Preinstallation Manual
DIAMOND™ E-1000 Series
OEM Lasers
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This manual provides facilities preparation information and installation instructions for the DIAMOND™ E-1000 Series lasers – OEM version.

Complete product information is contained in the DIAMOND E-1000 Series OEM Lasers Operator’s Manual, part number 1192674.

Thoroughly review the Operator’s Manual, especially the laser safety section, prior to operating the E-1000 Series OEM laser.

Read this Preinstallation Manual carefully before installing the laser. Special attention must be given to the material in the Safety section.

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

Use of the system in a manner other than that described within this manual may impair the protection provided by the system.

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

Export and re-export of lasers manufactured by Coherent are subject to the U.S. Export Administration Regulations administered by the Department of Commerce, Bureau of Export Administration.

The applicable restrictions vary depending on the specific product involved, intended application, and the product destination. In some cases, an individual validated export license is required from the U.S. Department of Commerce prior to resale or re-export of certain products. If you are uncertain about the obligations imposed by U.S. law, obtain clarification from Coherent.
Symbols Used in This Manual and on the Laser System

This symbol is intended to alert the operator to the presence of dangerous voltages associated with the laser 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.

This symbol identifies direct current electric potential.

This symbol identifies electrical ground.
Before installation, it is essential that the customer read this manual thoroughly. It is important that the user become familiar with all aspects of the installation and operation of the E-1000 Series laser system, including and specifically the information contained in Section Two: Laser Safety of the operator’s manual.

In order to perform a smooth integration of the laser system into a tool or installation at a customer site, it is necessary to prepare in advance. A pre-installation checklist outlining the general requirements is provided in Table 1.
**Table 1. Pre-installation Checklist**

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>GENERAL REQUIREMENTS</th>
<th>REFERENCE(S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confirm Laser Environment</td>
<td>[ ] Temperature and Humidity in specification</td>
<td>“Confirm Laser Environment” on page 4</td>
</tr>
<tr>
<td></td>
<td>[ ] Cleanliness</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[ ] Vibration</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[ ] Ventilated space</td>
<td>“Operation in Humid Environments” on page 4</td>
</tr>
<tr>
<td>Receive and Inspect</td>
<td>[ ] Area is clean and sufficiently large enough to uncrate laser</td>
<td>“Receive and Inspect” on page 5</td>
</tr>
<tr>
<td></td>
<td>[ ] Forklift or pallet jack capable of moving the fully loaded crate (320 kg/705 lbs.)</td>
<td>“Unpacking Instructions” on page 25</td>
</tr>
<tr>
<td></td>
<td>[ ] Forklift or hoist capable of lifting the 173 kg (381 lbs.) laser off the shipping pallet</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[ ] Cart capable of moving 173 kg (381 lbs.) laser to installation area</td>
<td></td>
</tr>
<tr>
<td>Laser Installation Area</td>
<td>[ ] Clear path to the installation site</td>
<td>“Laser Installation Area” on page 6</td>
</tr>
<tr>
<td></td>
<td>[ ] Forklift or hoist capable of lifting the 173 kg (381 lbs.) laser plus lifting hardware into tool</td>
<td>“Mount the Laser System” on page 35</td>
</tr>
<tr>
<td></td>
<td>[ ] Laser head mounting area prepared (lift access, mounting feet installed, able to support 173 kg (381 lbs.) laser system plus weight of cables, hoses, output aperture accessories, etc.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[ ] Service access provided</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[ ] All connections reach laser head</td>
<td></td>
</tr>
<tr>
<td>Laser System Cooling</td>
<td>[ ] Chiller installed and operational (loop test OK)</td>
<td>“Laser System Cooling” on page 8</td>
</tr>
<tr>
<td></td>
<td>[ ] Coolant is a mixture of water and corrosion inhibitor</td>
<td>“Coolant Composition” on page 10</td>
</tr>
<tr>
<td></td>
<td>[ ] 30 µm particle filter installed at laser head inlet</td>
<td>Table 1-2 on page 1-8 in the operator’s manual</td>
</tr>
<tr>
<td></td>
<td>[ ] Shut-off valves installed (optional, recommended)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[ ] 5/8” ID or greater hose between the laser and chiller</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[ ] Required flow rate, temperature set point and temperature stability capability verified</td>
<td></td>
</tr>
<tr>
<td>Laser System Purge Gas</td>
<td>[ ] N₂ or filters installed to provide clean, dry air</td>
<td>“Laser System Purge Gas” on page 14</td>
</tr>
<tr>
<td></td>
<td>[ ] Shut-off valve installed (optional, recommended)</td>
<td>“Purge Gas Filter Panel Assembly” on page C-2 in the operator’s manual</td>
</tr>
<tr>
<td></td>
<td>[ ] Output fitting installed to accept 1/4” OD tubing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[ ] Clean, flexible 1/4” OD tubing to connect purge gas supply to laser head</td>
<td></td>
</tr>
</tbody>
</table>
### Table 1. Pre-installation Checklist (Continued)

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>GENERAL REQUIREMENTS</th>
<th>REFERENCE(S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC Power Supply</td>
<td>[ ] Rack w/shelf, bench or frame (mounting) prepared</td>
<td>OEM Product Literature (external document(s))</td>
</tr>
<tr>
<td></td>
<td>[ ] Electrical circuit with circuit breaker/fuse and electrical disconnect ready</td>
<td>“DC Power Supply” on page 17</td>
</tr>
<tr>
<td></td>
<td>[ ] Mains input (electrical disconnect to power supply) power cable ready</td>
<td>Appendix C: Accessories and Options in the operator’s manual</td>
</tr>
<tr>
<td></td>
<td>[ ] Cooling water system, supply and return lines and fittings ready (for liquid-cooled DC power supplies only)</td>
<td></td>
</tr>
<tr>
<td>Beam Delivery System</td>
<td>[ ] Beam delivery system purge gas ready</td>
<td>“Beam Delivery System” on page 18</td>
</tr>
<tr>
<td></td>
<td>[ ] Optical Isolator installed (if cutting/marking reflective material)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[ ] External optical beam delivery system meets optical specifications</td>
<td></td>
</tr>
<tr>
<td>Laser Control, Measurement and Diagnostic</td>
<td>[ ] If using a Coherent E-Series Remote Controller, controller is available</td>
<td>“Laser Control, Measurement &amp; Diagnostic” on page 19 and Section Four: Control Interfaces in the operator's manual</td>
</tr>
<tr>
<td></td>
<td>[ ] If monitoring laser diagnostics with a personal computer via network cable, a computer Ethernet cross-over cable is required</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[ ] For 3rd party controller, see OEM documentation</td>
<td>DIAMOND E-Series OEM/Industrial Laser Remote Controller Operator’s Manual, part number 1153591 (external document)</td>
</tr>
<tr>
<td></td>
<td>[ ] Interlocks installed</td>
<td>“Power Meters and Sensors” on page C-1 in the operator’s manual</td>
</tr>
<tr>
<td></td>
<td>[ ] Suitable Power Meter and Detector Head available</td>
<td></td>
</tr>
<tr>
<td>Laser Safety</td>
<td>[ ] Laser Safety Officer (LSO) identified (recommended)</td>
<td>“Laser Safety” on page 20</td>
</tr>
<tr>
<td></td>
<td>[ ] Laser Safety Training completed</td>
<td>Section Two: Laser Safety in the operator’s manual</td>
</tr>
<tr>
<td></td>
<td>[ ] Laser Controlled Area established</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[ ] Personal Protective Equipment (laser safety eyewear) available</td>
<td></td>
</tr>
</tbody>
</table>
Confirm Laser Environment

The laser must be installed and operated in a temperature and humidity-controlled environment. The operating temperature must be 5 – 45°C (41 – 113°F). The humidity must be 5 – 95%, non-condensing, for the laser system coolant inlet temperature. Operating altitude must be <2,000 m (6,600 ft.). Additionally, the laser environment should be clean and free of air-borne particles, and mounted such that vibrations are within specification. If possible, create a “clean” area for the laser and initial beam delivery optics and a “dirty” area for the final beam delivery system and work piece.

Since the laser and/or associated beam delivery systems may be nitrogen purged and the cutting/marking processes generally create noxious fumes, make sure to provide adequate ventilation for all operators in the area.

Operation in Humid Environments

The cooling fluid of the E-1000 Series lasers can condense moisture from the air when the temperature of the cooling fluid is at or below the dew point of the air.

---

The system must not operate in a condensing environment since this condition will lead to catastrophic failure in both the laser head and the RF power supply. Doing so will void the warranty. It is the responsibility of the customer to ensure an E-1000 Series laser system is never operated in a condensing environment. Failed laser heads and RF power supplies must be returned to the factory for repair.

---

Condensation may form on any component surface when the surface temperature is at or below the dew point of the air. The typical condition that leads to condensation is warm, humid weather combined with fluid that is cooler than the surroundings.

High risk conditions which are likely to lead to condensation are:

- Operating the laser in a room that is not air conditioned in high humidity environments
- Using cooling fluid that is not temperature controlled
- Leaving the cooling fluid system on when the laser is not operating for extended time periods

Risk of Condensation: The information required to determine if the cooling fluid temperature will lead to condensation is:

- Room temperature
• Relative humidity

Since weather conditions change, these factors need to be periodically checked especially in spring, summer or wet seasons. In environments that are air conditioned, Coherent recommends setting the cooling fluid temperature to 23°C (73.4°F). For environments that are not air conditioned, Coherent recommends that the cooling fluid temperature be increased to the air temperature to avoid condensation in humid climates, but no higher than 26°C (78.8°F) and not less than 20°C (68°F).

The E-1000 Series laser system packaging has been designed for robust shipment. Upon receiving the system, inspect the outside of all containers immediately to ensure no damage occurred during transit. If there appears to be visible damage (holes in the containers, fluid damage, crushing etc.), immediately notify Coherent and a representative of the carrier. Request that a representative of the freight company be present when unpacking the contents.

Keep the original shipping containers and packing materials for transporting the E-1000 Series laser system from one location to another. If the system is to be returned to Coherent for repair, it must be transported in the original shipping container.

The containers may appear in good condition, but the contents may be damaged. Inspect all major components as they are unpacked. Unpacking procedure instructions are found in “Installation” on page 21.

To unpack the laser system, at least two people and the following tools will be required:

• Scissors or a package cutting knife
• 8” adjustable wrench
• Large Pliers (may be required to loosen 2 wing-nuts)
• Forklift or jack able to lift and move at least 320 kg (705 lbs.)
  - total weight of a fully loaded shipping crate
• Hoist capable of lifting the 173 kg (381 lbs.) laser system out of the crate
• Cart capable of supporting and transporting the 173 kg (381 lbs.) laser system to the installation area
While in transit, the shipping container and its contents may be exposed to cold temperatures. To prevent condensation from developing on and within the laser system, move the crate to a location near the installation area and allow it to acclimate before unpacking the laser.

Laser Installation Area

It is assumed that the laser will be integrated into a laser cutting or marking tool designed and manufactured by a third party. Because each system installation is unique, only general guidelines will be discussed.

Service Access

It is highly recommended that the system integrator follow Coherent’s recommendation for laser orientation with respect to service access within the customer’s equipment (see Figure 18a “Laser Head Mounting Dimensions”). If placing the laser inside a cabinet or enclosure, make sure to design sufficient access to all lifting and mounting points. Additionally, make sure to provide adequate service clearance at the rear (interface connectors), the front (coupling to beam delivery system), top and sides (to remove covers for service access), and above and around the RF power supply module, as the RFPS module is field replaceable.

- Mount the laser system with the RFPS module readily accessible through service access panels.
- Provide easy access to all electrical and signal connections.
- Provide easy access to cooling and purge connections.

Providing the recommended service access will provide ease and speed of service and repair of the E-1000 Series laser system.

Also, consider the interface/connection point locations at the rear end of the laser system and the length of cables, hoses and tubing, including service loops, when placing the DC power supply, chiller and control system.
Mounting Feet

Since all E-1000 Series laser beams are precisely aligned with reference to three kinematic mounting feet, it is recommended that laser integrators utilize this mounting feature. Refer to the mechanical drawing in Figure 18.

Because beam pointing is virtually identical for all lasers referenced to these feet, re-alignment of delivery system optics, in the event of a laser replacement, will greatly be minimized if aligned to the reference position. Since the laser is precisely aligned to these mounting features, a laser can be replaced with minimal or potentially no delivery system re-alignment.
Laser System Cooling

The E-1000 Series laser head and the RF power supply require a continuous flow of constant temperature cooling fluid. Because the properties of the cooling fluid are important for laser performance, ensure that the conditions remain within the tolerance limits listed in Table 1-2 on page 1-8 (operator’s manual) at all times.

A closed-loop cooling system (chiller) should be used to obtain consistent, stable laser performance. The chiller must be able to remove up to 20 kW of heat, plus an additional 2 kW if the liquid-cooled DC power supply option is used. The coolant composition for the closed-loop chiller is described in the following section.

A typical flow diagram is shown in Figure 1. The delivery system and/or laser power detector may be connected in parallel auxiliary loops as long as they do not reduce the required flow to the laser, or they may be cooled by a separate chiller.

If using the optional liquid-cooled power supply, it is to be connected in series after the laser system. The liquid-cooled power supply must be installed with the provided bypass loop to maintain the high flow required by the laser (as the power supply alone will restrict the flow).

Figure 1. Coolant Flow Diagram

Notes:
1. Recommended - customer supplied parts
2. Included with optional Liquid-cooled DC Power Supply
**Coolant Temperature**

At the laser head, the inlet temperature of the cooling fluid should always be above the dew point to prevent condensation from developing inside the laser head or RF power supply.

**Coolant Filtering**

To prevent accumulation of debris in the cooling system, the coolant should be filtered at the inlet to the laser system. Coherent recommends the use of a particle filter that traps particles larger than 30 µm in diameter, unless specified by the chiller manufacturer to use a finer filter.

A coolant kit is provided with each laser system, which contains ¾” NPT to Male GHT (Garden Hose Thread) and ¾” NPT to Female GHT fittings. This permits the use of off-the-shelf garden hose to connect the laser system to the chiller system. In general, Coherent recommends the use of hose with an ID of 5/8” (16mm) or greater to minimize the pressure drop from the chiller to the laser system. Hose fittings and clamps to connect hoses to the chiller are not included. Do not exceed the maximum hose length specified by the chiller manufacturer.

Shut-off valves on the supply and return lines are recommended to facilitate maintenance to the cooling system filters and laser system.
Coolant Composition

The recommended coolant composition is a mixture of clean distilled or de-ionized water and OPTISHIELD® Plus, a low toxicity, corrosion inhibitor. OPTISHIELD Plus is available from OptiTemp, Inc. and can be shipped worldwide. Contact information is provided in Table 2.

The required mixture is a 10% solution of OPTISHIELD Plus and distilled or de-ionized water (Example: 1 liter of OPTISHIELD Plus into 9 liters of distilled water). Contact OptiTemp for detailed water quality recommendations and for complete product information.

To prevent damage to the laser head and RF power supply, never operate the E-1000 Series liquid-cooled laser using untreated tap, distilled or de-ionized water as a coolant. The laser contains materials which will suffer corrosion damage when exposed to water without corrosion inhibitors. Corrosion caused by improperly treated coolant voids the warranty.

Table 2. Recommended Coolant for E-1000 Series Lasers

<table>
<thead>
<tr>
<th>PRODUCT NAME</th>
<th>MANUFACTURER’S NAME &amp; CONTACT INFORMATION</th>
<th>HEAT TRANSFER FLUID TYPE</th>
<th>REQUIRED HEAT TRANSFER FLUID CONTENT</th>
<th>FREEZING BURST PROTECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPTISHIELD® Plus</td>
<td>OptiTemp, Inc. <a href="http://www.optitemp.com">www.optitemp.com</a> US/Canada (231) 946-2931</td>
<td>Corrosion Inhibited Water</td>
<td>10% Solution in Water</td>
<td>Does not reduce water freezing point!</td>
</tr>
</tbody>
</table>

It is important to add the right amount of corrosion inhibitor in the coolant mix. Too much may result in poor cooling performance and too little will result in reduced protection against corrosion. Levels lower than the recommended amount may also encourage microbial growth, which can result in fouling and blockage of the cooling system. Also, only use fresh, clean coolant mix (OptiTemp recommends that the coolant be drained and replaced annually).

Freeze/Burst Protection

The recommended coolant mixture does not provide freeze protection; therefore the coolant temperature must be maintained above the freezing point of water. Since lower temperatures may occur during shipment and storage, the E-1000 Series laser system (or separate laser head or RF power supply components) should
never be stored or transported unless the coolant has been completely removed by using a compressed air supply to blow out all coolant passages.

---

Never store or ship a complete E-1000 Series laser system or laser head or RF power supply (or liquid-cooled DC power supply, optional) with coolant installed, as the coolant may freeze and cause permanent internal damage. Always remove the coolant prior to storage or shipment by using a compressed air supply to blow out all coolant passages. Plug or cap coolant inlet and outlet fittings after draining to prevent residual coolant leaks during storage or shipment. Damage to the laser during storage or shipment, as a result of failure to remove coolant and plug the inlet and outlet fittings after coolant removal, is specifically excluded from the product warranty.
Flow Direction

At the laser system, the flow direction must be as follows: coolant is to flow to the laser head first, then out to the RF power supply before being returned. Do not reverse flow direction or split the flow into two separate parallel circuits at the laser system. Refer to Figure 2.

**Figure 2. Coolant Flow to Laser System**
If any other components are included in the cooling loop (e.g. DC power supply, as shown in Figure 1), they must not reduce the coolant flow to the laser head, and any heat absorbing/generating components must come after the laser system.

**Chiller Electrical Supply**

A large industrial chiller normally requires a 230 or 480 VAC, 3-phase electrical supply with its own circuit breaker or fuse protection and an electrical disconnect. Refer to the chiller manufacturer’s installation guide for electrical requirements and installation instructions.

**Electrical Disconnect**

It is recommended that the chiller have a main power disconnect to electrically isolate it from mains power for maintenance and service. Consult a qualified electrician to select and install this hardware. A typical disconnect switch with fuse protection is shown in Figure 3.

![Figure 3. Electrical Disconnect Switch (with Fuse Protection)](image-url)
The use of specified purge gas will extend the life and reduce cost of ownership of the E-1000 Series laser systems.

The quality of the purge gas is extremely important factor for trouble free operation of the laser. The preferred purge gas is nitrogen with a purity of 99.95%.

E-1000 Series lasers are used in a wide range of material processing which often has by-products of dust, smoke, fumes, oil and various gases. These by-products can cause contamination of the laser head optics as well as the beam delivery optics and electronic components. Contamination will severely degrade the system performance and can lead to damage or failure of sensitive components.

Passing a purge gas through the laser head and RF power supply can prevent component damage by creating an internal positive pressure. Also under some conditions of high humidity, the laser beam can be distorted by optical absorption of the laser beam by fluid vapor. This effect can be totally eliminated by use of a proper gas purge.

Delivery System Purge Gas

Purge gas is brought to the laser system and split by a Tee into two paths, one to the laser head and the other to the RF power supply.

The purge gas fills the RF power supply and slowly leaks out of small gaps between enclosure covers. The gas purge to the laser head exits primarily via the beam output aperture. While this is the primary exit path for the purge gas, small gaps in the interfaces between the component comprising the protective housing result in additional purge exit paths. Therefore the user should not rely on purge gas exiting the beam output aperture to provide purge gas to the user's beam delivery optics. A separate purge should be used for external beam delivery optics.

Threaded holes in the output end plate provide a convenient means to connect the user's beam delivery optics while maintaining a gas seal at this interface.

Do not rely on purge gas exiting the beam output aperture to purge the external beam delivery optics. A separate purge line should be used to purge the external beam delivery optics.
If a shared purge gas supply is directed to both the laser system and the beam delivery system, make certain the supply and supply line is properly sized to provide an adequate flow rate to the laser system.

Other inert gases such as argon (Ar) must not be used. Use of inert gases will result in damage to the RF power supply and associated matching network components. Only nitrogen as described above or compressed air as described below should be used as a purge gas.

**Guidelines for Use of Compressed Air for Purge**

If nitrogen is not available, the alternative is clean, dry, oil-free compressed air. Compressed air is available in many facilities but typically is contaminated with water and oil vapors. The purity requirements for the compressed air are:

1. Filtered to remove particles larger than 1 micron.
2. Dried so that dew point is 10°C (18°F) lower than the inlet cooling fluid temperature to the E-1000 Series laser.
3. Oil free to better than 99.995%.

Recommended purge gas configurations are shown in Figure 4.

---

**Figure 4. Purge Gas Diagram**
A pre-assembled filter panel (see Figure 5) designed to provide clean, dry air (CDA) is available that contains items 4, 5 and 6 shown in Figure 4. The output is attached to a Tee that splits the CDA to the laser and delivery systems (if no separate purge gas line is provided to the delivery system). Install flow regulators on all lines to establish and monitor proper flow rates. Use only Teflon tape to seal all connections, and provide drain tubing at the vent of each auto drain (on the coalescing filters).

Coherent P/N:
1166836

CT Components P/N:
600218COH
(860) 633-0277
sales@ccives.com

Figure 5. Purge Filter/Dryer Panel Assembly (optional)

For additional information on the Purge Filter/Dryer Panel Assembly, refer to the “Purge Gas Filter Panel Assembly” on page C-2 in the operator’s manual.

It is the responsibility of the customer to provide purge gas of either nitrogen or compressed air that meets the specifications stated above, and clean flexible tubing to carry the purge gas. Failure to comply with these specifications will void the warranty and the customer is responsible for all cost of repair or damage to the laser.
See “Preventive Maintenance” on page 61 in Section Six: Maintenance and Troubleshooting in the operator’s manual for the routine maintenance required for the purge gas filters.

**DC Power Supply** Coherent has qualified the DC power supplies listed in Appendix C: Accessories and Options in the operator’s manual for use with the E-1000 Series laser systems. These DC power supply recommendations include both air-cooled and liquid-cooled options. The air-cooled type requires proper ventilation, while the liquid-cooled type requires a continuous supply of liquid coolant. Both types require an electrical disconnect to reset faults and to provide a disconnection for service.

Coherent can provide the DC power cables that connect the DC power supply output to the +48 VDC and 48 VDC return terminals on the RF power supply.

**DC Power Supply Electrical Service** Consult the instruction manual provided by the DC power supply manufacturer for electrical service requirements. Also, consult local electrical codes to determine the current rating for fuses or circuit breakers for the electrical service to the power supply.

**Electrical Disconnect** Both supplies require an electrical disconnect to reset faults and to provide a disconnect for service. Coherent recommends that a main power disconnect (to the DC power supply) be located in the same room as the laser system. Consult a qualified electrician to select and install this hardware. Refer to Figure 6.

![Figure 6. Electrical Disconnect Switch (with Fuse Protection)](image-url)
Mains Power Cord

The integrator must provide the AC mains cable of suitable size (gauge) for the chosen length and current carrying requirement. Depending upon local electrical code, the power cord may need to be hard-wired into a junction box or electrical disconnect switch, or may be connected to mating plug and receptacle. Consult a qualified electrician and wire to local electrical code.

Beam Delivery System

The beam delivery system is typically designed and built by the system integrator.

Verify that the beam delivery system is designed for the E-1000 Series laser beam specifications: wavelength, beam diameter, power density, divergence, output beam height (with respect to base-plate or mounting ball), mirror cooling, etc.

Shutter

If the laser is equipped with the optional internal shutter assembly, a red (visible) aiming laser is provided whenever 48 VDC is on and the shutter is closed. This aiming beam serves as a visual indicator of the process beam path, and can be used to align the beam delivery system. This optional internal shutter is intended to be a safety device - it is not to be used as a process shutter.

If the optional internal shutter assembly is not installed, it is recommended to provide an external safety shutter or beam block near the laser aperture to prevent laser exposure when servicing the delivery system. Make sure the beam block is made of suitable material to safely trap and dissipate the laser power.

Accessory Coupler

The laser head output aperture provides accommodation for a 50 mm (2") OD beam tube to couple to the laser head. Enclosing the beam within gas-purged metallic tubes is a safe and recommended method of transmitting the beam from the laser head to the work piece.

Purge

Providing a constant flow of purge gas to the delivery optics is recommended to keep optical surfaces clean and moisture free. If sharing a purge gas supply between the laser and deliver system, make certain that the laser system purge gas flow rate is maintained at the specified volume. See “Laser System Purge Gas” on page 14.
If cutting or marking reflective materials, an optical isolator must be installed between the laser and the process material to prevent work piece reflections from returning to the laser head.

### Optical Isolation

An Optical Isolator must be installed between the laser and the process material if cutting or marking reflective materials to prevent work piece surface reflections from returning to the laser head.

Coherent has qualified the optical isolators listed in Appendix C: Accessories and Options in the operator’s manual for use with the E-1000 Series laser systems.

### Laser Control, Measurement & Diagnostic

There are several methods of controlling and monitoring the laser. Some offer limited control, while others allow total control. Depending upon the end-user application, one or a combination of methods may be employed.

- Built-in Java Applet running on a PC
- Coherent E-Series Remote Controller (optional)
- Java Applet + Coherent Remote Controller
- TCP/IP via LAN/Internet Connection and TCP Client Software
- 3rd Party/Customer Designed Controller (Real-time control interface)

Laser control methods are discussed in Section Four: Control Interfaces in the operator’s manual. Please consult with Coherent’s Applications Department to determine which control method is best suited to requirements, schedule and budget.

### External Interlock Circuit

Regardless of which control method is used, the laser requires that an external interlock (user supplied) be satisfied (closed) for operation. It is highly recommended to incorporate a serial interlock loop consisting of switch contacts on all service access doors and panels, and interlock switches or light curtains on all material access gates and doors.
Laser Power Measurement

To accurately measure delivered laser power, a calibrated optical power meter (detector head plus display console) is necessary. Liquid (water) cooling is generally required for the detector head at E-1000 Series power levels. Make sure to provide adequate cooling for the detector head.

Coherent manufactures a wide range of power meters (display consoles and sensor heads). Refer to Appendix C: Accessories and Options in the operator’s manual for recommended measurement tools.

Laser Safety

Safety First! Read and understand the contents of Section Two: Laser Safety in the operator’s manual. Accidents can generally be reduced or eliminated by following all recommended safety guidelines.

Coherent recommends that each facility appoint and train a Laser Safety Officer (LSO) responsible for overseeing all aspects of laser safety.

Design systems with safety in mind. Use engineering controls such as: enclosed beam paths, interlocked covers, and safety shutters.

Designate a laser controlled area and keep all untrained and non-essential personnel out. Provide beam blocks, light shields and/or curtains, as required, to establish a controlled area.

Insist that all operators and maintenance personnel receive proper training (and re-training) in laser and electrical safety. Require all personnel to have appropriate Personal Protective Equipment (PPE), especially laser safety eyewear suited to the laser in use and the job at hand.
**Installation**

The installation procedure consists of performing the following steps:

1. Prepare facility (all items on the Pre-installation Checklist are satisfied)
2. Receive and unpacking the shipment.
   - Allow the laser system temperature to equilibrate.
   - Remove laser, DC power supply, loose parts and accessories from shipping crates.
   - Inspect system components.
3. Mount the laser system and the DC power supply.
5. Connecting coolant lines and perform a leak check.
6. Connect the electrical cables.
7. Remove the output aperture cover and mount output accessories (couple beam delivery system to laser head).
8. Connect a laser controller.

**Required Tools**

To following tools will be required to unpack and install the laser system:

- Scissors or a package cutting knife
- Forklift or jack to lift 320 kg (705 lbs.) - the weight of a fully loaded shipping crate
- A hoist capable of lifting at least 173 kg (381 lbs.) - the weight of the laser system
- A cart capable of supporting and transporting at least 173 kg (381 lbs.) - the weight of the laser system
- Metric hex wrench set (Allen keys)
- 1/4” flat-blade (−) screw driver
- #1 Phillips (+) screw driver
- Roll of 1/2” wide Teflon tape (included in coolant filter kit)
- 9/16” open end wrench (or 8” adjustable wrench)
- 3/4” open end wrench (or 8” adjustable wrench)
- Common hand tools
Table 3 lists parts and equipment required to perform the installation. Note that some items are supplied with the laser system while others must be obtained locally.

### Table 3. Parts and Equipment Required for Installation

<table>
<thead>
<tr>
<th>ITEM</th>
<th>QUANTITY</th>
<th>PURPOSE</th>
<th>INCLUDED W/LASER SYSTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>+48 VDC power supply</td>
<td>1</td>
<td>Provides +48 VDC power to the RF power supply and the laser head.</td>
<td>No</td>
</tr>
<tr>
<td>AC power cord for DC power supply</td>
<td>1</td>
<td>Connects AC electrical supply to DC power supply input</td>
<td>No</td>
</tr>
<tr>
<td>Electrical disconnect for DC power supply</td>
<td>1</td>
<td>Disconnects power cord (to DC power supply) from AC electrical supply; can be mating plug/receptacle (if allowed by local code), or panel mounted disconnect</td>
<td>No</td>
</tr>
<tr>
<td>DC power supply cables</td>
<td>4 each 3 m (10 ft.) in length</td>
<td>48 VDC cables Qty 4, 3/0 AWG cables (2 red &amp; 2 black - each color to be connected in parallel) Transmits 48 volts to RF power supply.</td>
<td>No</td>
</tr>
<tr>
<td>Mounting bolts/feet</td>
<td>3 feet, 3 bolts and 3 washers</td>
<td>The Coherent supplied mounting feet &amp; bolts used to secure the E-1000 Series. • Mounting Kit (P/N 1174342) • Bolts: M8 X 75 mm length (high strength steel) torque to 23.7 N·m (210 lb-in) Customer must prepare the mounting surface and supply hardware to mount the feet to the mounting surface (refer Figure 18c)</td>
<td>Yes</td>
</tr>
<tr>
<td>Liquid-cooling System/Chiller</td>
<td>1</td>
<td>Provides temperature regulated liquid coolant to laser system (and to optional liquid-cooled DC power supply)</td>
<td>No</td>
</tr>
<tr>
<td>Coolant filter</td>
<td>1</td>
<td>Filters particle from coolant - 30 micron or better</td>
<td>No</td>
</tr>
<tr>
<td>Hose fittings</td>
<td>1</td>
<td>3/4” male NPT to male GHT (garden hose thread)</td>
<td>Yes</td>
</tr>
<tr>
<td>Hose fittings</td>
<td>1</td>
<td>3/4” male NPT to female GHT (garden hose thread)</td>
<td>Yes</td>
</tr>
<tr>
<td>Coolant hoses</td>
<td>as required</td>
<td>Provides coolant to the laser head and RF power supply (and to optional liquid-cooled DC power supply). 5/8” ID or greater hose is recommended</td>
<td>No</td>
</tr>
<tr>
<td>Coolant</td>
<td>Amount varies</td>
<td>The heat transfer medium used to remove heat from the laser system; consists of a mixture of distilled (or de-ionized) water and corrosion inhibitor</td>
<td>No</td>
</tr>
<tr>
<td>ITEM</td>
<td>QUANTITY</td>
<td>PURPOSE</td>
<td>INCLUDED W/LASER SYSTEM</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>----------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Corrosion inhibitor</td>
<td>Amount varies</td>
<td>Prevents corrosion of metal parts in contact with the coolant</td>
<td>No</td>
</tr>
<tr>
<td>Purge Gas (Regulated Supply)</td>
<td>1</td>
<td>Used to displace atmosphere of air within the laser head and the RF power supply; typically N₂ or clean, dry air (CDA).</td>
<td>No</td>
</tr>
<tr>
<td>Purge Gas Filter</td>
<td>N/A if using N₂; required if using CDA</td>
<td>Removes water vapor, oil and particulates from compressed air; see Appendix C: Accessories and Options in the operator’s manual</td>
<td>No</td>
</tr>
<tr>
<td>Purge Gas tubing (between laser head and RF power supply)</td>
<td>1 piece</td>
<td>A short length of 1/4 inch (6 mm) OD Teflon, polyethylene or polypropylene tubing to connect the purge gas line between the laser head and RF power supply</td>
<td>Yes</td>
</tr>
<tr>
<td>Tee</td>
<td>1</td>
<td>1/4 inch (6 mm) OD Tee for splitting the purge gas tubing at the laser head and RF power supply</td>
<td>Yes</td>
</tr>
<tr>
<td>Purge Gas tubing (between purge gas supply and laser system)</td>
<td>as required</td>
<td>1/4 inch (6 mm) OD Teflon, polyethylene or polypropylene tubing to connect the purge gas supply to the laser head</td>
<td>No</td>
</tr>
</tbody>
</table>
Facility Preparation

Prepare the facility (installation site) as described in Table 1 on page 2.

Unpacking and Inspection

The E-1000 Series laser system packaging has been designed for robust shipment. Upon receiving the system, inspect the outside of all containers immediately for damage that may have occurred during transit. If there appears to be visible damage (holes in containers, fluid damage, crushing, etc.), immediately notify Coherent and a representative of the carrier. Request that a representative of the freight company be present when unpacking the contents.

---

Keep the original shipping crates, lifting hardware and packing materials for shipping the E-1000 Series laser system from one location to another. If the system is to be returned to Coherent for repair, it must be in the original shipping container.

---

Carefully unpack the crate in a clean, dry area. Inspect all major components as they are unpacked.

---

The E-1000 Series laser system is not designed to be lifted or carried by hand. Always lift, move and place the laser using equipment approved for lifting and properly rated for the weights listed. To avoid personal injury, never place any body parts below a lifted or suspended laser.
Unpacking Instructions

1. Unlock all six (6) clasps of the top cover (Figure 7).

Figure 7. Removing Crate Cover
2. Lift up and pull off to remove the top cover (Figure 8).

Figure 8. Top Cover Removed
3. Un-strap the system by releasing both (2) ratchet strap tie-downs (Figure 9).

4. Locate the two eye-bolts (lifting eye-bolt, M6, 20 mm ID X 36 mm OD, zinc plated steel) included in the user documents bag (bag not shown).

STOP! Before proceeding, allow enough time for the laser to reach room temperature, especially when transported during the winter months, before cutting the moisture seal bag.
5. At the center of each end, carefully cut through the moisture seal bag as shown in Figure 10. Peel away the moisture seal bag and the bubble wrap underneath to expose the eye-bolt holes.

*Figure 10. Exposing the Eye-bolt Holes*
6. Fully turn all threads of the eye-bolts into the holes at the top of each end of the laser system (Figure 11).

*Figure 11. Installation of Eye-bolts*
7. Loosen and remove the wing nuts (2 places) that secure the spreader bar to the inside of the crate, then pull the spreader bar off of the bolts and lift it up (Figure 12).

Figure 12. Removing Spreader from Crate
When originally shipped, the wooden spreader bar and associated lifting hardware were inspected to be in good condition. Always inspect the lifting components before use. Do not use any component that is rusted, rotted or broken.

8. Place the spreader bar on top of the laser system with the shackles toward the eye-bolts. Shackle the eye-bolts to the spreader bar as shown in Figure 13. Fully thread the shackle pin and tighten the pin with a pliers or wrench.

*Figure 13. Attaching Eye-bolts to Spreader Bar*
9. Cut the moisture seal bag along the groove between the laser head and RF power supply from eye-bolt to eye-bolt, then cut across the bag top at both ends (Figure 14).

Figure 14. Cutting Top of Moisture Seal Bag
Steps 10 through 15 involve lifting and suspending a heavy object (the laser system). Only use approved lifting equipment rated for the load. Wear appropriate safety shoes or protective shoe covers. Always keep hands and body parts out from under a suspended load.

10. Secure the spreader bar to a hoist capable of lifting 173 kg (381 lbs.). Carefully lift the laser system straight up, remove the moisture seal bag (Figure 15).

Figure 15. Lifting the DIAMOND E-1000 Series
11. Place the laser system on a cart capable of supporting and transporting 173 kg (381 lbs.) (Figure 16).

![Figure 16. Place Laser System on Cart](image1)

12. Locate and remove the sealed plastic bag containing the RF power supply system cable (Figure 17).

![Figure 17. RF Power Supply System Cable](image2)
13. Using the necessary lifting equipment, carefully set the laser system on a clean and flat surface, such as an optical table.

14. Remove the spreader bar and return it to the shipping crate.

15. Remove the eye-bolts from the top holes and store for future use.

**Mount the Laser System**

The integrated laser system has provisions for stress free kinematic mounting.

A protective cover is mounted to protect the beam output aperture of the laser during shipment. This must be removed before mounting the laser as it blocks access to one of the mounting holes.

Mount the laser using mounting feet as shown in Figure 18d. The M8 x 75 mounting bolts must be torqued to 23.7 N·m (210 lb.-in.). Do not over torque these mounting bolts. Doing so will distort the mounting feet.

---

**Torque specification for the M8 X 75 mounting bolts is 23.7 N·m (210 lb.-in.). Do not over torque. Over torquing will damage mounting feet.**

See Figure 18a, b, c & d.
Figure 18. DIAMOND E-1000 Series System Installation in OEM Equipment
c. Interface Mounting Dimensions

Figure 18. DIAMOND E-1000 Series System Installation in OEM Equipment (Continued)
Alternate Mounting Orientations

The laser head can be mounted in any orientation. If mounted vertically with the beam tube up, ensure no dust or other particulates fall into the output aperture during installation.

---

Customers mounting the laser in a 'non-horizontal' feet down configuration are responsible for properly supporting the laser during installation (and de-installation). Great care must be taken that the laser (173 kg/381 lbs.) plus weight of hoses, cables and externally mounted accessories is supported without damage to the laser structure. The top eye-bolts cannot be used for vertical installation.

---

Vertical Mounting

For “beam up” vertical mounting, refer to Figure 19. For “beam down” vertical mounting, refer to Figure 20.

---

Do not use the top eye-bolt locations (previously used for lifting the laser system out of the crate) for a vertical lift!

---

1. Fully install the eye-bolts into the screw holes.
Figure 19. Vertical Mounting Eye-bolt Positions (Beam Up)

1. Install eye-bolt in upper hole
2. Remove Phillips head (+) screw from base
3. Install eye-bolt in lower hole
2. Securely connect appropriate slings or chains to the eye-bolts and spreader bar. Chains/slings must be vertical when under load. See Figure 21.

The eyebolts with hex nuts and shackle can be removed from the provided spreader bar and installed on the user supplied vertical lifting spreader bar.
If lifting laser in the Beam Up position, take extreme care to protect the interface connections from damage as the laser is tilted from horizontal!

3. Carefully lift the laser system while preventing the free end from moving around.
Mount the DC Power Supply

Refer to the information provided in Appendix C: Accessories and Options in the operator’s manual for mounting information.

Since the DC power cables (available from Coherent) are 3 m (10 ft.) in length, position the power supply output terminals within reach of the RF power supply input terminals. Refer to Figure 22 for RF power supply connection points.

Laser Head Indicators and Connections

Refer to Figure 22 and Table 4 for the location and description of the laser head indicators and connections.

Figure 22. E-1000 Series Interface Connectors
<table>
<thead>
<tr>
<th>CALL-OUT</th>
<th>DESCRIPTION</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Coolant (inlet)</td>
<td>Connection for the cooling fluid hose that supplies coolant from the coolant source.</td>
</tr>
<tr>
<td>2</td>
<td>Embedded Control/Diagnostic (interface connector)</td>
<td>LAN connector for control, diagnostics and troubleshooting.</td>
</tr>
<tr>
<td>3</td>
<td>DCPS/Auxiliary I/O (connector)</td>
<td>DB-15 connector provides for an auxiliary 48 VDC input to permit operation of control/diagnostic electronics without application of main 48 VDC power supply and reserved I/O to support advanced control options.</td>
</tr>
<tr>
<td>4</td>
<td>Extended I/O (connector)</td>
<td>DB25 connector that provides extended capability (including shutter control and additional fault signals).</td>
</tr>
<tr>
<td>5</td>
<td>Shutter LED</td>
<td>LED illuminates when the (optional) internal shutter is open.</td>
</tr>
<tr>
<td>6</td>
<td>Real Time I/O (control connector)</td>
<td>DB25 connector that supplies control and input modulation signals from the user to the RF power supply and supplies status information from the laser system.</td>
</tr>
<tr>
<td>7</td>
<td>Power Indicator LEDs</td>
<td>LEDs illuminate when 48 VDC is applied to the RFPS terminals and when the Connector Cable (Item 9) is connected.</td>
</tr>
<tr>
<td>8</td>
<td>48 VDC (+) (terminal)</td>
<td>Connects +48 VDC from the DC power supply to the RF power supply. Use a 3/4” wrench. Apply 190 lb.-in. (21.4 N·m) torque to nut supplied.</td>
</tr>
<tr>
<td>9</td>
<td>Laser to RFPS connector cable</td>
<td>Connector cable provides internal laser head to RFPS signals.</td>
</tr>
<tr>
<td>10</td>
<td>48 VDC Return (–) (terminal)</td>
<td>Connects the RF power supply ground to the DC power supply. Use a 9/16” wrench. Apply 190 lb.-in. (21.4 N·m) torque to nut supplied.</td>
</tr>
<tr>
<td>11</td>
<td>FWD &amp; REFL Power Monitor (BNC connectors on RF Power Supply)</td>
<td>For service use only.</td>
</tr>
<tr>
<td>12</td>
<td>Coolant (outlet)</td>
<td>Connection for the cooling fluid hose. Cooling fluid travels from the laser head through the RF power supply and out to the drain.</td>
</tr>
<tr>
<td>13</td>
<td>Nitrogen Purge (inlet)</td>
<td>Provides for gas purge of the laser head and RF power supply. Requires 1/4 inch (6.3 mm) OD Teflon, polyethylene or polypropylene tubing. Nitrogen is the preferred purge gas. Refer to “Installation” on page 21 for additional information on purging the laser head. Note that the purge line on the laser head has a small filter (internal). This filter protects the laser optics from any particles that are generated as a result of connecting the purge gas tubing to the laser head. If customer supplied purge meets required specifications, this internal filter should last a lifetime.</td>
</tr>
</tbody>
</table>
Optics Purge Connection

Locate the 1/4 inch Tee provided with the laser system at the purge input on the laser head. The Tee splits the purge line directing some purge gas to the RF power supply.

Use 1/4 in. (6 mm) OD clean polyethylene, polypropylene or Teflon tubing and insert it into the Tee. Fully insert the tubing (until it bottoms out), then give it a slight pull and verify that the tube is held in place.

The purge gas at this input must meet the requirements discussed earlier in this chapter.

Set-up Purge

Set-up purge is required in order to eliminate moisture from the system prior to use. This is required even though the system packaging is designed to ship the laser in a ‘dry condition’. Note that system purge is required whenever the system has been off for an extended period of time without purge.

1. Connect the tubing to the Tee as described “Optics Purge Connection”. Refer to Figure 22 for the purge gas line connection point.

2. Purge the laser system with nitrogen or clean, dry air for a minimum of two hours.

---

Failure to purge the system leaves the system at substantial risk of optics failure. Guidelines for system purge gas are found in “Delivery System Purge Gas” on page 14.

---

Connect Coolant Lines

Connect the fittings and coolant lines to the laser system, with the particle filter connected to the inlet coolant line near the laser head. Connection points are shown in Figure 22. Use Teflon tape on fittings. Observe the coolant flow direction shown in Figure 2.

The recommended coolant source is a closed-loop cooling system. Coolant composition must meet the requirements stated in “Coolant Composition” on page 10. Refer to “Laser System Cooling” on page 8 and “Installation” on page 21 for additional information.

The recommended hose for coolant consists of a 5/8 inch (16 mm) minimum ID hoses up to 15 m (50 ft.) total.
After connecting the water hoses, verify that there are no water leaks as follows:

- Close supply and return valves, then turn the chiller on.
- Open the valve in the water return (drain) line.
- Slowly open the valve in the water supply line.
- With the water supply pressure and water line differential pressure in accordance with Table 1-2 on page 1-8 (in the operator’s manual), check all connections for leaks.
Connect Electrical Cables

1. Connect the short interface cable between the laser head (J14 - Laser to RFPS) and the RF power supply (J1 - RFPS to Laser). Tighten the jack screws.

Never connect or disconnect the laser to RFPS connector cable when the laser is powered on. Wait at least 2 minutes after power is turned off before connecting or disconnecting the cable.

2. Connect all four DC power cables between the DC power supply and the RF power supply.

Refer to the DC power supply manufacturer’s instructions for terminal identification, recommended fasteners and torque specifications for connections at the DC power supply.

On the RF power supply, fasten the cables as shown in Figure 23.

Figure 23. RF Power Supply DC Input Terminal Fasteners

At the RFPS, place the protective terminal boots over the red cable ends before fastening the cables.

Use the RED cables for the “+48 VDC” positive (+) connections, and the BLACK cables for the “48V Return” negative (–) connections.

Apply 190 lb.-in. (21.4 N·m) torque to both supplied hex nuts.
Shut off the electrical power source before connecting the mains power cord. Consult a qualified electrician to make the main power connection.

3. Connect the AC power cord to the DC power supply. Refer to the power supply manufacturer’s instructions for terminal identification, recommended fasteners and torque specifications.

Remove Output Aperture Cover

Before attaching an optical isolator or other beam delivery components and before operating the laser, remove the output aperture cover. To remove the aperture cover, loosen the two thumbscrews. Set the cover aside for re-installation at future shipments.

Failure to remove the output aperture cover before operation (and lasing on the cover) will cause permanent damage to optical surfaces inside the laser head.
Mounting Accessories to Laser Aperture

The E-1000 Series lasers have provisions for the customer to mount optics/accessories via the laser front plate. The following provisions must be followed:

- Accessory mount maximum load: 2.3 kg (5 lbs.) at 254 mm (10 in.) or equivalent.
- The customer must provide a continuation of optical purge through the added components using a separate purge line.

Controller Connection

Install and connect the controller cable(s) to the laser.
EMBEDDED CONTROL AND DIAGNOSTICS

E-1000 Series
HTTP and TCP
Server

Introduction

The E-1000 Series Control Electronics have embedded control and integrated sensors that allow remote monitoring of the E-1000 Series system status via TCP/IP over Ethernet. The system is capable of serving HTTP (web) pages to a client via a local area network (LAN) or by direct connection using a crossover cable. Using the LAN connection, it is possible to interrogate or control an E-1000 Series system remotely via the Internet. As every end-user is slightly different, the details of enabling Internet access are left to the end user. Check with the network administrators for strategies that make the most sense in your organization.

In addition, the E-1000 Series can serve a Java Applet that can monitor the E-1000 Series operation (live) or perform simple control of the E-1000 Series. This functionality allows operation of the E-1000 Series with only a computer, a network interface card (NIC) and a web browser compatible with HTTP and Java.

The next few subsections will:

- Illustrate a simple connection to the E-1000 Series.
- Test the connection using the ping utility.
- Go over the various pages available to the connected client.
- Go into a few advanced connection schemes.
Initial Connection and Configuration

Connections

Using an Ethernet crossover cable, connect the computer's Network Interface Card port to the Ethernet port on the E-1000 Series.

The default IP address for every E-1000 Series is 169.254.12.13. A different IP address may be assigned by the user, and a system data page is provided to allow the end-user to do this. See Figure 26. If a different IP address is required, it is recommended to connect locally and change the IP address before connecting to a LAN. Local connection instructions are given in the following section.

![System Data Screen](image)

Figure 26. IP Address Change (On System Data Screen)
Client Configuration

The next few illustrations are geared towards clients running Microsoft Windows Operating Systems but most modern operating systems are very similar. Begin by navigating to the Control Panel (START -> CONTROL PANEL). Double click on NETWORK CONNECTIONS to get to the Network Connections screen (Figure 27).

![Network Connections Screen](image)

Figure 27. Network Connections Screen
Double click on LOCAL AREA CONNECTION to get to the Local Area Connection Properties screen (Figure 28).

**Figure 28. Local Area Connection Properties Screen**
In the General tab, scroll down the pane and Double Click on INTERNET PROTOCOL (TCP/IP). This will open the Internet Protocol (TCP/IP) Properties screen (Figure 29).

Figure 29. Internet Protocol (TCP/IP) Properties Screen

Select “Use the following IP address:” and enter the numbers exactly as they appear in the Figure 29. When done, dismiss all the open windows by selecting OK. The E-1000 Series is now ready to be connected.

Once the DC connections to the E-1000 Series have been verified, apply +48 VDC to the laser before proceeding with the next sections.
Connection to the E-1000 Series can still be obtained, even without the necessary permissions. Simply connect the Ethernet crossover cable as above and turn on the +48 VDC power supply. The operating system in the computer will attempt to obtain an IP address from the E-1000 Series. Since the E-1000 Series does not have a DHCP server, the computer will self assign an IP address (APIPA) that should be within the pool that includes the default E-1000 Series IP address (169.254.x.x). This procedure can take a bit longer but a message will appear when the connection is ready with limited or no connectivity.

Testing the Connection Using PING

Start the Windows PING utility by selecting START->RUN…

Next, type CMD to bring up the Command Prompt.

Type `ping 169.254.12.13` and press ENTER.

The following screen should be displayed after a few moments.

![Ping Screen](image)

This IP address is the default address for the E-1000 Series. The following sections will explain how this IP address can be changed and how connection to the LAN can be achieved. But first, the pages available to clients will be described.
HTTP Information and Diagnostic Pages

Home Page

Open the computer's web browser (Microsoft Internet Explorer in this case) and type the following URL:


The following screen (Figure 31) will be displayed:

![Welcome Screen](image)

**Figure 31. Welcome Screen**

This is the home page for the E-1000 Series Web Server. Navigation to all other client services is available with links from here. The bottom third of the page has these links.
This page (Figure 32) provides general system data. In addition, there is a utility to change the IP address of the system. Coherent recommends that the system be first used with its default IP address.

Figure 32. System Data Screen
System operation diagnostics are provided on this page (Figure 33):

This screen logs the total system run time (+48 VDC ON) and the enabled run time (System Enable asserted). All the times described on this page now and in the future will be in the Days:Hours:Minutes:Seconds format. The system will also keep track of time that both the LASER and RFPS spend above the warning temperature. This along with a count of warning temperature threshold crossings will provide some insight into the usage of the DIAMOND E-1000 Series system.

The lower part of this page has System Warning and Fault information. The customer will have to navigate to this page in order to determine what condition is causing a System Warning.
FAQ

This page (not shown) will keep a list of Frequently Asked Questions for users of the E-1000 Series system. In addition, the Coherent web site can be reached from any E-1000 Series web page via a link at the bottom (Note: LAN connection is necessary for the link to work).

Java Applet

Java Runtime Configuration

Before using the JAVA applet, the JAVA runtime engine (JRE) must be installed on the client. A link to the download web page is provided on the E-1000 Series home page. The system needs version 1.4.2 or later. Once JRE is downloaded and installed, disable the cache for the E-1000 Series JAVA applet to run properly. This only needs to be done once. Again, launch the Windows Control Panel (START->CONTROL PANEL). Next, double click on Java to bring up the JAVA CONTROL PANEL. The look of this panel has changed from version to version. Consult the documentation to find out how to disable the cache. In this version (1.5.0), on the GENERAL tab at the bottom of the page in the Temporary Internet Settings. Press the SETTINGS button:
Figure 34. Java Control Panel Screen
Next, press the VIEW APPLETS… button.

In the bottom left corner, uncheck ENABLE CACHING. Dismiss all opened windows by pressing OK.

Note that if there is a running instance of the web browser when doing the JAVA configuration, it must be closed before proceeding. In other words, close all instances of Internet Explorer before continuing with the JAVA applet.

Figure 35. Java Applet Cache Viewer Screen

In the bottom left corner, uncheck ENABLE CACHING. Dismiss all opened windows by pressing OK.

Note that if there is a running instance of the web browser when doing the JAVA configuration, it must be closed before proceeding. In other words, close all instances of Internet Explorer before continuing with the JAVA applet.
Opening a Socket

Start the Java Client after reopening a client connection to the E-1000 Series. See the sections above if not already running an active client. After several seconds, the following screen (Figure 36) will be displayed:

![E-1000 Series Laser Ethernet Control Applet](image)

**Figure 36. E-1000 Series Laser Ethernet Control Applet**

To begin using this tool, click the OPEN SOCKET button to open a TCP connection to the E-1000 Series system.

Diagnostics Elements

The bottom left section is devoted to visual diagnostic indicators. Faults are kept apart from interlock and general system status indicators. Serious faults are indicated in RED and warnings are indicated in yellow. Temperature is indicated in the center of the applet. RF power is shown underneath the temperature. The activity window will track all faults and system messages with a timestamp.
Control Elements

The right hand portion of the applet is devoted to controlling the E-1000 Series. Note that control this way is only available if the Ethernet Control Input is asserted on the Extended I/O Connector (refer to Section Four: Control Interfaces in the operator’s manual). Shutter control is also available from this applet. To control the laser, press LASER ENABLE and then RF ENABLE. Slowly slide the DUTY CYCLE slider to the right and LASER POWER indicated in Watts should be seen.

Extended Diagnostics Pages

Access to these pages is password protected. From any web page, press the Diagnostics link. At the bottom of this page (Figure 37) enter the password in the text field provided and press the SUBMIT key. Access to the Extended Diagnostics pages is now possible.

![Diagnostics Main Menu](image)

Figure 37. Diagnostics Main Menu
**Onboard Time Page**

This page (Figure 38) reports the current time reported by the battery backed up onboard real time clock:

![Onboard Time](image)

**Figure 38. Onboard Time**

Provisions are also provided at the bottom of this page to reset the time and date. Please be very careful how you enter the new time and date values.
EEPROM Maintenance

Several non-volatile system parameters can be cleared from this web page (Figure 39). To do so select the appropriate section and click SUBMIT.

System Enabled Time as well as RFPS Time in Warning Temp is explained in the Diagnostics web page, above.

The Rolling Buffer Pointer Location is reserved for logging fault data to EEPROM. Since the log is a rolling buffer, the last used location is also saved to EEPROM. Use this option to clear the last location to the base location.
Rolling Buffer

This web page (Figure 40) provides a time-stamped log of system faults. Currently, the buffer is only eight entries deep. The ninth entry will overwrite the first and so on.

Figure 40. Rolling Buffer
System Monitoring Applet

This applet adds the ability to monitor system status more closely. It intercepts the CAN bus traffic internal to the E-1000 Series and parses it into this display. Operation starts by opening a socket exactly as the previous applet, above. Fault status and Activity Log is also provided. Please note that the screen shots provided in Figure 41 were taken during a test case condition and does not reflect the nominal values present in an actual system.

With “RFPS 1 to 5” Tab Selected

Figure 41. System Monitoring Applet
With “RFPS 6 to 10” Tab Selected

Figure 41. System Monitoring Applet (Continued)
TCP Client Connections

In addition to the functionality introduced above, there are a few more options available to users. Since web pages and JAVA applets are suitable only for a ‘human to machine’ interface, we have also provided some limited ‘machine to machine’ functionality. A user can use any TCP client software to open a TCP socket to the DIAMOND E-1000 Series.

Connection Requirements

Any TCP client software or firmware can communicate with the E-1000 Series. However, only one socket to port 5000 is allowed at this time. Simply open a socket to the IP address of the E-1000 Series using port 5000. When done, close this socket.
API Available

Commands to the E-1000 Series follow the standard ‘GET’ and ‘SET’ protocol. For example, to get the temperature of the LASER head the user or client software would type ‘glt’ and press return or concatenate the end of line character (\n\r). The E-1000 Series would return the temperature in degrees Celsius. See end of document for command summary and structure. Some commands also require additional parameters to work properly. For instance, set shutter open also requires a ‘1’ for true or a ‘0’ for false. So, to open the shutter the user or client software would need to send ‘sso 1\n\r’. ‘grp’ and ‘gfp’ optionally require additional parameters. Issuing ‘gfp’ without parameters will return total forward power in 10s of Watts. However, adding an integer from 1 to 5 (inclusive) will give the forward power of that particular RFPS in 10s of Watts.
Using Pueblo TCP Client

A very easy to use TCP client is Pueblo. Pueblo is available from [http://pueblo.sourceforge.net/pueblo/](http://pueblo.sourceforge.net/pueblo/). Download and install the Pueblo application. Launch Pueblo, and using the QuickConnect feature, type in the IP and port of 5000 as shown in Figure 42:

![QuickConnect](image)

**Figure 42. QuickConnect**

Type commands and receive responses directly (Figure 43):

![QuickConnect Response](image)

**Figure 43. QuickConnect Response**
## Command Line Interface Details

**Table 5. Get Commands (available at any time)**

<table>
<thead>
<tr>
<th>COMMAND</th>
<th>DEFINITION</th>
<th>PARAMETERS</th>
<th>RETURNS</th>
</tr>
</thead>
<tbody>
<tr>
<td>grt</td>
<td>Get RFPS temperature</td>
<td>none</td>
<td>RFPS maximum temperature in degrees Celsius</td>
</tr>
<tr>
<td>glt</td>
<td>Get LASER temperature</td>
<td>none</td>
<td>Laser maximum temperature in degrees Celsius</td>
</tr>
<tr>
<td>gfp</td>
<td>Get forward power</td>
<td>none, 1-4</td>
<td>RFPS peak forward power in 10s of watts. No parameters returns the total forward peak power. gfp 1 returns peak forward power for amp #1 in 10s of watts</td>
</tr>
<tr>
<td>grp</td>
<td>Get reflected power</td>
<td>none, 1-4</td>
<td>RFPS peak reflected power in 10s of watts. No parameters returns the total reflected peak power. grp 1 returns peak reflected power for amp #1 in 10s of watts.</td>
</tr>
<tr>
<td>gms</td>
<td>Get modulation strength</td>
<td>none</td>
<td>Modulation on percentage in percent</td>
</tr>
<tr>
<td>gmd</td>
<td>Get modulation direction</td>
<td>none</td>
<td>1 if RFPS is being modulated and 0 if the RFPS is not modulating</td>
</tr>
<tr>
<td>gsn</td>
<td>Get serial number</td>
<td>none</td>
<td>Serial number of system in decimal. This number is related to the MAC, see above.</td>
</tr>
<tr>
<td>glp</td>
<td>Get LASER power</td>
<td>none</td>
<td>LASER optical power in watts</td>
</tr>
<tr>
<td>gcs</td>
<td>Get CAN status</td>
<td>none</td>
<td>1 if no CAN bus is detected and 0 if CAN is functioning normally</td>
</tr>
<tr>
<td>gso</td>
<td>Get shutter open</td>
<td>none</td>
<td>1 if shutter is open and 0 if shutter is closed.</td>
</tr>
<tr>
<td>gsf</td>
<td>Get system frequency</td>
<td>none</td>
<td>Modulation frequency in kHz</td>
</tr>
</tbody>
</table>
**Table 6. Set Commands**

<table>
<thead>
<tr>
<th>COMMAND</th>
<th>DEFINITION &amp; PURPOSE</th>
<th>PARAMETERS</th>
<th>RETURNS</th>
</tr>
</thead>
<tbody>
<tr>
<td>sms</td>
<td>Set modulation strength&lt;br&gt;Sets modulation on percentage in percent.</td>
<td>integers (1-100), default is 1</td>
<td>CRLF</td>
</tr>
<tr>
<td>smd</td>
<td>Set modulation direction&lt;br&gt;This command should be used to toggle the laser on and off</td>
<td>1 to set modulation on and 0 to set modulation off</td>
<td>CRLF</td>
</tr>
<tr>
<td>sme</td>
<td>Set modulation enable&lt;br&gt;This command should be used to enable the system prior to operation</td>
<td>1 to enable and 0 to disable</td>
<td>CRLF</td>
</tr>
<tr>
<td>sso</td>
<td>Set shutter open&lt;br&gt;This command is used to open and close the shutter</td>
<td>1 to open and 0 to close</td>
<td>CRLF</td>
</tr>
<tr>
<td>ssf</td>
<td>Set system frequency&lt;br&gt;Sets modulation frequency in kHz</td>
<td>integers (10-100), default is 25</td>
<td>CRLF</td>
</tr>
</tbody>
</table>

**Ethernet Control must be enabled via the Expanded Input Output Interface Connector for Set Commands to become effective.**

---

**Table 7. Special Commands (available at any time)**

<table>
<thead>
<tr>
<th>COMMAND</th>
<th>DEFINITION</th>
<th>PARAMETERS</th>
<th>RETURNS</th>
</tr>
</thead>
<tbody>
<tr>
<td>log</td>
<td>start/stop transmission of log file data</td>
<td>none</td>
<td>A data stream from the system including fault status with timestamp and CAN traffic.</td>
</tr>
</tbody>
</table>
Example sequence for turning on the DIAMOND E-1000 Series via TCP:

1. Turn on power with Ethernet crossover cable connected.
2. Wait for the IP address assignment to occur.
3. Start a TCP Client.
4. Open socket.
5. Type ‘sme 1’ to enable the system.
6. Type ‘ssf x’ to set a modulation frequency (replace x with the desired frequency in kHz).
7. Type ‘sms x’ to set the modulation strength (replace x with the desired on percentage).
8. Check that safe operation of the LASER is possible!
9. Type ‘smd 1’ to turn on the LASER.
10. Verify the LASER is operating by typing ‘glp’.

Generating a Log File

In order to retrieve the log file from a running E-1000 Series system, use a TCP client software that allows buffering. For demonstration purposes in this manual the Pueblo/UE will be used for this example and is available at: http://pueblo.sourceforge.net/pueblo/.

To generate a log file using Pueblo, perform the following steps:

1. Find the IP address of the unit to be logged (default laser IP address is 169.254.12.13).
2. Connect a PC with the Pueblo application to the laser.
3. Configure the PC network adapter card to use static IP address 169.254.12.12, with subnet mask 255.255.0.0.
4. Launch the Pueblo application.
5. From the Worlds tab, select QuickConnect. Enter the laser IP address and port 5000. See Figure 42. The port used to open the TCP socket is 5000; only one TCP port can be opened at one time. Press “Connect.”
6. From the Pueblo command line, select File->Log to a File. Click on “Log to a File” and note a check mark at this line.
7. A new “Save As” dialog box will open. Choose an appropriate path/folder for the log file, then create a file name using the laser serial number and date (serialnumber_DDMMYY). Leave the extension .txt and press “Save.”
8. From the Pueblo window, type LOG (or log, case does not matter) followed by a return to start the logging function. The logging function will begin and the following data will appear approximately once a second (example data shown).

```
225421192008
096|000|000|000|001|000|000|021
032|000|000|005|105|019|000|048
065|000|000|000|021|000|000|048
066|000|000|000|021|000|000|048
067|000|000|000|021|000|000|048
068|000|000|000|021|001|000|049
069|000|000|000|021|000|000|048
096|000|001|021|024|030|006|047
032|000|000|005|105|019|000|048
065|000|000|000|021|000|000|048
066|000|000|000|021|000|000|048
067|000|000|000|021|000|000|048
068|000|000|000|021|001|000|049
069|000|000|000|021|000|000|048
070|000|000|000|021|000|000|048
071|000|000|000|021|000|000|048
072|000|000|000|021|000|000|048
073|000|000|000|021|001|000|049
074|000|000|000|021|000|000|048
096|000|002|020|021|020|019|021
```

9. Allow approximately 15 minutes worth of data to be logged. During the log time, command the laser to perform a sequence that is causing a problem, generates a fault or where performance is in question.

10. At the end of the logging period, type LOG (or log), followed by a return to stop the logging function.

11. From the Pueblo command line, select File->Log to a File and note the check mark should disappear. This will “write” the logged data to the file *serialnumber/DD/MM/YY.txt*. 

Interpreting the Raw Data from an E-1000 Series Log File

Before interpreting the data from this actual file, two types of data must be discussed.

The following is the first type and is a time stamped entry showing the FPGA status:

225421192008

The first 6 digits encode the time of day. The format is SSMMHH. The number for each is logged in decimal but must be converted to hex to get the BCD information. In the entry above:

Seconds are 22 decimal or 16 hex
Minutes are 54 decimal or 36 hex
Hours are 21 decimal or 15 hex

So, the time of this entry is 15:36:16 or 3:36PM

The next 3 digits (192) are the decimal representation of the first FPGA status byte. The last 3 digits (008) are the decimal representation of the second FPGA status byte. See Table 8 on page 81 describing the bit wise representation of this information. These types of codes are only recorded when there is a change in the FPGA status bytes. They do not occur as often as the next type of log entry.

The second type of log entry is the CAN message received from the various CAN nodes:

096|000|000|000|001|000|000|021

The format is as follows:

CAN node address | Fault Code | Data Page | Data 3 | Data 4 | Data 5| Data 6 | Data 7

In the above entry:

CAN node address = 096
Fault Code = 000
Data Page = 000
Data 3 = 000
Data 4 = 001
Data 5 = 000
Data 6 = 000
Data 7 = 021

See “CAN Node Addresses” on page 83 and “CAN Data Page Contents:” on page 84 for a listing of the various address types, fault codes and data pages.
Now continuing with the interpretation:

032|000|000|005|105|019|000|048
   CAN node address = 032 (OSC/DRV)
   Fault Code = 000 (No Faults)
   Data Page = 000 (Data Page 0)
   Data 3 = 005 (Coolant Temp In in °C)
   Data 4 = 105 (Coolant Temp Out in °C)
   Data 5 = 019 (Highest Temp on Assembly in °C)
   Data 6 = 000 (DC Current in Amps)
   Data 7 = 048 (DC Voltage in Volts)

065|000|000|000|021|000|048
   CAN node address = 065 (RFPA1)
   Fault Code = 000 (No Faults)
   Data Page = 000 (Data Page 0)
   Data 3 = 000 (Peak Forward Power in 10s of Watts)
   Data 4 = 000 (Peak Reflected Power in 10s of Watts)
   Data 5 = 021 (Highest Temp on Assembly)
   Data 6 = 000 (DC Current)
   Data 7 = 048 (DC Voltage)

066|000|000|000|021|000|048
067|000|000|000|021|000|048
068|000|000|000|021|001|049
069|000|000|000|021|000|048
070|000|000|000|021|000|048
071|000|000|000|021|000|048
072|000|000|000|021|000|048
073|000|000|000|021|000|048
074|000|000|000|021|000|048

   These 9, above from the next 9 RFPA assemblies.

096|000|001|021|024|030|006|047
   CAN node address = 096 (LASER)
   Fault Code = 000 (No Faults)
   Data Page = 001 (Data Page 1)
   Data 3 = 021 (Thermistor 6 in °C)
   Data 4 = 024 (Ambient Temperature in °C)
   Data 5 = 030 (Humidity)
   Data 6 = 006 (Dew Point in °C)
   Data 7 = 047 (DC Voltage in Volts)

032|000|000|005|105|019|000|048
   Data 3 and Data 4 will always be 005 and 105 until pilot
RF is still off. No forward, reflected or current

096|000|002|020|021|020|019|021
CAN node address = 096 (LASER)
Fault Code = 000 (No Faults)
Data Page = 002 (Data Page 2)
Data 3 = 020 (Thermistor 1 in °C)
Data 4 = 021 (Thermistor 2 in °C)
Data 5 = 020 (Thermistor 3 in °C)
Data 6 = 019 (Thermistor 4 in °C)
Data 7 = 021 (Thermistor 5 in °C)

No changes on RF or OSC/DRV

096|000|000|005|105|019|000|048
CAN node address = 096 (LASER)
Fault Code = 000 (No Faults)
Data Page = 000 (Data Page 0)
Data 3 = 000 (Optical Power in Watts, multiply by 256....
Data 4 = 002 .....and add to this byte for total optical power)
Data 5 = 000 (Bit wise Faults Byte 0)
Data 6 = 000 (Bit wise Faults Byte 1)
Data 7 = 021 (Highest Temp on Assembly)
Skipping down to the action….

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>065</td>
<td>RF now fired up, must be low duty since only 2 amps</td>
</tr>
<tr>
<td>068</td>
<td>FPGA reports shutter open</td>
</tr>
<tr>
<td>096</td>
<td>-48 Optical Watts</td>
</tr>
<tr>
<td>365</td>
<td>FPGA reports a General and System Fault (latched)</td>
</tr>
</tbody>
</table>
-LASER node reports temp fault, Thermistor 5 at 8°C
-15:37:27, FPGA reports +24 Disabled

-RF power falling off

-15:37:33, FPGA reports General Fault cleared
-Laser node still not clear

-No faults reported by any nodes however, user must toggle the Enable line to restart the system.
## Table 8. FPGA Status Byte Codes

### RTIO_ENABLE_STATUS (1st Byte)

<table>
<thead>
<tr>
<th>Interlock Flag</th>
<th>Shutter Interlock Flag</th>
<th>System Fault</th>
<th>System Enable</th>
<th>Ethernet Control</th>
<th>Temperature Fault</th>
<th>General Fault</th>
<th>Shutter Fault</th>
<th>Decimal</th>
<th>Hex</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>16</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>128</td>
<td>0x80</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>144</td>
<td>0x90</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>176</td>
<td>0xB0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>178</td>
<td>0xB2</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>192</td>
<td>0xC0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>194</td>
<td>0xC2</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>200</td>
<td>0xC8</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>208</td>
<td>0xD0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>240</td>
<td>0xF0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>241</td>
<td>0xF1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>242</td>
<td>0xF2</td>
</tr>
</tbody>
</table>

### RTIO_FPGA_STATUS (2nd Byte, Modulating Faults)

<table>
<thead>
<tr>
<th>Not Used</th>
<th>Not Used</th>
<th>Not Used</th>
<th>Stimmer</th>
<th>Shutter Position*</th>
<th>Shutter Command**</th>
<th>Duty Cycle</th>
<th>VSWR</th>
<th>Decimal</th>
<th>Hex</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0x02</td>
</tr>
<tr>
<td>0</td>
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<td>0</td>
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<td>1</td>
<td>3</td>
<td>0x03</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0x04</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>0x05</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>7</td>
<td>0x07</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>0x08</td>
</tr>
<tr>
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<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
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<td>0</td>
<td>1</td>
<td>9</td>
<td>0x09</td>
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<tr>
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<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>16</td>
<td>0x10</td>
</tr>
</tbody>
</table>

*High is closed, Low is open or opening
**High is commanding to open
The following is provided for information only.

**Table 9. CAN FAULT CODES**

<table>
<thead>
<tr>
<th>NAME</th>
<th>CODE (HEX - $XX)</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Fault</td>
<td>0</td>
<td>No Faults Detected - Reset Faults State</td>
</tr>
<tr>
<td><strong>NODE FAULTS (0x01-0x7F)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RFPS SWR</td>
<td>0x01</td>
<td>RF SWR exceeds maximum</td>
</tr>
<tr>
<td>Shutter Interlock</td>
<td>0x02</td>
<td>Shutter Interlock Open</td>
</tr>
<tr>
<td>Shutter Transition</td>
<td>0x03</td>
<td>Shutter Transition Failure</td>
</tr>
<tr>
<td>Node Temperature</td>
<td>0x04</td>
<td>Node Temperature Out of Range</td>
</tr>
<tr>
<td>Node Dew Point</td>
<td>0x05</td>
<td>Node Dew Point Out of Range</td>
</tr>
<tr>
<td>Reserved</td>
<td>0x06</td>
<td>Reserved</td>
</tr>
<tr>
<td>+48V Power Supply</td>
<td>0x07</td>
<td>+48V DCPS Out of Range</td>
</tr>
<tr>
<td>+5V Power Supply</td>
<td>0x08</td>
<td>+5V DCPS Out of Range</td>
</tr>
<tr>
<td>I2C Communication</td>
<td>0x09</td>
<td>I2C Communication Failure</td>
</tr>
<tr>
<td>Microcomputer EEPROM</td>
<td>0x0A = 10</td>
<td>Microcomputer EEPROM Failure</td>
</tr>
<tr>
<td>Microcomputer RAM</td>
<td>0x0B = 11</td>
<td>Microcomputer RAM Failure</td>
</tr>
<tr>
<td>Microcomputer Memory</td>
<td>0x0C = 12</td>
<td>Microcomputer Program memory checksum failure.</td>
</tr>
<tr>
<td>Microcomputer ADC</td>
<td>0x0D = 13</td>
<td>Microcomputer ADC Failure</td>
</tr>
<tr>
<td>Reserved</td>
<td>0x0E = 14</td>
<td>Reserved</td>
</tr>
<tr>
<td>+48V DCPS Current</td>
<td>0x0F = 15</td>
<td>+48V DCPS Current fault</td>
</tr>
<tr>
<td><strong>COMMUNICATION AND MESSAGE FAULTS (0x80 - 0xFF)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NFOR (RS-232 noise, framing, overrun error)</td>
<td>0x80</td>
<td>Serial Comm Character Reception Fault</td>
</tr>
<tr>
<td>RS-232 Time-out</td>
<td>0x81</td>
<td>Serial Comm Message Time-out</td>
</tr>
<tr>
<td>Bad RS-232 Header</td>
<td>0x82</td>
<td>Bad Serial Comm Message Header Character</td>
</tr>
<tr>
<td>Bad RS-232 Footer</td>
<td>0x83</td>
<td>Bad Serial Comm Message Footer Character</td>
</tr>
<tr>
<td>Bad Checksum</td>
<td>0x84</td>
<td>Bad Serial Comm Message Checksum</td>
</tr>
<tr>
<td>Command Sequence</td>
<td>0x85</td>
<td>Improper Command Sequence</td>
</tr>
<tr>
<td>Bad Command</td>
<td>0x86</td>
<td>Illegal or Invalid Node Command</td>
</tr>
</tbody>
</table>
Table 9. CAN FAULT CODES (Continued)

<table>
<thead>
<tr>
<th>NAME</th>
<th>CODE (HEX - $XX)</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Command Parameter</td>
<td>0x87</td>
<td>Remote Command Parameter Invalid or Out of Range</td>
</tr>
<tr>
<td>Bad Message</td>
<td>0x88</td>
<td>Illegal or Invalid Node Message</td>
</tr>
<tr>
<td>Node Reset Completed</td>
<td>0x89</td>
<td>Node has completed a local reset</td>
</tr>
<tr>
<td>Reflash Command ACK</td>
<td>0xAA</td>
<td>Acknowledgement of Command</td>
</tr>
<tr>
<td>Reflash Image CRC Fail</td>
<td>0xAB</td>
<td>CRC of Image Space Failed</td>
</tr>
<tr>
<td>Reflash Application CRC Fail</td>
<td>0xAC</td>
<td>CRC of Application Space Failed</td>
</tr>
<tr>
<td>Reflash Stuck in Bootloader</td>
<td>0xAD</td>
<td>Node cannot leave boot code space</td>
</tr>
</tbody>
</table>

CAN Node Addresses

032 = OSC/DRV  
065 = RFPA1  
066 = RFPA2  
067 = RFPA3  
068 = RFPA4  
069 = RFPA5  
070 = RFPA6  
071 = RFPA7  
072 = RFPA8  
073 = RFPA9  
074 = RFPA10 
096 = LASER
CAN Data Page

Contents:

Byte 2 - 7 - Data message

- RFPA Message 0
  Byte 2 - Message type - 0x00
  Byte 3 - Output forward power
  Byte 4 - Output reflected power
  Byte 5 - Highest temperature
  Byte 6 - RFPA current
  Byte 7 - Vdd voltage

- RFPA Message 1
  Byte 2 - Message type - 0x01
  Byte 3 - BLF #1 Temperature
  Byte 4 - BLF #2 Temperature
  Byte 5 - BLF #3 Temperature
  Byte 6 - BLF #4 Temperature
  Byte 7 - RFPA current

- RF Exciter Message 0
  Byte 2 - Message type - 0x00
  Byte 3 - Coolant Temperature In
  Byte 4 - Coolant Temperature Out
  Byte 5 - Highest Temperature
  Byte 6 - DC Current
  Byte 7 - Vdd voltage

- RF Exciter Message 1
  Byte 2 - Message type - 0x01
  Byte 3 - BLF #1 Temperature
  Byte 4 - BLF #2 Temperature
  Byte 5 - Temperature 3 - binary, 1°C resolution
  Byte 6 - Temperature 4 - binary, 1°C resolution
  Byte 7 - Dew Point

- Laser Head Message 0
  Byte 2 - Message type - 0x00
  Byte 3 - Optical Power High Byte
  Byte 4 - Optical Power Low Byte
  Optical power reading is 10 bits, right justified
  Byte 5 - Boolean Fault 0 - “1” - Fault, “0” Safe
    Bit 0 - Flow
    Bit 1 - 48V Monitor
      Fault when V< 42V or V> 53V
    Bit 2 - Reserved
    Bit 3 - 5V Monitor
      Fault when V<4.75V or V>5.25V
    Bit 4 - Dew Point
      Fault when Dew Point < Ambient Temperature - 5°C margin
    Bit 5 - Spare
Bit 6 - Spare
Bit 7 - Spare
Byte 6 - Boolean Fault 0 - “1” - Fault, “0” Safe
Bit 0 - Thermistor 0
   Fault when T<10°C or T >50°C
Bit 1 - Thermistor 1
   Fault when T<10°C or T >50°C
Bit 2 - Thermistor 2
   Fault when T<10°C or T >50°C
Bit 3 - Thermistor 3
   Fault when T<10°C or T >50°C
Bit 4 - Thermistor 4
   Fault when T<10°C or T >50°C
Bit 5 - Thermistor 5
   Fault when T<10°C or T >50°C
Bit 6 - Spare - set to 0
Bit 7 - Spare - set to 0
Byte 7 - Highest temperature

• Laser Head Message 1
  Byte 2 - Message type - 0x01
  Byte 3 - Temperature 6 - binary, 1°C resolution
  Byte 4 - Ambient Temperature - binary, 1°C resolution
  Byte 5 - Humidity
  Byte 6 - Dew Point
  Byte 7 - Reserved

• Laser Head Message 2
  Byte 2 - Message type - 0x02
  Byte 3 - Temperature 1 - binary, 1°C resolution
  Byte 4 - Temperature 2 - binary, 1°C resolution
  Byte 5 - Temperature 3 - binary, 1°C resolution
  Byte 6 - Temperature 4 - binary, 1°C resolution
  Byte 7 - Temperature 5 - binary, 1°C resolution