Preinstallation Manual
The Coherent INNOVA®
Sabre FRED™ Ion Laser

COHERENT®
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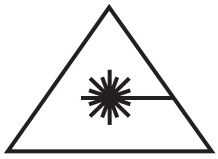
Preface

This manual provides preinstallation instructions for the Innova Sabre FreD Ion Laser. Please refer Chapter Three, Laser Safety, in the operator's manual which describes laser safety features and precautions. If you are unfamiliar with ion lasers in general, refer to Chapter Ten, Theory of Operation, in the operator's manuel.

Read this manual carefully before operating the laser for the first time. Give special attention to the material in Chapter Three, Laser Safety, in the operator's manual, which describes the safety features built into the Innova Sabre FreD Ion Laser.



Use of controls or adjustments or performance of procedures other than those specified in this manual may result in hazardous radiation exposure.

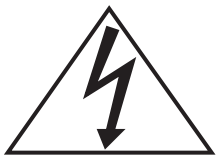
U.S. Export Control Laws Compliance

It is the policy of Coherent to comply strictly with U.S. export control laws.

Export and re-export of lasers manufactured by Coherent are subject to U.S. Export Administration Regulations, which are administered by the Commerce Department. In addition, shipments of certain components are regulated by the State Department under the International Traffic in Arms Regulations.

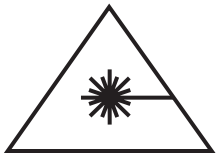
The applicable restrictions vary depending on the specific product involved and its destination. In some cases, U.S. law requires that U.S. Government approval be obtained prior to resale, export or re-export of certain articles. When there is uncertainty about the obligations imposed by U.S. law, clarification should be obtained from Coherent or an appropriate U.S. Government agency.

Symbols Used in This Manual and on the Laser System



This symbol is intended to alert the operator to the presence of dangerous voltages within the product enclosure that may be of sufficient magnitude to constitute a risk of electric shock.

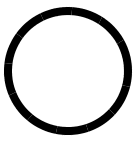
This symbol is intended to alert the operator to the presence of important operating and maintenance instructions.



This symbol is intended to alert the operator to the danger of exposure to hazardous visible and invisible laser radiation.

ALTERNATING CURRENT.

DIRECT CURRENT.



OFF OR STOP.

ON OR START.

PROTECTIVE CONDUCTOR TERMINAL. DO NOT REMOVE.

EARTH (GROUND) TERMINAL. DO NOT REMOVE.

STANDBY.

Introduction

Although some initial tasks can be performed by the customer, first system turn-on must only be performed by a Coherent service engineer.

Utility Requirements

The Sabre FreD ion laser requires electrical power and cooling water for the system. The electrical power must meet the specifications in Table 1. The pressure and temperature requirements for the cooling water is shown in Figure 2.

Electrical Service

The electrical service needs to be three phase 480 VAC in WYE configuration, with no neutral and the yellow/green wire to building ground. There is no neutral connection. The Sabre FreD system will operate with either 60 Hz or 50 Hz line frequency.

Electrical power must meet the specifications in Table 1. The power supply is delivered with a 3 m (10 feet) power cable without a connector attached to the free end unless otherwise specified at the time of order. The cable is type HAR-4/4, #4 AWG, four wires. You must provide the hardware necessary to connect this cable to your electrical service. The facility outlet must have a fuse or circuit breaker on each phase. Consult applicable local electrical codes to select this hardware.

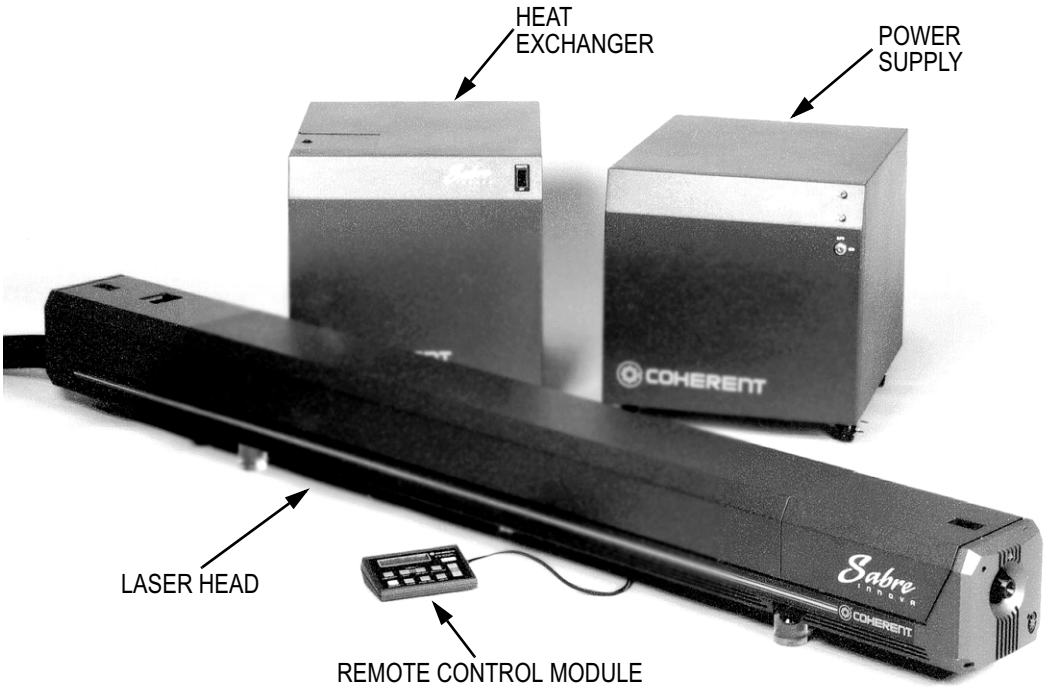


Figure 1. Sabre FRED Ion Laser System

Table 1. Utility Requirements

ELECTRICAL: Line voltage:	480 VAC +10%[1], 3-phase with ground, no neutral, WYE configuration. Phase balance <3% between phases. Maximum current consumption (typical): 70 Amps per phase at 480 VAC [2]
Line frequency:	50/60 Hz
Maximum power consumption:	55 kW
ENVIRONMENTAL:	For optimum performance, the laser should be located in a room maintained at a temperature of 10 to 40°C (50 to 104°F).

1. The laser system will operate properly between 432 VAC and 528 VAC provided that the voltage between each pair of phases is within 3% of each other. Power companies almost always provide balanced 3-phase power, but if a heavy load is connected asymmetrically, the line balance can be disturbed. This results in excessive ripple current through the capacitors of the DC filter. This ripple current degrades the noise performance of the laser and shortens the lifetime of the filter capacitors.
2. Consult applicable electrical codes for your area to select appropriate electrical service hardware. Power supply is fused at 80 amps.

In addition, Coherent recommends that a main power disconnect be located in the same room as the laser system. Consult applicable electrical codes for your area to select this hardware.

Cooling Water

The Sabre FreD Ion Laser requires a flow of water to cool the laser head and electrical components inside the power supply. Because the properties of the cooling water are critically important to the performance of the laser, the Sabre FreD is delivered with a separate heat exchanger that connects to the power supply to form a closed water loop. This allows the quality of the water through the laser system to be carefully controlled which translates to longer life span of the plasma tube. It also eliminates condensation as a source of system failure. The use of a heat exchanger also improves beam pointing and power stability since the heat exchanger regulates the cooling water temperature within ±1°C (±1.8°F). The plant water required for the water to water heat exchanger can be either tap water or any closed loop water cooling system. The requirements for the plant water are illustrated in Figure 2.

To determine the minimum pressure requirements of the facility water, the temperature of the water must first be determined. The following illustrates, through example, how to use the attached graph to determine the facility water requirements. Note that the graph is for maximum heat load of the laser system, 55 kW.

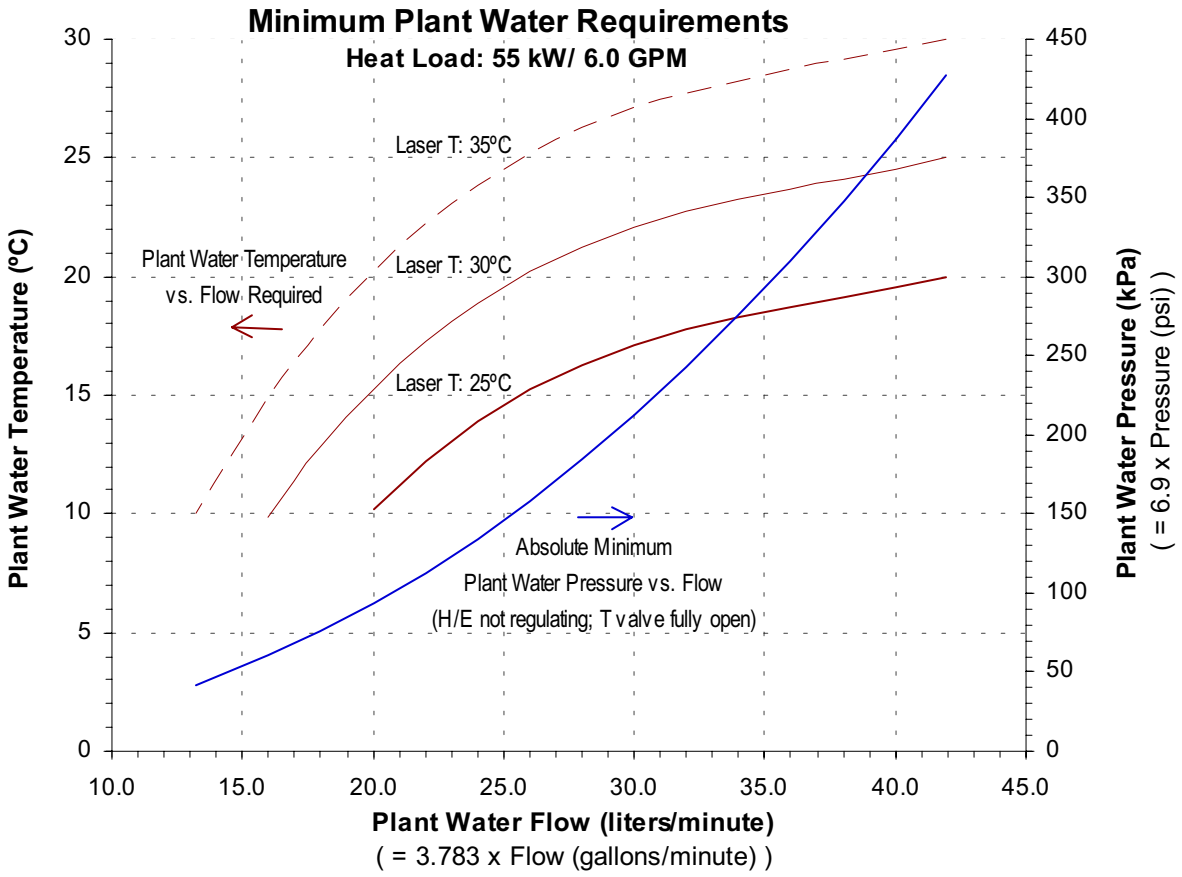


Figure 2. Minimum Plant Water Requirements

Typical: The Sabre system is factory set (referring to the Customer data sheet delivered with the system) for operation at 30°C (86°F). The temperature of the plant (facility) water is measured to be 20°C (68°F).

Determination of required facility water flow:

From the "Plant Water Temperature" axis draw a level horizontal line connecting the 20°C mark to the 30°C "Laser T" curve. From the point where the horizontal line intersects the 30°C curve, drop a vertical line down to the "Water Flow" axis. The point of intersection on the flow axis gives the flow requirement for the facility water, which in this case is read to be 25.6 liters/minute (6.8 GPM).

Determination of absolute minimum facility water pressure:

Draw a vertical line from the required facility water flow (determined in the previous step) up to the "Plant Water Pressure" curve. From the point where the vertical line intersects the pressure curve, draw a level horizontal line over to the "Plant Water Pressure" axis. The point where the horizontal line intersects the pressure axis gives the required facility water pressure, which in this case is read to be 155 kPa (23 psi).

This is the absolute minimum pressure required to cool the laser to 30°C with the heat exchanger temperature valve fully open and not regulating. To properly operate the heat exchanger with the valve regulating, it is recommended that the facility pressure exceed this minimum by at least 10 to 20 psi.

The laser cooling water properties are maintained by the heat exchanger and the deionizing cartridge. A summary of these properties are given in Tables 2a and 2b.

It is advisable to check local and state regulations which may control the use of city water for cooling. Some regulatory codes will not allow the discharge of cooling water into the sewer system.

Table 2a. Laser Cooling Water Properties

LASER COOLING WATER: Hardness:	<100 mg/liter (5.9 grains/gallon) or 100 parts per million of calcium
Resistivity	50 kΩ-cm to 2.0 MΩ-cm; (>100 kΩ-cm recommended) Resistivity <100 kΩ-cm: Warning to replace cartridge
pH	6 to 8
Particulate size:	<200 microns in diameter
Heat load:	55 kW
Pressure differential (1):	240 kPa (35 psi) at 22.7 liters/minute (6.0 gallons/minute) (2)
Maximum static pressure (3)	620 kPa (90 psi)
Inlet temperature:	10°C to 35°C (41°F to 95°F) (4)

(1) The pressure differential is the inlet pressure minus the drain pressure.

(2) Standard system with 7.6 m distance (25 feet) between facility water and heat exchanger; (3/4 inch diameter hoses).

(3) The static pressure is the inlet pressure measured under conditions of zero flow.

(4) The temperature control valve should be set to a temperature between 20°C (68°F) and 35°C (95°F) [30°C (86°F) recommended] to avoid condensation inside the laser system in case of high humidity.

Table 2b. Plant Water Requirements

PLANT WATER: Hardness:	<100 mg/liter (5.9grains/gallon) or 100 parts per million of calcium
Heat load:	55 kW
Pressure differential (1):	170 kPa typ. (25 psi); 415 kPa max. (60 psi) (2)
Maximum static pressure (3)	620 kPa (90 psi)
Inlet temperature:	10°C to 30°C (41 to 86°F) (4)

(1) The pressure differential is the inlet pressure minus the drain pressure.

(2) Standard system with 7.6 m distance (25 feet) between facility water and heat exchanger; (3/4 inch diameter hoses).

(3) The static pressure is the inlet pressure measured under conditions of zero flow.

(4) The temperature control valve for the laser cooling water should be set to a temperature between 20°C (68°F) and 35°C (95°F) [30°C (86°F) recommended] to avoid condensation inside the laser system in case of high humidity.

Do not use de-ionized water in the internal cooling loop.

Nitrogen Purge

Sabre FreD operation in SHG wavelengths requires a source of high purity nitrogen gas. The end user must supply a grade 5 (99.999%) quality or better. Nitrogen boil-off is recommended. A regulator that is oil and contaminate free must also be provided. Teflon tubing must be used and is provided in the maintenance kit.

When the crystal is not in use, store it in a desiccant box or leave it in the system. If the crystal is left in the system, both of the following conditions must be satisfied:

- **The keyswitch must be in the ON position to insure proper heating of the crystal.**
- **The Nitrogen purge must be turned on.**

Failure to follow these requirements will likely result in irreversible damage from condensation of water vapor on the crystal Brewster surfaces. When the system is in operation, the Nitrogen purge must be on.

Site Preparation

To assist in planning the work space, the dimensions of the components constituting the Sabre FreD system are listed in Table 3. Enough space should be left around the laser head so that the components inside can be accessed. The laser head and power supply are connected through a 3 m (10 feet) umbilical. When planning the work space, allow sufficient space to avoid bending or crimping the umbilical sharply. Allow for a bend radius of at least 30 cm (12 inches). In order to maximize the system's immunity to externally generated electromagnetic interference, take care not to route system cables in close proximity to other equipment cables.

The Sabre FreD ion laser is a precision instrument whose performance depends on its environment. Vibrations can be transmitted to the laser head from the surface on which it rests, causing beam pointing instability and power fluctuations. To minimize vibrations, the laser head should be placed on a stabilized optical table and isolated from mechanical contact with other equipment.

All Sabre FreD systems include purge kits for dry nitrogen because of the hygroscopic nature of the BBO frequency doubling crystal. The purge kit consists of a variable flowmeter, necessary connectors and hoses, a particulate filter, and special intracavity parts. A user-supplied source of dry nitrogen is required. The recommended grade of bottled nitrogen has a minimum purity of 99.999% and is sometimes known as scientific grade. A high purity "boil-off" nitrogen source may be used as an alternative. Dry air may not be used as it contains oxygen which can be converted to ozone by the deep UV produced by the plasma discharge.

Table 3. System Dimensions

	LENGTH	WIDTH	HEIGHT
LASER HEAD	257.5 cm (101.4 inch)	20.3 cm (8 inch)	19.1 cm to 20.4 cm (7.53 inch to 8.03 inch)
POWER SUPPLY	57.8 cm (22.75 inch)	47.8 cm (18.8 inch)	50.8 cm (20.0 inch)
HEAT EXCHANGER	57.8 cm (22.75 inch)	47.8 cm (18.8 inch)	50.8 cm (20.0 inch)

Receiving the System

The Sabre ion laser is shipped in three crates: one contains the power supply, one the heat exchanger and the third the laser head. Accessories, including the remote control module, are packed in separate boxes and shipped in the laser head crate. Do not unpack the laser system unless directed to do so by a Coherent representative. This process is normally completed by the Coherent field representative who will be installing the system.

Please advise your receiving department to perform the damage inspection procedure prior to signing the bill of lading.

Damage Inspection

Carefully inspect each crate and note any damage. All Sabre ion laser crates are shipped with rough handling indicators affixed to their front and back. Examine these indicators upon receipt. If the indicator bar is red, the crate has received handling which may have damaged the contents. Indicate any such signs on the bill of lading.

Report any damage immediately to the shipping carrier and to the Coherent Order Administration Department, 800-438-6323.

Pre-Installation

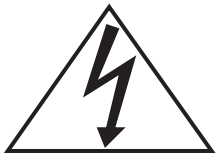
Placement of Power Supply and Heat Exchanger

Both power supply and heat exchanger are designed to fit next to each other under tables that have at least 53 cm (21 inches) of clearance. The connecting cable and water hoses are 4.6 m long (15 feet), if a different placement is desired.

Installing the Electrical Connector

The AC electrical connector must only be installed by a qualified individual in accordance with all applicable codes. The unterminated 4-wire main power cable from the power supply rear panel (Figure 3), contains brown, blue, black and yellow/green wires. Install your power connector onto this power cable. The yellow-green wire is earth ground. The brown, black and blue wires are incoming power lines that need to be connected to the three phases in the correct phase order. There is no neutral connection. The heat exchanger uses a three-phase motor, which will run in opposite direction if the incorrect phase order is used. The correct phase order is brown- blue- black. Incorrect phase orders are

connections where the number of interchanged pair of wires is odd. The laser system will not turn on if the phase order is incorrect and the remote will display the fault: “Line Phase Order”. In that case the power connector wiring needs to be corrected by swapping one pair of phase connections. The work should be performed by a qualified individual in accordance with all applicable codes.



Do not change any wiring inside the power supply or heat exchanger.

External Interlock

The Sabre FreD ion laser is equipped with an external interlock connection located on the rear of the power supply. When the system is shipped, this connection is jumpered. An external interlock circuit can be connected to the laser system and wired to, for example, a door switch to provide additional laser operating safety. When the door is opened, the laser will shut down.

For more information, refer to Chapter Five, System Description and Control, in the section titled, POWER SUPPLY COMPONENTS AND CONTROLS, in the operator’s manual.

External Switch

The Sabre FreD power supply is equipped with an externally accessible switch that closes when the laser tube becomes energized. This provides a convenient way of having e.g., a safety light automatically switched on as the laser starts. The switch is located on the rear of the power supply.

For more information, refer to Chapter Five, System Description and Control, in the section titled, POWER SUPPLY COMPONENTS AND CONTROLS, in the operator’s manual.

Specifications

This section contains performance specifications for the Innova Sabre FRED Ion laser system.

Output Powers

Sabre FRED systems are available in only one tube configurations – tubes with two Brewster windows (DBW – dual Brewster window).

Table 4. Power Specifications For Sabre FreD Systems – Fundamental

SABRE FRED SYSTEMS – FUNDAMENTAL		
WAVELENGTH (nm)		SABRE FRED MODELS
		DBW 20
Multiline Visible	**Standard**	20
528.7	528.7 green option	1.0
514.5	**Standard**	8.0
496.5	blue-green option	2.4
488.0	**Standard**	6.5
476.5	blue-green option	2.0
457.9	457.9 blue option	1.2
		DBW 20 / 3
333.6 - 363.8	**Standard**	**3.0**
351.1	**Standard**	**1.0**
363.8	**Standard**	**1.0**

Table 5. Power Specifications For Sabre FRED Systems – SHG

SABRE FRED SYSTEMS – SHG		
WAVELENGTH (nm)		SABRE FRED MODELS
		POWER (WATTS)
264.3	528.7 green option	0.100
257.2	**blue-green option**	**1.000**
248.2	blue-green option	0.300
244.0	**blue-green option**	**0.500**
238.2	blue-green option	0.100
229.0	457.9 blue option	0.050

The Sabre FRED can cover wavelength ranges from the visible to the UV. A variety of optional optic sets and fold boards with different power specifications and wavelength ranges can be purchased with these configurations.

Output Beam Characteristics

Power stability, noise and beam pointing stability are measured at 514.5 nm for argon visible operation and 248.2 nm for SHG operation.

Table 6. Beam Specifications

PARAMETER(1)	DESCRIPTION	
Beam pointing stability (2):		
Angle	<10 µrad/°C	
Offset at output coupler	<10 µm/°C	
Long-term power stability(3):		
Light regulation	± 0.5%	
Current regulation	± 1.0%	
Optical Noise (RMS):	**514 NM**	**248 NM**
Light regulation	± 0.2%(4)	< 1.0%(5)
Current regulation	± 0.2%(4)	< 1.0%(5)

The above specifications subject to change without notice.

(1) All performance specifications are measured at the specified output at 514.5 nm for argon visible systems.

(2) Beam pointing and offset are measured per °C change of ambient air or cooling water temperature.

(3) Maximum peak variation after a 15 minute warm-up.

(4) Measured with a 10 Hz to 2 MHz photodiode driving a resistive load.

(5) Measured with a 10 Hz to 100 kHz photodiode driving a resistive load.

Beam Parameters

The following beam parameters are measured. Intracavity absorption even as low as 0.05% typically creates some thermal lensing which impacts the beam parameters. Beam diameter, waist diameter and divergence are less effected and are typically within ±5% of the values in Table 7. Since ion laser beams have very low divergence, even a small amount of thermal lensing has a more significant effect on beam waist location.

Table 7. Argon Beam Parameters

BEAM PARAMETERS	514.5 NM	248.2 NM
Beam Diameter @ $1/e^2$ points at output coupler	2.1 mm	Refer to Chapter Nine
Beam Divergence (full angle)	0.35 mrad	Refer to Chapter Nine
Virtual Beam Waist Diameter @ $1/e^2$ points	2.0 mm	Refer to Chapter Nine
Virtual Beam Waist Location (Measured from the output coupler toward the rear mirror)(1)	–2.5 m	Refer to Chapter Nine
Beam polarization	100:1, vertical	100:1, horizontal
(1) The beam waist is located at the flat high reflector inside the resonator for visible operation and within the crystal in SHG operation. The long-radius output coupler acts as a weak lens to transform the output beam parameters. The values listed for beam divergence takes into account the weak lens effect.		

System Parameters

Table 8. Operating Tube Voltage/Current Range

LASER MODELS	NOMINAL TUBE VOLTAGE AT MAXIMUM TUBE CURRENT	MAXIMUM TUBE CURRENT
Sabre FreD	538	65
The above specifications subject to change without notice.		

System Weight and Dimensions

Table 9. System Weights

	LASER HEAD	POWER SUPPLY	HEAT EXCHANGER
CRATED	215 kg (475 lbs)	134 kg (295 lbs)	102 kg (225 lbs)
UNCRATED	129 kg (285 lbs)	107 kg (235 lbs)	75 kg (165 lbs)
The above specifications subject to change without notice.			

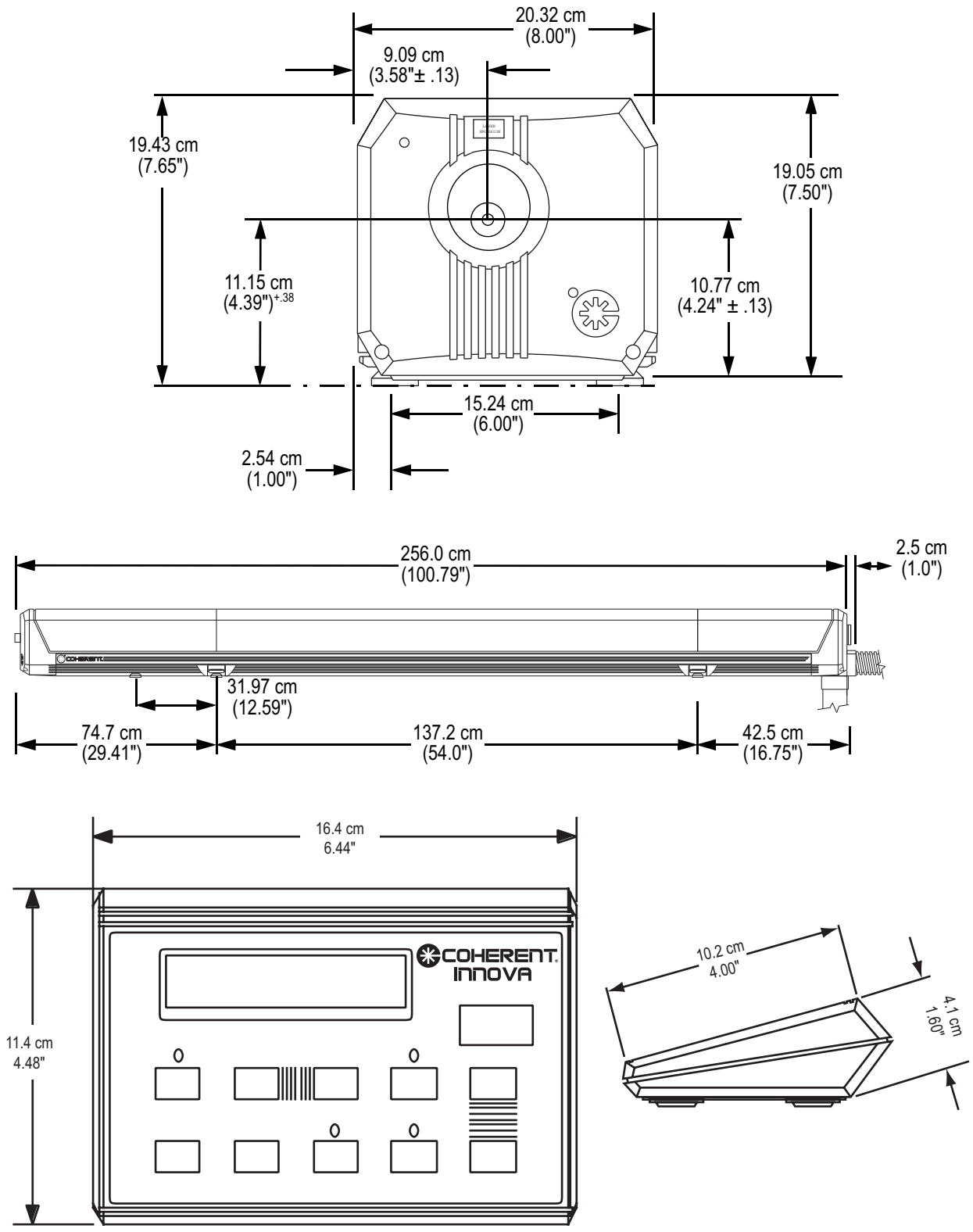


Figure 3. Laser Head and Remote Dimensions

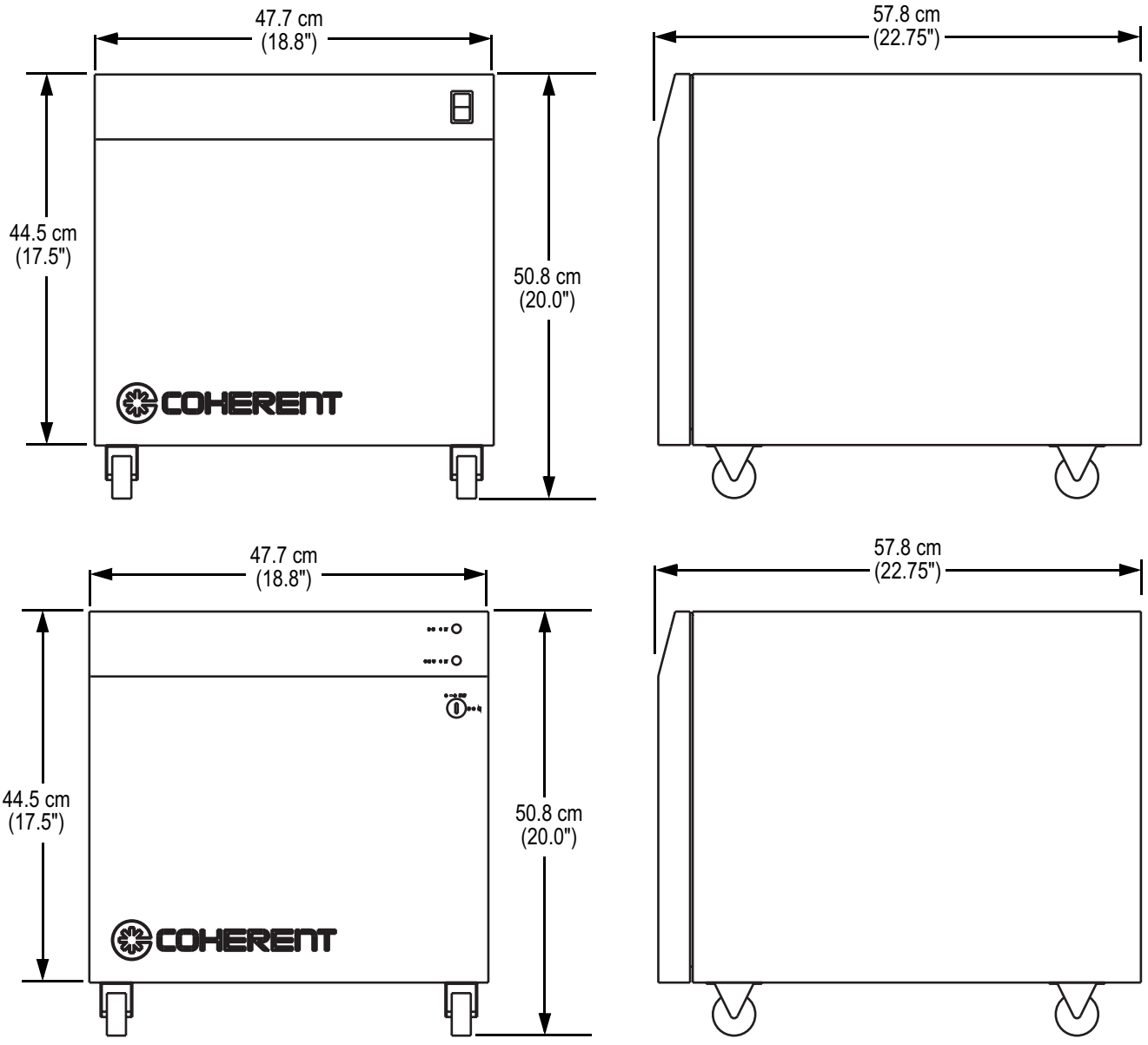


Figure 4. Power Supply Dimensions

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Coherent Part Number: 0175-284-00, Rev B