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Standard Operating Procedure
for the 145mW, 1550nm Thorlabs Turnkey Laser, 45
mW, 1550nm TeraXion LXM-U Laser Module, NKT
Photonics Koheras BOOSTIK HP 15W Amplifier, and
Covesion WGCO-M-1550-40 Second Harmonic
Generator
in East Bridge B111

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1. Introduction

This document is the Standard Operating Procedure (SOP) for 145mW, 1550nm Thorlabs Turnkey Laser (ULN15TK), 45 mW, 1550nm TeraXion LXM-U Laser Module, NKT Photonics Koheras BOOSTIK HP 15W Amplifier, and 775 nm light in East Bridge B. This laser system is used for the operation of GQuEST related interferometers and filter cavities.

The ULN15TK is a Class 1M, fiber Bragg grating (FBG) laser system with output at 1550nm, with an absolute maximum output of 145mW.

The Teraxion LXM-U Laser Module has an output at 1550nm, with nominal operating output power of 45 mW. The ULN15TK and Teraxion LXM-U are both options for seed lasers for the NKT Photonics amplifier and should never be used to seed the amplifier at the same time. Damage to the laser modules may occur if so.

The use of an NKT Photonics Koheras BOOSTIK HP 15W Amplifier will also be used in B111. This product is a class 4 Laser system; class 4 laser systems are dangerous and has the potential to cause damage and injury.

We will be using up to 10 kW of laser power inside of laser cavities. This light will be contained within vacuum chambers and 10 kW of power cannot be discharged continuously. The vacuum chambers will physically block access to the 10 kW light. This “in cavity power buildup” is fairly standard.

We will be using up to 20 mW of 775 nm light from a Covesion WGC0-M-1550-40 Second Harmonic Generator.

1.1 Room B111

The floor plan of East Bridge B111 is shown in Figure 1. **The grey area indicated by waves is the Nominal Hazard Zone.** The area between the laser safety barrier (curtains) and the entrance door is non-hazard area that is designated for storing and donning laser safety glasses.

2. Hazards

All laser light used is infrared and is invisible to the naked eye. The output power of this ULN15TK alone can be operated above the accessible emission limit (AEL) of 9.6 mW at 1550 nm for both eye and skin. With the amplifier in use, the output can be operated at well above the AEL. Extreme caution

should be taken when operating the laser with the amplifier. The 775 nm light AEL is 0.56 mW, below the power that is output from the Coversion SHG.

2.2 Electrical Hazards

The Thorlabs ULN15TK seeder laser is powered using Thorlabs' DS12 power supply (12 V, 4 A). The LXM-U is powered using USB-C to USB-C cable and wall connector. The NKT Photonics Koheras BOOSTIK HP 15W Amplifier is powered with a standard wall outlet and the Coversion SHG is not powered but is connected to a temperature controller. The seeder laser and amplifier are connected to a Furman Power Conditioner (CN-2400S) that limits the total input current to 20A. *There are no electrical hazards when operating the laser.*

2.3 Fire Hazards

Operating the NKT Photonics Koheras BOOSTIK HP 15W Amplifier at powers on the order of 10 W has the potential for fire. Ensure the beam is only directed at approved optics equipment or qualified beam dumps. **Check Figure 1 for fire extinguisher location.** Fire extinguisher #21957.

3. Hazard Controls

3.1 Access Controls

There are no active access controls to East Bridge Room B111.

Access to laser areas requires a key card and physical key.

An interlock will be added.

3.2 Beam Controls

There is a Laser Enable PushButton Switch that be used to shutter the laser. The laser will remain on at all times to increase the operating life length of the laser.

3.3 Laser Interlock

The ULN15TK is equipped with a remote interlock connector located on the rear panel. In order to enable the laser, a short circuit must be applied across the terminals of the Remote Interlock connector. This connection is made available to allow the user to connect a remotely actuated switch to the connector. All units shipped from Thorlabs are configured with a shorting device installed in the interlock connector. This device can be removed, and a 2.5 mm mono jack can be installed to provide remote interlock connectivity.

A similar shorting device is plugged into the back of the LXM-U to allow for lasing.

A safety door switch circuit is connected to the LEMO interlock connector of the BOOSTIK HP system. The door switch circuit is part of the system's interlock circuit and connected to the BOOSTIK HP amplifier through an External bus connection from the seed laser. Refer to the ADJUSTIK or ACOUSTIK product guides for specific information on connecting a safety door switch to either device. This interlock must be CLOSED for emission to be permitted.

3.4 Safety Sign

Laser hazard indicator signs are located at the outside of the rooms. Whenever there is a possibility to use the laser beam for a task, this sign shall be turned on by a switch. See Figure 1 for the switch locations.

3.5 Laser Safety Eyewear

The use of laser safety eyewear is mandatory whenever the laser power supply is energized. If the ULN15TK alone is in use, a minimum optical density (OD) of 2 at 1550 nm is required (OD 1.2 absolute mathematical minimum with a required safety factor of OD 0.8). When the amplifier is in use, a minimum of **OD 4 at 1550nm is required** (OD 3.2 absolute mathematical minimum with a required safety factor of OD 0.8). 20 mW of 775 nm light will be used, although the maximum Coversion SHG output is 500 mW. Therefore, a minimum of **OD 4 at 775 nm is required** (OD 3 absolute mathematical minimum with a required safety factor of OD 1). C2KG5 laser safety goggles will be stored in the entrance area. These goggles have filtering at the following wavelengths:

OD 6+ @530-570nm
OD 4+ @655-664nm
OD 5+ @665-679nm
OD 6+ @680-695nm
OD 7+ @696-1550nm
OD 4+ @1551-2750nm

Always double check the listed filtering on the side of the goggles before entering the laser hazard area and ensure there are no scratches or cracks in the goggles.

Please note the comfortable safety margin of OD 4 required vs. OD 7 for the goggles. These goggles pass through a lot of visible light, so we encourage but do not require the use of goggles in the areas separated from the lasers with curtains.

3.6 Handling of the optical fiber

The laser source output is a PM, FC/APC Bulkhead optical fiber. This will initially be connected to a fiber coupler, where the max output of this fiber is 145 mW. The laser source should be turned off when handling the output fiber. This output will be connect to the BOOSTIK amplifier.

Other optical fibers will be used with up to 15 W. Use extreme caution, ensure 90%+ coupling efficiency into the fiber, and do not adjust open the output of fiber with any power going through the fiber.

4. Training

Users of the ULN15TK laser, BOOSTIK amplifier, and Coversion SHG should have received the Caltech basic laser safety training. They are not permitted to operate the laser by themselves until they have received this training.

5. Operating Procedures

The following section describes how to turn on the appropriate seeder laser and amplifier. The seed lasers are plugged into a four-port fiber beam splitter, where one output is then plugged into the amplifier, and one is plugged into a collimator on the table. **Note that both seeders should never be powered on at the same time in this configuration. It is important to ensure both are powered off fully before powering a new one on.** Items such as jewelry and watches should not be worn while manipulating beams on the optical table. Caution should be exercised when one's head passes through the plane of the laser beam.

5.1 Steps prior to turning on the laser:

- Check the beam path to ensure that there are no reflective objects in the beam path that may unintentionally deflect the beam or burn
- Alert any personnel in the room that the laser is about to be operated and ensure that everyone is wearing the appropriate laser safety eyewear
- Check that the laser warning signs are illuminated
- Ensure the doors into B111A and B111B are shut and locked
- Ensure curtains are closed
- Ensure the window shades are closed
- Please make a courtesy electronic notification (via Mattermost or email) and log post


5.2 Steps for turning on the Thorlabs ULN15TK seeder laser (when electronics and fibers are already connected)





- Switch the key on the Furman Power Conditioner from Off to On (180° degrees clockwise)
 - Delay Switch 1 should now be illuminated green
 - The power button on the Thorlabs ULN15TK laser should be illuminated green
- Open the drawer in the electronics rack box (be aware that if you pull out the rack box too far a lock like mechanism will hold the rack in an extended position)
- Press the “enable” button on the seeder laser
 - The emission LED should now be illuminated green
 - The seeder laser is now outputting up to 145 mW, but is currently outputting closer to 50 mW

5.3 Steps for turning on the TeraXion LXM-U seeder laser

- Connect one end of the USB-C to USB-C cable to the POWER port of the LXM laser module.
- Make sure the optical connector is safely connected to the fiber beamsplitter or a device that can accept the emitted power and then connect the other end of the USB-C cable to the sole available connector of the USB power supply.
- Connect the USB-A end of the USB-A to USB-C cable to an available port of the control PC.
- Connect the other end of the cable to the DATA port of the laser module. In the “Device Manager” windows of the control PC, a new COM port should become available. Take note of the COM port # as it will be useful in the following steps. As of writing this, we are using Comm Port 4.

5.3.1 Steps for turning on the TeraXion LXM-U seeder laser when electronics and fibers are already connected

- Switch the key on the Furman Power Conditioner from Off to On (180° degrees clockwise)
 - Delay Switch 1 should now be illuminated green
 - The power button on the TeraXion LXM-U laser should be illuminated green
- Open the LXM-CONTROL dedicated user interface of the LXM laser module.
 - It can be downloaded, together with the required driver, using the link below.
 - Cloudshare link : <https://cloudshare.teraxion.com/>
 - Username : purespectrum
 - Password : terax1on223
 - Folder : LXM
- To achieve connection between the laser and the LXM-CONTROL software, first refresh the list of available COM ports using the refresh button . Then, in the drop-down menu, select the COM port identified above. Finally, click on the «Connect» button. The symbol should turn green:




- If this is the first time connecting on a new computer or if the software interlock is enabled, disable the software interlock, press on the software interlock button , enter «1234» in the password prompt message box and press «Ok». No password is required to lock the software interlock.
- Click on the start button the to activate the «LASER ON» Sequence. 
- From this point, follow the steps in section 5.2 starting under the bolded note saying the processes are now the same.

5.4 Steps for turning on the NKT Photonics Koheras BOOSTIK HP 15W Amplifier

- **NOTE: the power on process for the amplifier is the same for both seeders.**
- Wait 15 seconds until Delay Switch 3 is illuminated, then turn on the NKT Boostik Amplifier with a switch on its back if the amplifier screen is not illuminated
- Ensure the amplifier laser current is set to its minimum value (0.01 A)
- Turn the key on the NKT Amplifier to the ON position
 - The Enable/Disable button should now be flashing
- Press the Enable/Disable button
 - The Enable/Disable button should stop flashing and stay illuminated
 - The NKT Boostik Amplifier is now outputting 300-500 mW
- To increase the laser power, turn the Browser/Adjust knob, select the setpoint current I_{dl} , press the enter button, turn the Browser/Adjust knob, set the current to the desired value, press the enter button. Please see Figure 2 for a conversion from input current to output power. It was noted [here](#) that the beam shape does not depend on the input current.

Please note that these steps are slightly different from the NKT Photonics Manual

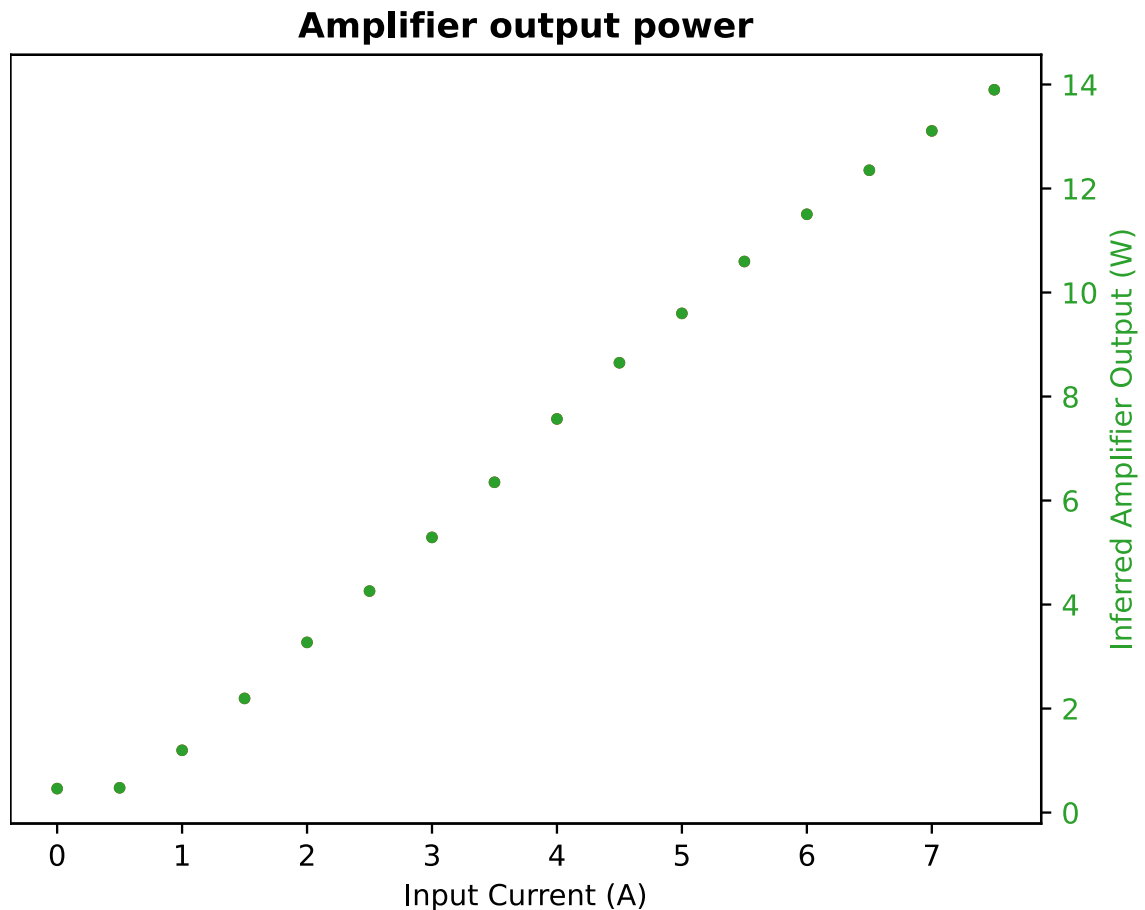


Figure 2. Inferred Amplifier Output Power (W) as a function of Input Current (A). From [Lee Log 11325](#).

Beam Size out of Amplifier: the 2σ radius of the amplifier was measured with a beam profiler to be 1.00 mm with a waist at the output. See [here](#).

5.5 Steps for turning *off* the NKT Photonics Koheras BOOSTIK HP 15W Amplifier and THEN the seeder laser

In short, ensure the NKT Amplifier is turned off before the seeder laser.

- Scan the optical table for any stray beams and correct the situation as necessary
- On the NKT Amplifier, turn the Browser/Adjust knob, select the setpoint current I_{dl} , press the enter button, turn the Browser/Adjust knob, set the current to the minimum value, and press the enter button
- Press the Enable/Disable button on the NKT Amplifier
- Turn the key to the OFF position on the NKT Amplifier
- The switch on the back of the NKT Amplifier does not need to be switch off unless the amplifier will be unplugged
- If using the Thorlabs ULN15TK seeder laser, press the “enable” button on the seeder laser
 - The seeder laser emission LED should no longer be illuminated green
- If using the TeraXion LXM-U seeder laser, click the red stop button in the LXM-CONTROL program.

- Switch the key on the Furman Power Conditioner from On to Off (180° degrees counterclockwise)
 - The amplifier screen should immediately no longer be illuminated and the seeder laser power should be cut after 15 seconds

5.5.1 Steps for completely shutting down the TeraXion LXM-U Laser

- **Ensure the NKT Amplifier is fully shut down.**
- We recommend turning off the laser by using the software command «laser stop». For complete shut-down, please follow the procedure below:
 - Press the stop button to stop the laser emission. You can validate that the laser stopped emitting light looking at the «Laser On» LED on the «Laser» menu.
 - Press the disconnect button to disconnect the LXM from the software. Please be aware that the disconnect function does not turn off the laser.
 - Disconnect the USB-C connector on the POWER port to turn off the module.
 - Click «Exit» on the bottom right of the window.

6. Emergency Procedures

In case of an emergency, call x5000.

To turn the laser off quickly but without damaging equipment, turn the key on the Furman Power Conditioner from On to Off

Follow the emergency response guide.