock LED	– Green	Interlock Open output	– Open
Temp LED	– Green	Over Temperature output	– Open
Ready LED	– Yellow	Laser Ready output	– Closed
Lase LED	– Off or On	Laser Active output	– Open or Closed

The remote interlock circuit momentarily opened.

Remote interlock faults are not latched on OEM lasers. This means that if an interlock open fault occurs, the Remote Interlock indicator will turn red, the Interlock Open output will Close, the Ready light goes out, and lasing is disabled. However, if the interlock circuit closes, the Remote Interlock indicator will change from red to green, the Ready light illuminates, and five seconds later lasing is enabled.

Symptom:

There is no output laser beam and all LED status indicators are Off

Possible Causes:

The 20 A fast-acting fuse has blown.

Remove DC power from the laser and then check each fuse on the rear panel. Replace as required using only a Bussman ABC-20 or equivalent.

Symptom:

There is no output laser beam from your f201 laser, but status indicators appear as:

Remote Interlock LED	– Green	Interlock Open output	– Open
Temp LED	– Green	Over Temperature output	– Open
Ready LED	– Off	Laser Ready output	– Open
Lase LED	– Off	Laser Active output	– Open

maintenance/ troubleshooting

Troubleshooting

Possible Causes:

One of the two 20 A fast-acting fuses has blown.

On f201 lasers, a single blown 20 A fuse on the laser's rear panel may cause the Ready lamp to remain Off while other LEDs indicate normal status. Remove DC power from the laser and then check each fuse on the rear panel. Replace as required using only a Bussman ABC-20 or equivalent.

Beam delivery optics

Troubleshooting

Symptom:

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

Possible Causes:

Beam delivery optics are coated by vapor residue or debris.

Shut down the laser and carefully inspect each optic in the beam delivery path, including the laser's output coupler. Remember that optics are fragile and must be handled carefully; preferably by the mounting ring only. If the optic requires cleaning, refer back to Maintenance for cleaning instructions. Use only recommended cleaning materials (see Table 5-1) to prevent scratching delicate optical surfaces.

If the focusing optic is pitted, it must be replaced immediately. Because of the extremely high power density of Firestar lasers, pits or debris on the lens surface may absorb enough energy from the focused beam to crack the lens. If this happens, other optics in the beam path may be contaminated or damaged as well.



Warning
serious
personal
injury

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 CO₂ laser systems because difluoroethane persists for long time periods over wide areas.

maintenance/ troubleshooting

Troubleshooting

Caution possible equipment damage

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

When operating f201 lasers, connect nitrogen or breathing-grade air to the Gas Purge connector. Purging the laser creates a positive pressure inside the laser housing that prevents dirt and debris from accumulating on optical surfaces including beam combiner, telescope, and turning optics. In condensing atmospheres, a gas purge helps to reduce the potential for condensation damage. See Connecting in the Getting Started chapter for information on using a gas purge. Table 2-6 in the Getting Started chapter provides filtering and drying specifications for recommended purge gases.

Danger serious personal injury

Ensure that DC power to the laser is turned off and locked out before inspecting optical components in the beam path. Invisible CO₂ laser radiation is emitted through the aperture. Corneal damage or blindness may result from exposure to laser radiation.

In addition to a gas purge for the laser housing, many laser processing applications like cutting, welding, and drilling require an assist gas for the focusing/gas jet assembly. When the application requires air (instead of nitrogen) as an assist gas, we recommend the use of breathing quality air available in cylinders from a welding supply company. Because compressed shop air contains minute particles of oil and other contaminants that will damage optical surfaces, it must be carefully filtered and dried before use as a purge or assist gas. Refer to Table 4-1, Assist gas purity specifications, in the Technical Reference chapter for a list of common assist gases and their corresponding filtering and drying specifications.

Warning serious personal injury

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

maintenance/ troubleshooting

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index

Symbols

- +5 VDC Auxiliary Power 73
- +5 VDC output 74
 - signal description, 75
- +24 VDC ,?83
- +24 VDC Auxiliary Power 73
- +24 VDC output 74
 - signal description, 75

A

- American National Standards Institute (ANSI) 13
- Analog current control 70
- Analog voltage control 70
- Aperture
 - see Laser aperture
- Aux. DC Power Ground 74
 - signal description, 75
- Auxiliary DC power 74–75
 - +5 VDC, 74,?75,?76
 - +24 VDC 75
 - +24 VDC, 74
 - Aux. DC Power Ground 74
 - Aux. DC Power Ground, 75
 - internal wiring diagram, 76
- Auxiliary DC Power Ground 108
 - pin description, 74

B

- Beam block 55,?58
- Beam characteristics 65
- Beam delivery optics
 - troubleshooting, 109,?110,?111
- Block diagram 100
- BNC Control cable 31

C

- Caution
 - condensation, 57,?59
 - condensation damage, 58,?60
 - dirty optics, 65,?95,?97
 - single-phase operation, 34,?37,?40,?42,?43,?50,?51,?57,?60
 - User I/O connector, 67
 - voiding warranty, 94,?98,?110
- CDRH 18
- Chiller
 - connection, 40
 - coolant temperature, 37,?38
 - dew point temperature, 37,?38
 - fittings, 31
 - flow rate, 107
 - temperature setpoint, 38,?40,?41,?55,?58

- Chiller fittings 31
- Class IV safety features 21
- Code of Federal Regulations (CFR) 18,?19
- Collimator 66
- Command signal 69
- Condensation damage 94
- Connecting 36
 - control, 42,?43,?44
 - cooling, 36
 - f200 lasers, 40
 - other connections, 50
- Continuous wave (CW) 71
- Controlling laser power 68,?69
- Controls and indicators 53
 - f100/f201 lasers 53
- Control signals 68–69
 - Command signal, 69
 - Pulse width modulation (PWM), 68
 - Tickle pulse, 68
- Cooling connections 36
- Cooling tubing 31
 - connecting, 39,?40
 - guidelines, 37
- Cooling water
 - flow rate, 40
 - temperature setpoint, 40
- Copyright information vi
- Customer Service viii

D

- Daily inspections 94
- Danger
 - hazardous voltages, 42
 - laser radiation, 10,?11,?12,?13,?98
 - OEM faults, 104,?107
- DC-96 DC power supply
 - AC input section, 44
 - specifications, 44,?46
- DC Power cable 31,?44,?94
 - connecting, 42,?44
 - disconencting, 44
- DC Power connector 43,?44,?53
- DC power supply 41
 - requirements, 41
- Delivery optics 66
- Dew point
 - chart, 38
- Diode Pointer 56,?59
- Disabling Firestar 94
- Divergence 65,?66
- Duo-Lase 64

E

Expander/collimator 66
External control 70

F

f201
 mounting drawing,
f201 specifications ,?90
Faults
 remote interlock, 102
 resetting, 104
Final Test report 31
Firestar
 introduction, 26
 nomenclature, 26
Flowchart
 laser start-up, 99
Focusing optics 67
Food and Drug Administration (FDA) 18
Functional block diagram 100
Fuse 31
Fuse holder 53

G

Gas Purge connector 50,?54
 connecting, 50
Gas purge specifications 51
General specifications
 f201, ,?90

H

Hazard information 11
 label locations, 15,?16,?17
 terminology, 11

I

Initial start-up 55
 with a UC-2000 Controller, 55
 without a UC-2000 Controller, 57
Input circuit
 equivalent schematic, 78
 specifications, 78
Input Common 77
 pin description, 74
Input signals
 PWM Return, 76
 Remote Interlock, 76,?77
 Shutter Open Request, 77,?78
Inspections
 daily, 94
Integrating Firestar safety features 85
Interlock
 see Remote Interlock
Interlock Open 80

 pin description, 74,?80
Interlock Open fault 102
Interlock Open output 101,?106,?107,?108,?109
Inventory
 f100/f201 lasers, 29
 f100/f201 ship kit contents, 31

K

Keystwitch 55,?58,?59,?108
Keystwitch functions
 integrating, 87
Keystwitchc 101

L

Label locations 15,?16,?17
Lase indicator 54,?57,?59,?101,?108
Lase (LASE) indicator 106,?107,?108,?109
Laser Active 73
 pin description, 79
Laser Active output 101,?106,?107,?108,?109
Laser aperture 53
Laser Institute of America (LIA) 14
Laser Ready 79
 pin description, 74,?79
Laser ready output 101
Laser Ready output 106,?107,?108,?109
Lift handles
 removing, 29

M

Maintenance 94,?95,?96
 daily inspections, 94
 disabling Firestar, 94
 storage/shipping, 95
Marking/engraving operation 72
Mounting 32
 f100/f200, 32
 from above, 32
 f201/f400, 33,?35
 from below, 34
Mounting bolts 31,?33,?34,?35

O

Occupational Safety and Health Administration (OSHA) 14
Operating modes
 analog current control, 70
 analog voltage control, 70
 continuous wave (CW), 71
 external control, 70
 marking/engraving operation, 72
Optical accessories mounting 53

index

Optics

cleanliness, 65,?95,?97

Outline and mounting drawings

f201,

Output circuit

specifications, 46,?80

Output Common 79,?80,?84,?88

pin description, 74,?80

Output signals 79

Interlock Open, 80,?106,?107,?108,?109

Laser Active, 106,?107,?108,?109

Laser Ready, 79,?106,?107,?108,?109

Output Common, 80

Over Temperature, 79,?106,?107,?108,?109

Shutter Open, 80,?106,?107,?108,?109

Over Temperature 73,?79

pin description, 79

Over Temperature output 101,?106,?107,?108,?109

P

Package outline drawings

f201,

Packaging

guidelines, 27

PLC

multiple inputs, ,?84

multiple outputs, ,?82

Remote Interlock output, ,?82

Pulse Width Modulation (PWM) 68

PWM 68

signal levels, 70

PWM Input 69,?71,?76,?77

pin description, 74

PWM Input signal

description, 77

specifications, 78

PWM Return 69,?71,?73,?76

PWM Return signal

description, 76

Q

Quick Start Plug 31,?48,?49,?55,?57,?58

connecting, 48

wiring diagram, 79

R

Ready indicator 54,?56,?101,?108

Reference materials viii

Remote Interlock 73,?76

customer-supplied circuit, 81

from PLC, ,?82

Remote Interlock functions

Remote Interlock indicator 53,?58,?88,?101,?108

Remote Interlock input

49,?55,?57,?65,?87,?88,?101

Remote Interlock signal

specifications, 78

Remote Reset/Start Request 73,?76

Remote Reset/Start Request input 56,?59,?65

Remote Reset/Start Request signal

specifications, 78

RoHS 20

S

Safety features

integrating, 85

Sales and Applications viii

Sample I/O circuits 81

Sample output circuits ,?83

Shorting plug

see Quick Start Plug

Shutter indicator 56,?58,?101

Shutter Open 80

pin description, 80

Shutter Open output 101,?106,?107,?108,?109

Shutter Open Request 77

Shutter Open request input 65

Shutter Open Request input 49,?55,?57,?87,?101

Shutter Open Request signal

description, 77,?78

specifications, 78

Shutter switch 56,?57,?58,?59,?65,?101,?108

Spherical washer set 31,?34,?35

Storage/shipping 95

T

Technical overview 64

control circuit, 65

cooling, 64

Duo-Lase, 64

laser tube, 64

optical resonator, 64

optical setup, 66

RF power supply, 65

Technical Support viii

Temp indicator 54,?58,?101,?108

Tickle pulse 68

Trademark information vi

Troubleshooting 96

beam delivery optics, 109,?110,?111

functional block diagram, 100

introduction, 98

laser faults, 106

operational flowchart, 99
resetting faults, 103,?104

U

UC-2000 Controller 70
UC-2000 Laser Controller 46,?48,?55,?57,?68
 connecting, 48
Unpacking 27
 guidelines, 27
 inspection, 27
 removing lift handles, 29
 unboxing the f400, 27
User I/O
 connection summary, 73
 pin descriptions, 73
User I/O connections 73,?74
 input/output signals 73
 sample input circuits, 81
 sample I/O circuits, 81
 sample output circuits, ,?83
User I/O connector 48,?49,?54,?55,?57,?70,?87,?101,?108

W

Warning
 laser output, 49,?50,?56,?58,?60,?68,?69,?71,?78
 laser radiation, 94,?96,?109,?110
 lifting, 27,?46,?47
 OEM faults, 56
Warranty information vii
Water In/Out ports 39,?40
Water Out/In ports 53

Y

“Y” tubing connectors 41