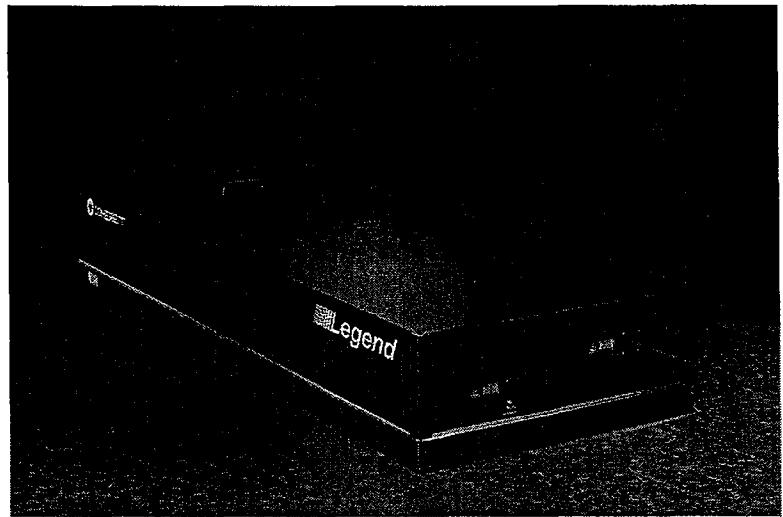




MANUAL ADDENDUM
HIGH-ENERGY VERSION



LEGEND-HE

Preface

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Disclaimer

This manual provides information regarding the operation and maintenance of the Coherent Legend-HE.

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Coherent personnel will install the laser system. We do not guarantee laser performance unless the laser is installed by Coherent personnel or by an authorized representative of Coherent.

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1 System Description

1.1 Introduction

Congratulations on your purchase of the Legend-F-HE. The Legend-F-HE is a high-energy, kilohertz rep-rate, Ti:Sapphire regenerative amplifier with a stretcher and compressor, high speed synchronization electronics, and computer-controlled electronics to provide thermal management of the Ti:Sapphire laser rod.

This manual addendum describes the features and operation of the components of the Legend-F-HE that differ from a standard Legend, specifically the Environmental Control Unit (ECU), the control software for the ECU, and the layout of the regenerative amplifier (regen). For the setup and operation of the rest of your Legend system, please refer to the standard Legend manual.

1.2 Theory of Operation

The Legend-F-HE differs from a standard Legend in two main areas: the regenerative amplifier design and the thermal management of the Ti:Sapphire laser rod. The regen cavity design, based on the compact z-fold cavity common to most Legends, has been optimized for efficiency and stability in high pulse energy performance. The Ti:Sapphire rod is pumped from both sizes by a single, high-power Evolution pump laser. The two pump beams are precisely aligned and focused in the Ti:Sapphire rod to match the lasing mode defined by the regen cavity.

To compensate for the increased heat load in the Ti:Sapphire rod due to the high pump power, the rod assembly is actively cooled by a thermoelectric cooler (TEC). The temperature of the rod assembly is monitored through an embedded RTD sensor, and the temperature is regulated to maintain optimum performance, typically in the range of 0-5° C. The hot side of the TEC is regulated by contact with a water-cooled copper heat sink which contains an embedded thermistor temperature sensor.

To prevent condensation at low operating temperatures, the top of the rod assembly is enclosed in a sealed housing with dry air continuously circulated through this housing. Brewster-angle windows are attached at both ends of the housing to transmit the regen and pump beams. The housing also contains a humidity sensor to detect whether the air inside the housing is adequately dry to prevent condensation at the operating temperature of the Ti:Sapphire rod.

The ECU comprises hardware and software that enable the temperature of the Ti:Sapphire rod in your Legend-F-HE to be controlled automatically in conjunction with the operation of the Evolution pump laser. The temperature control circuit includes a commercial temperature controller (Watlow 96) for adjustment of the temperature set-point and monitoring of the Ti:Sapphire temperature. The temperature controller monitors the RTD in the rod assembly and sends a control signal to the power supply for the TEC to regulate the temperature. The ECU also includes interlock electronics monitor the humidity sensor and the thermistor in the cooled copper heat-sink. The interlocks prevent the operation of the TEC if there is high humidity in the laser rod housing or if the temperature of the heat sink exceeds a safe operating temperature. The ECU also contains a small air pump and two desiccant cartridges that supply dry air to the laser rod housing.

The temperature regulating functions of the ECU can be controlled by computer through a USB interface on the front panel of the ECU. The pre-installed software for the Legend-F-HE enables the user to set and monitor the temperature of the laser rod. The software also works in conjunction with the Evolution control software to change the laser rod temperature based on the operating state of the Evolution.

1.3 System Layout

The standard component layout for a typical Legend-F-HE system, including the Evolution pump laser, Mira seed oscillator, and Verdi pump laser, is shown in Figure 1.

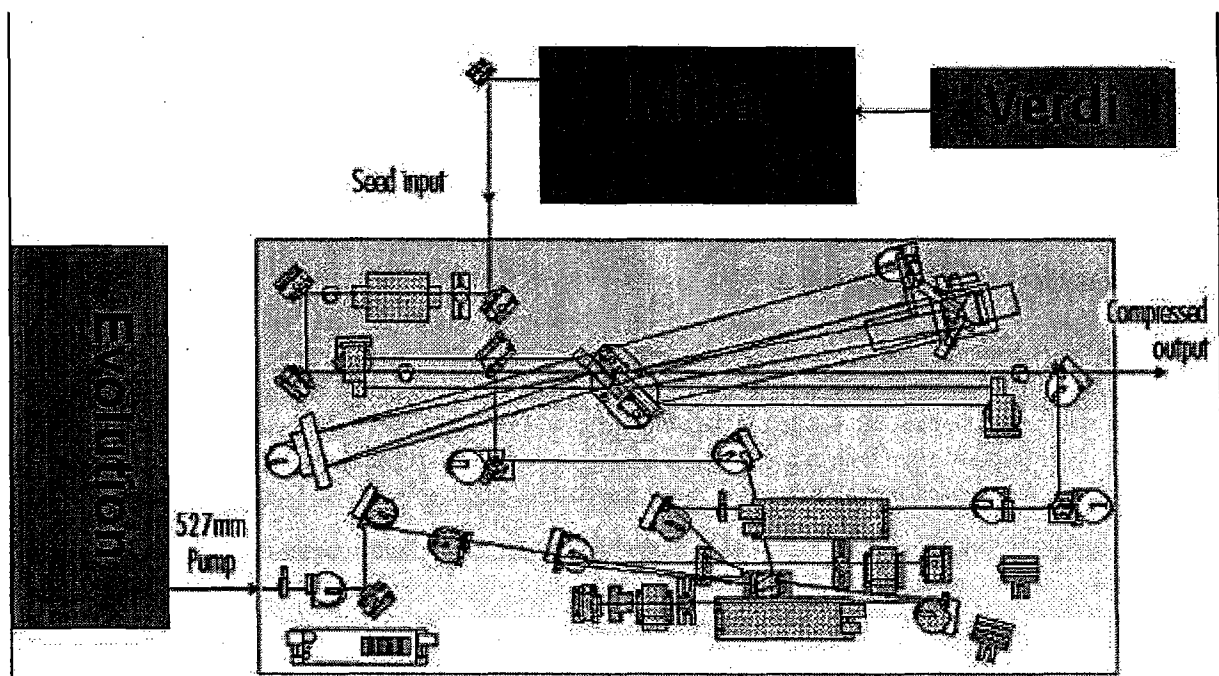


Figure 1: Standard optical layout for a Legend-F-HE system with an Evolution-30 pump and Verdi-pumped Mira seed laser.

1.4 Regenerative Amplifier

The optical layout of the regenerative amplifier is shown in Figure 2. The Evolution pump beam is expanded and collimated by a telescope and then split 50/50 by a dielectric beam splitter. Each pump beam is aligned and focused into each side of the Ti:Sapphire rod. The seed light from the stretcher is reflected from one of the Brewster windows mounted on the laser rod housing.

Refer to the standard Legend manual for a detailed explanation of the other components of the regenerative amplifier.

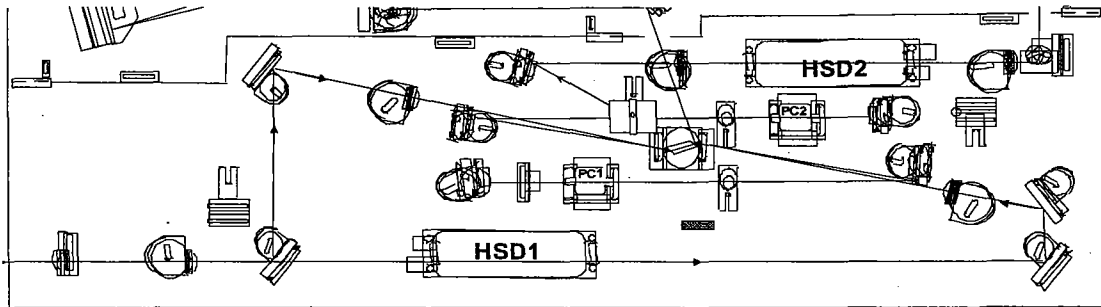


Figure 2: Optical layout of the Legend-F-HE regenerative amplifier.

1.5 ECU

The ECU electronics are contained in a 3U rack-mount enclosure (Figure 3) designed to be mounted in the same rack as the Evolution power supply.

Front panel connections:

- **POWER LED** – illuminates when the ECU power is on.
- **HUMIDITY FAULT LED** – illuminates if there is a high-humidity interlock condition in the laser rod housing.
- **CHILLER FAULT LED** – illuminates if there is a high temperature interlock condition in the water-cooled heat sink (e.g. if the chiller is turned off when the TEC is cooling).
- **USB** – A-type female connection for connecting to the control computer using the supplied USB A-male to A-male cable.
- **TE COOLER CONTROL** – front panel display of the Watlow temperature controller. The top display in green shows the measured temperature of the laser rod mount; the bottom display in red shows the set-point temperature.

Back panel connections:

- **OUT & RETURN** – Quick-connect supply and return fittings for the dry air loop.
- **TEC** – Hybrid D-sub electrical connector to connect to the side-panel of the Legend-F-HE using the included umbilical.
- On/Off switch for the ECU with an integrated fuse and IEC-320-C14 power connector inlet.

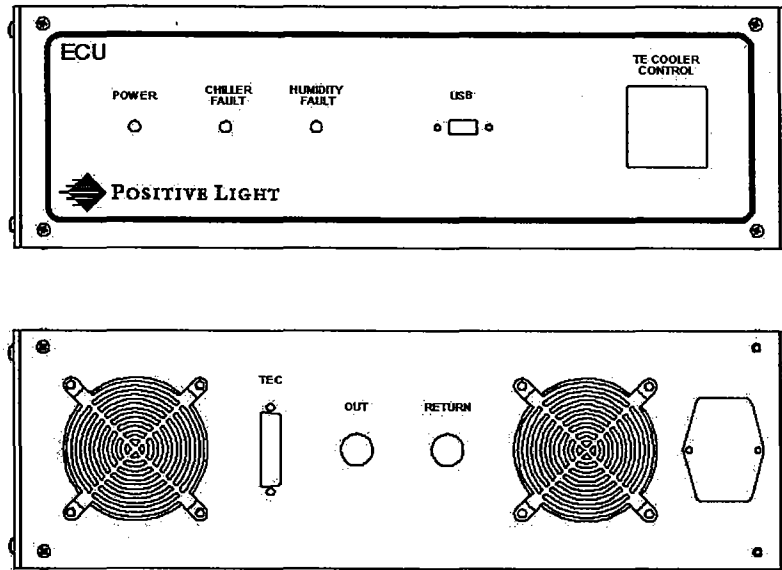


Figure 3: Front- and back-panel of the ECU.

1.6 Software Control

The Legend-F-HE control software includes a window running a version of the Evolution control software (refer to the Evolution manual for a description of these controls) and a window running the ECU control panel shown in

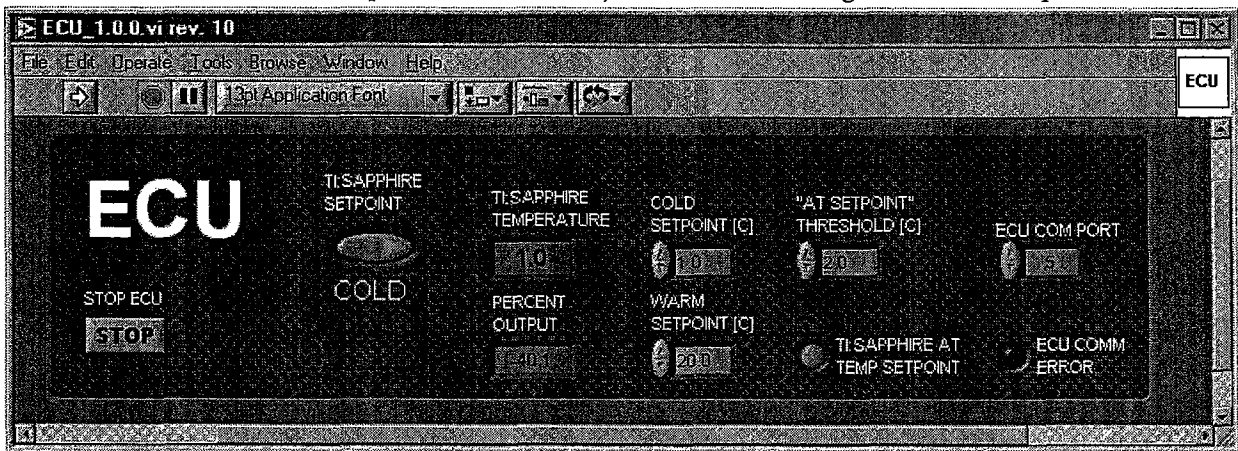


Figure 4: ECU control panel in Legend-F-HE control software.

The controls for the ECU software are:

- **STOP ECU** – Button to stop the ECU software and save the changes made to the other settings.
- **TI:SAPPHIRE SETPOINT** – Toggle switch control to change the setting of the ECU temperature controller between a the Cold set-point and the Warm set-point. Note that when the Evolution control software is running, the state of this control is determined by whether the Evolution is lasing (Cold set-point) or not lasing (Warm set-point). Evolution software is stopped, the user can toggle the set-points.

- **TI:SAPPHIRE TEMPERATURE** – Indicator showing the temperature of the Ti:Sapphire laser rod mount as detected by the ECU temperature controller. Units are degrees Celsius.
- **PERCENT OUTPUT** – Indicator showing the percentage of maximum output power of the TEC power supply. The range is 0 to -90.
- **COLD SETPOINT [C]** – Control for the set-point of the laser rod temperature when the set-point switch is in the ‘Cold’ position. Units are degrees Celsius, and typical values for this parameter are 0 to 5.
- **WARM SETPOINT [C]** – Control for the set-point of the laser rod temperature when the set-point switch is in the ‘Warm’ position. Units are degrees Celsius, and typical values for this parameter are 20 to 25, usually the same as the set-point of the Evolution water chiller.
- **“AT SETPOINT” THRESHOLD [C]** – Control for the threshold difference between the temperature set-point and the actual Ti:Sapphire temperature. When this difference is less than the value set, the “At Setpoint” LED illuminates. Units are degrees Celsius, and typical values for this parameter is 2.0. Note that this setting has no effect on the function of the ECU.
- **TI:SAPPHIRE AT TEMP SETPOINT** – LED indicator that illuminates when the difference between the temperature set-point and the actual Ti:Sapphire temperature is less than the “At Setpoint” Threshold. This indicator is meant as a convenience to the user to quickly determine if the Ti:Sapphire is at the proper set-point.
- **ECU COM PORT** – Control to set the communications port associated with the ECU. This is set at the factory and should not be changed.
- **ECU COMM ERROR** – LED indicator that illuminates when there is a communications error between the control laptop and the ECU.

Note that the ECU control software only interacts with the temperature controller in the ECU. The status of the ECU interlocks is not monitored by the ECU software. The settings of the ECU software will be set by the service technician who installs your Legend-F-HE laser. Under normal circumstances there is no need for user interaction with the ECU software except to monitor the performance of the temperature controller in the ECU.

2 Legend-F-HE Operation

2.1 TE Cooled Legend Start-up Procedure

**Eyewear
Required**



The following procedure will result in a laser beam being emitted from the Legend output port. Ensure all persons in the room are wearing adequate laser eye protection. Ensure that the anticipated beam is terminated.

2.1.1 Short Pulse Oscillator:

1. Turn on the external city water supply if any part of the short pulse oscillator requires so.
2. Turn on the chiller corresponding to the short pulse oscillator if one is required.
3. Initiate the **“turn-on”** procedure for standard operation of the short pulse oscillator as described in the system manual. Allow ample warm-up time following turn on for the oscillator to thermally stabilize. Following ample war-up time, ensure optimum power and wavelength.

2.1.2 Environmental Control Unit (ECU):

1. Turn **“On”** the AC switch located behind the back panel.

2.1.3 Evolution Diode Pump Laser:

1. Turn **“On”** the Chiller AC switch.
2. Initiate the turn on procedure for operating the Evolution laser via the control computer.
3. Depress the Evolution AC switch located on the left side of the front panel of the Power Supply to the **“1”** position. The switch will illuminate following turn on.
4. Turn the key located to the right of the AC circuit breaker clock-wise, to the **“ON”** position.
5. On the control computer, open the program labeled **“Legend-F-HE Control”**
6. Turn on the Positive Light Evolution laser by pressing on the **“ON”** button of the Evolution control software. Doing so will set the ECU to the ‘Cold’ temperature set-point.

2.1.4 Synchronization Delay Generator (SDG):

1. Turn on the SDG. Ensure that the SDG module switch controlling delay output 1 is off. The corresponding LED is will not be illuminated when in the off position.

Note: if the Tsunami laser is not turned on then the SDG will give a "sync error" indication. By overriding the BWD, the user may operate the regenerative amplifier unseeded with the Tsunami laser turned off and switching the SDG sync enable switch to off.

2.1.5 5 kHz Power Supply (5 kHz systems only):

1. Turn on the external 5 KHz High Speed Driver power supply via the AC circuit breaker located behind the unit.

If the system operation does not work as described above, it may be necessary to follow more detailed procedure described later in the standard Legend manual.

2.2 Legend Shutdown Procedure

1. Stop the Evolution lasing by pressing the red "STOP" button located on the computer screen via the control computer. Doing so will cause the ECU to set the Ti:Sapphire rod temperature to the 'Warm' set-point (e.g. 20 C).
2. Stop the Evolution control software by pressing the "Stop and Save Settings" button.
3. Stop the ECU control software by pressing the "STOP ECU" button.
4. Disable the Evolution power supply by turning the "on/off" key counter-clock-wise to the "OFF" position.
5. Depress the Evolution power supply circuit breaker to the off position "0".
6. Turn "off" the Evolution Chiller.
7. Turn off "OUT 1" on the SDG. This disables the regen from working. It is also good to start the system next time it is to be used with this in the off position.
8. Power "off" the SDG.
9. Power off the "on/off" switch corresponding to the ECU unit.
10. Turn off the "on/off" switch corresponding to the 5 kHz, High Speed Driver power supply module (5 kHz systems only).
11. Power down the short pulse oscillator/pump source as described in its system manual.
12. If necessary, replace the Legend external covers on the Legend breadboard.

3 Trouble-Shooting

This chapter contains a general user-troubleshooting guide. It is provided to assist you in isolating some of the problems that might arise while using the system. A complete repair procedure is beyond the scope of this manual. For problems that you cannot solve using this guide, contact your authorized service representative.

3.1 Trouble-Shooting Guide

Use this guide if your Legend-F-HE performance drops unexpectedly. If you try the corrective actions and are unable to bring your Evolution-15 performance up to specification, call your authorized service representative for assistance.

Symptom: Ti:Sapphire rod will not reach set-point temperature	
<i>Possible Causes</i>	<i>Corrective Action</i>
Humidity interlock	Trouble-shoot humidity fault (see below).
Temperature interlock	Trouble-shoot temperature fault (see below)
Water temperature set incorrectly	Ensure that the water chiller temperature is set to its factory value (typically 20 C).
Pump laser power set too high	Ensure that the Evolution pump laser is operating at the same power level as when the laser was installed.

Symptom: Comm error in control software	
<i>Possible Causes</i>	<i>Corrective Action</i>
USB cable unplugged	Stop and close software. Check USB cable connections to the Evolution and ECU. Plug back in if necessary. Restart software.
COM port set incorrectly	Refer to the original values of the COM port settings at the time of installation. Adjust settings as needed.
Evolution or ECU power supply not turned on.	Ensure that both power supplies are turned on before launching the Legend-F-HE software.

Symptom: Humidity interlock illuminated	
<i>Possible Causes</i>	<i>Corrective Action</i>
ECU just started up	Wait a few minutes for the ECU to pump dry air through the laser rod housing.
Air hoses disconnected or kinked	Check quick-connects on back of ECU, check hose-barbs on side panel of Legend-F-HE and on laser rod assembly.
Air pump not running	Listen for sound of air pump. If ECU is on and pump is not running, contact your service representative for repair.
Desiccant cartridges consumed	Look through window in top of ECU to see if both desiccant cartridges have turned completely pinkish from exposure to moisture. Replace cartridges if necessary.
Humidity sensor disconnected	Check connections at the laser rod assembly.

Symptom: Temperature interlock illuminated	
<i>Possible Causes</i>	<i>Corrective Action</i>
Water hoses disconnected or kinked	Check water connections from Evolution to the hose-barbs on side panel of Legend-F-HE and on laser rod assembly.
Water chiller not running	Turn on water chiller.
Temperature sensor disconnected	Check connections at the laser rod assembly.