THORLABS

MIR Turn-Key Laser System

MIR Laser System Operation Manual

2019

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Contents

We aim to develop and produce the best solution for your application in the field of optical measurement techniques. To help us live up to your expectations and constantly improve our products, we need your suggestions. Therefore, please let us know about possible ideas. We and our international partners are looking forward to hearing from you.

Thorlabs Quantum Electronics

Warning

Sections marked by this symbol explain dangers that might result in personal injury or death. Always read the associated information carefully, before performing the indicated procedure.

Attention

Paragraphs preceded by this symbol explain hazards that could damage the instrument and the connected equipment or may cause loss of data.

Note

This manual also contains "NOTES" and "HINTS" written in this form.

Please read this advice carefully!

1 General Information

The MIR Laser System is comprised of a compact laser system controller (laser diode current diode and temperature controller) with a USB 2.0 interface and a laser head.

Key features of the MIR Laser System are:

- Turn-key system for operating QCL and ICL lasers
- Control unit MLSC is compatible with any laser head
- Calibrated optical power
- Calibrated output spectrum (DFB only), selectable as either wavenumber or wavelength values
- Choose output spectrum units of either wavenumbers (cm^{-1}) or wavelength (nm)
- Collimated output beam
- Air-cooled laser head supports QCL/ICL devices with up to 24 W power dissipation (96 W total thermal dissipation)
- MLSC controller automatically identifies the type of the connected laser head and adjusts for maximum efficiency
- External (DC to 100 kHz) and internal (10 Hz to 100 kHz) modulation capability
- Separate modulation input for precision tuning over an absorption line
- Low laser output noise
- Interlock for automatic switch off by an external emergency switch or by a cable interruption
- Output Shutter
- Integrated internal temperature safety monitoring
- Laser head: user-adjustable front leg height for vertical pointing alignment
- Touch panel for easy operation
- USB interface for remote operation supporting the USB TMC protocol
- SCPI compliant command set
- VXIpnp Instrument Drivers for various programming environments including NI-LabVIEW®, NI-LabWindows/CVI and MS-Visual Studio

The MLSC controller is compatible with both QCL and ICL type laser heads.

1.1 Safety

Attention

All statements regarding safety of operation and technical data in this instruction manual will only apply when the unit is operated correctly as it was designed for.

Prior to applying power to the MIR Laser System, make sure that the protective conductor of the 3 conductor mains power cord is correctly connected to the protective earth ground contact of the mains power socket outlet! Improper grounding can cause electric shock with damages to your health or even death!

The MIR Laser System must not be operated in explosion endangered environments!

Do not remove covers! Do not obstruct the air ventilation slots in the housing!

Refer servicing to qualified personnel!

Only with written consent from Thorlabs may changes to single components be made or components not supplied by Thorlabs be used.

This precision device is only serviceable if properly packed into the complete original packaging. If necessary, ask for a replacement package prior to return.

Follow the common recommendations for handling of ESD sensitive devices when operating the MIR Laser System.

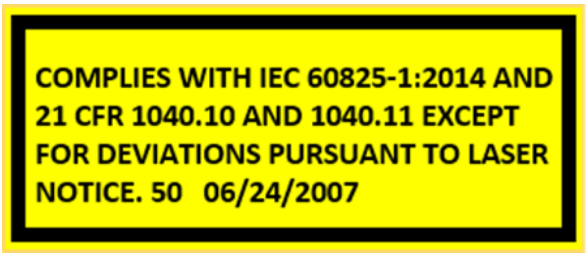
Warning

The MIR Laser System emits high-power and invisible optical radiation that is hazardous to eyes, skin, and other living tissue.

Never look into the emitting aperture. Protect against exposure to reflected beams, which can also cause significant injury. Always wear the appropriate laser safety eyewear and observe the necessary safety procedures when operating the laser system.

The MIR Laser System is a Class 3B or Class 4 Laser Product, depending of the type of the laser head. Please contact Thorlabs regarding requests for lasers with power over 500 mW.

The MIR Laser System complies with the following safety standards:



Attention

The following statement applies to the products covered in this manual, unless otherwise specified herein.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules and meets all requirements of the Canadian Interference-Causing Equipment Standard ICES-003 for digital apparatus. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Thorlabs is not responsible for any radio television interference caused by modifications of this equipment or the substitution or attachment of connecting cables and equipment other than those specified by Thorlabs. The correction of interference caused by such unauthorized modification, substitution or attachment will be the responsibility of the user.

The use of shielded I/O cables is required when connecting this equipment to any and all optional peripheral or host devices. Failure to do so may violate FCC and ICES rules.

Attention

Mobile telephones, cellular phones or other radio transmitters are not to be used within the range of three meters of this unit since the electromagnetic field intensity may then exceed the maximum allowed disturbance values according to EN 61326-1.

This product has been tested and found to comply with the limits according to EN 61326-1 for using connection cables shorter than 3 meters (9.8 feet).

1.2 Ordering Codes and Accessories

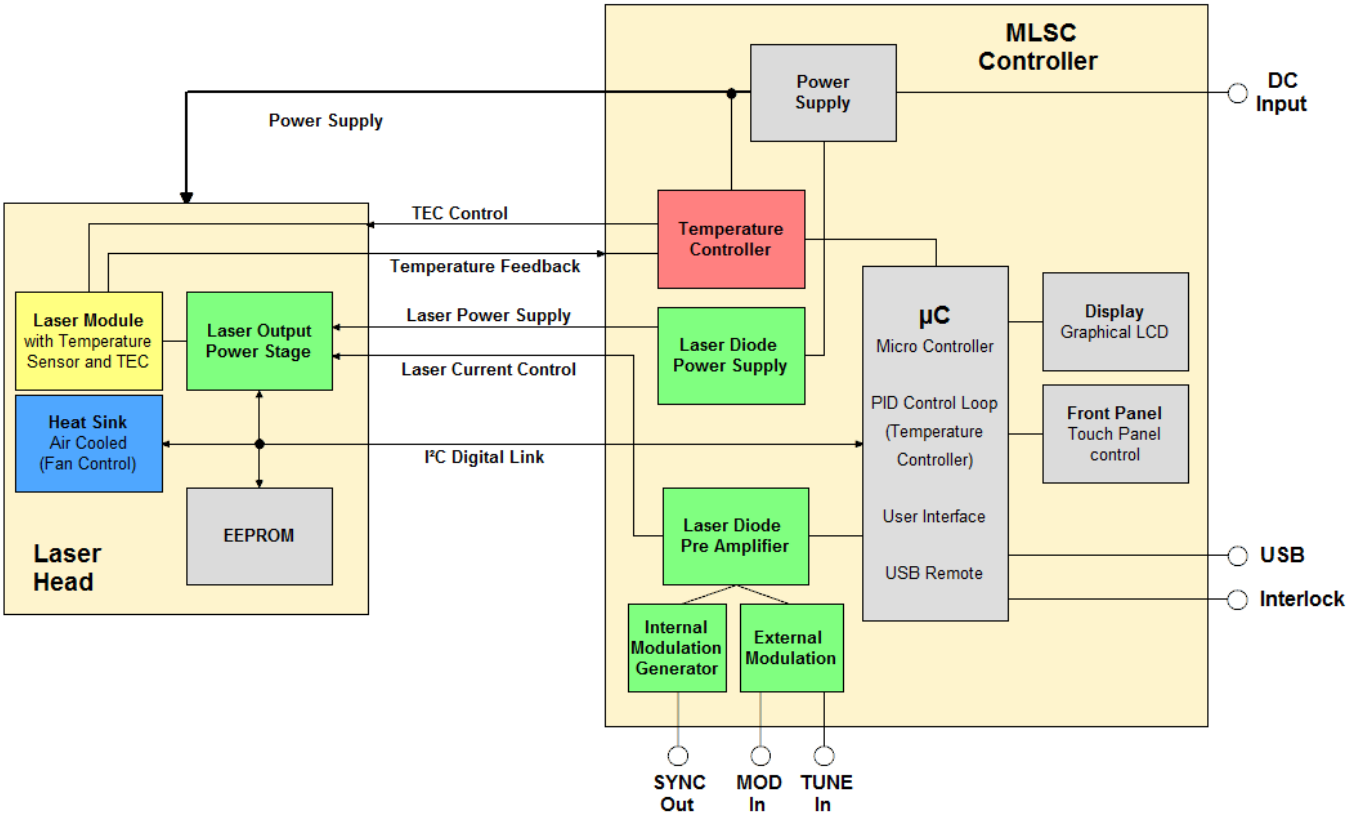
Note

For parts included in the delivery please see section Parts List. Please see also Thorlabs website for services, spare parts and available accessories.

2 Operating Principle

The MIR Laser System is comprised of the MLSC Controller, the Laser Head (DFB or Fabry Perot QCL), a desktop power supply and a cable to connect the laser head to the controller.

This section is intended to explain in brief how the MLSC controller and the laser head work, and how they interact each with other.



Block Diagram of the MIR Laser System

Laser Head

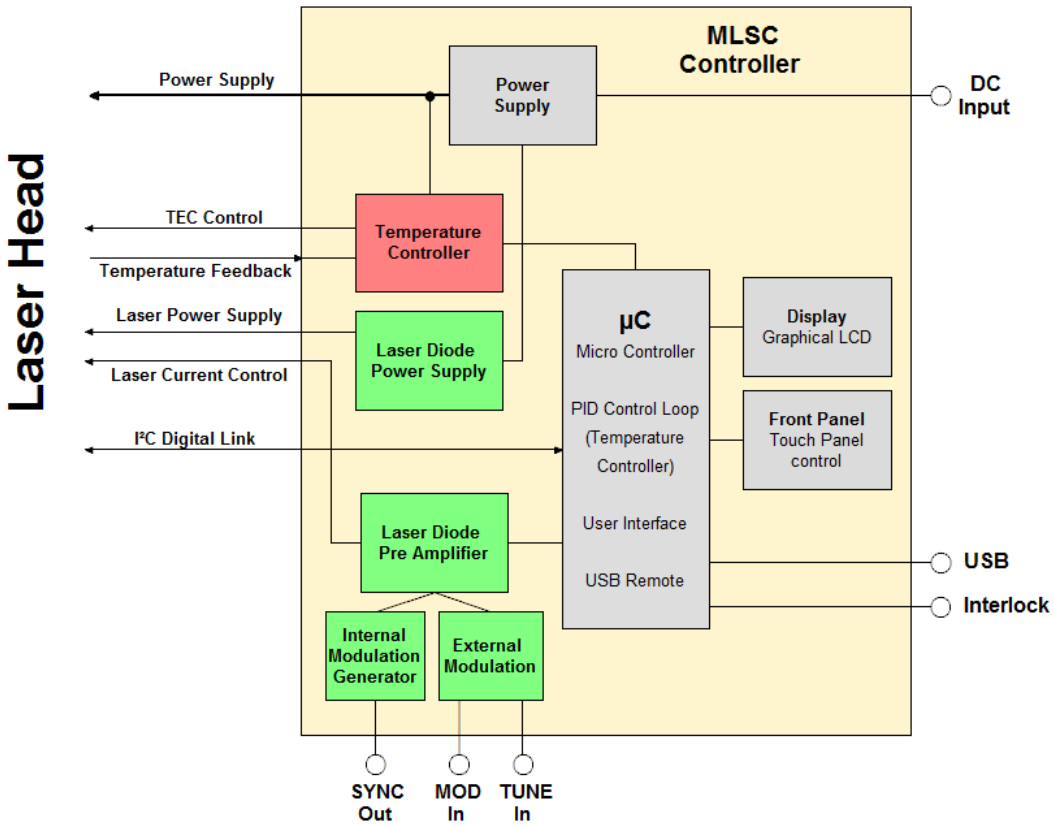
The laser head is comprised of the **Laser Module,** an air-cooled **Heat Sink**, the **Laser Output Power Stage** and a control circuit with an **EEPROM** where laser-specific parameters are saved.

The HHL **Laser Module** package combines the laser chip, a temperature sensor (NTC thermistor) and a TEC element for active temperature control. The TEC is mounted to an **air-cooled heat sink**. Power is dissipated from the laser to the heat sink where it is rejected by forced convection.

The **Laser Output Power Stage** is powered by the MLSC controller, whereas the laser current is controlled by a voltage signal out of the MLSC.

In the **EEPROM** are stored individual laser parameters, such as laser type, serial number, maximum current limit, four memory set-points, most recent settings and the calibration table. The calibration table allows the user to directly set the laser optical output, either power (FP and DFB) or output optical spectrum (DFB only) by automatically adjusting the laser head operating parameters (laser current and temperature).

A control circuit provides the digital communication between the components of the laser head and the MLSC controller via an I²C interface, so for example the laser output current, the heat sink temperature, the EEPROM information etc.



Block Diagram of the MLSC Controller

MLSC Controller

The controller is powered by a wide range switching power supply. All controls are provided via a touch-sensitive LC display and the micro controller.

The **Temperature Controller** regulates the temperature the laser module and incorporates the temperature measurement (NTC feedback signal from the laser module) and the TEC current controller. The measured temperature is compared by the micro controller with the temperature set value. The µC provides the closed loop control with fixed PID values so that the temperature control is optimized for fastest settling time without overshoots.

The **Laser Diode Power Supply** delivers a maximum current of 1.2 A to the laser output stage in the laser head. The LD output stage in the laser head generates a laser current that depends on the control voltage out of the **Laser Diode Pre-Amplifier**. This control voltage summarizes the laser current setpoint (micro controller) and the modulation.

The modulation can be either internal (**Internal Modulation Generator**) or external. The **External Modulation** has two inputs - an AC coupled **MOD In** and a DC input **TUNE In** for fine tuning the laser current.

The **Micro Controller** is the heart of the MLSC. It communicates with all electronic modules in the MLSC and via the I²C interface with the laser head, controls the display and retrieves commands from the LCD touch panel. The MLSC can be controlled remotely via a USB 2.0 interface.

3 Operation

3.1 Parts List

Inspect the shipping container for damage.

If the shipping container seems to be damaged, keep it until you have inspected the contents and you have inspected the product mechanically and electrically.

Verify that you have received the following items within the package:

MIR Turnkey Laser System

1 Laser Head (e.g. QF4550LH containing FP-QCL Laser)
1 MLSC MIR Laser System Controller
1 Compact wide range power supply (PSU-30DC) (AC 100-240 V to DC 30 V / 6.0 A; not for Laser Heads, connects directly to Controller)
1 Power cord for power supply (not for Laser Heads)
1 CAB-MLSC Cable, connects Laser Head to MLSC Controller
1 USB 2.0 A to Mini B cable, 1.5 meters
1 Bag with interlock jumper, keys for the lock switch, VRC6S detector card and Quick Reference guide
3 Clamping forks for mounting of the Laser Head to an optical table

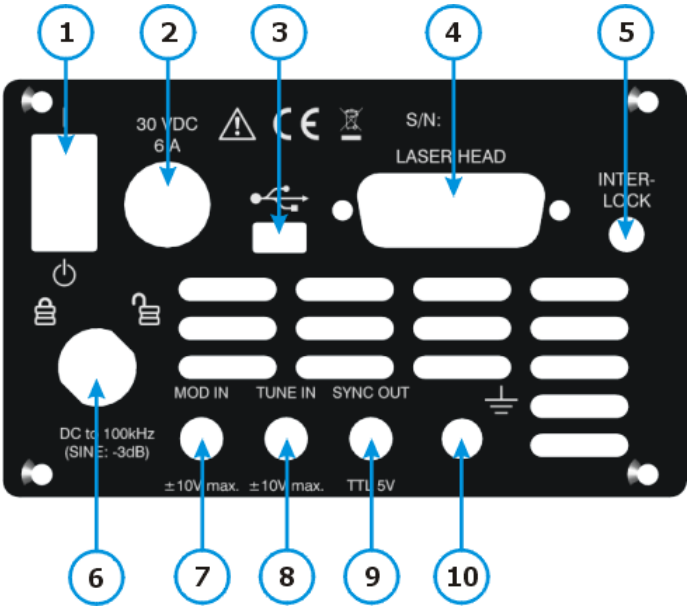
Please visit our website for available configurations of the MIR Turnkey Laser System. different configurations of the MIR Turnkey Laser System.

3.2 Operating Elements MLSC

Front panel

The compact laser driver MLSC has a touch-sensitive LCD front panel. The controls are intuitive, for detailed explanations please see subsequent chapters.

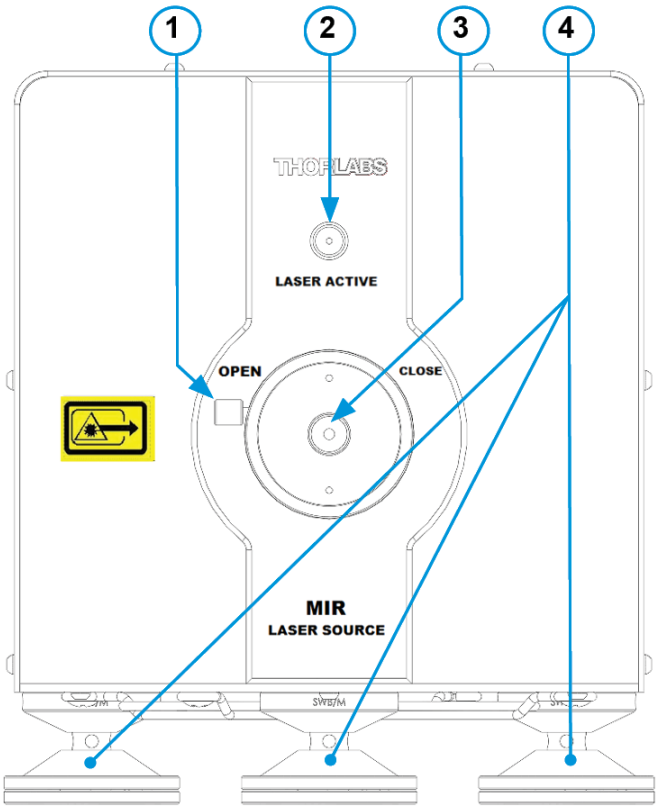
Rear panel



1 Power Switch
2 DC Power Supply Input
3 USB 2.0 Interface
4 Laser Head Connector
5 Interlock Connector
6 Locking Key
7 Modulation Input (SMA)
8 Tuning Input (SMA)
9 Mod Sync Output (SMA)
10 Ground jack

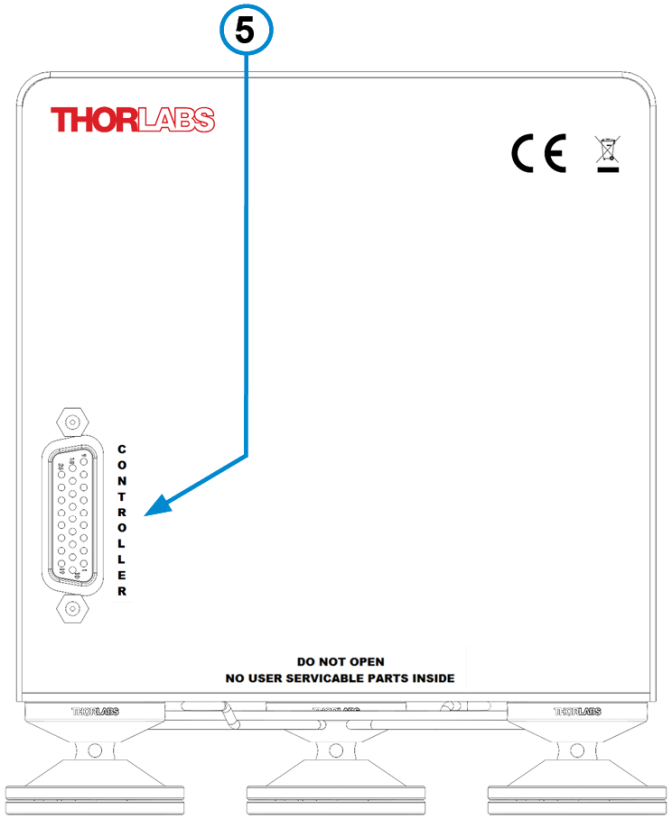
3.3 Operating Elements Laser Head

Front panel



1 Shutter Handle
2 Laser Status LED
3 Laser Aperture with Shutter
4 Articulated Mounting Base SWB/M

Rear panel



5 Connector To MLSC

3.4 Safety and Protection Features

The MLSC console incorporates a number of safety and protection features in order to prevent damage to the laser diode and to protect the user.

Key lock switch

The key switch disables the laser current output. This feature complies with the Center for Devices and Radiological Health (CDRH) requirements and prevents unauthorized usage of the laser driver.

Interlock

The interlock function provides several protection functions simultaneously.

- Safety lock to prevent unintentional use
- An external emergency-stop switch may be connected
- To connect your external automatic protection equipment, e.g. for temperature monitoring

The laser will operate only with the interlock input shortened. Please refer to section Laser Protection for details.

Soft start

The soft start function protects the laser diode against undesired peaks during the laser switch-on process.

Switch-On Delay

As required by Laser Safety Regulations, laser products of Class 3B and 4 are required to have a delay between switching on the laser and emitting radiation. The MIR Laser System has a delay of min. 3 s, and it can be extended to up to 60 sec.

Laser current limit (hardware limit)

The maximum laser current can be adjusted by the laser current limit, that can be set in the Laser Driver Setup menu.

Temperature window protection of the laser diode

This feature protects the laser diode from unwanted operating temperatures in combination with the integrated TEC controller: Defining a temperature window around the laser temperature set-point, the laser can be paused or permanently switched off, if the actual temperature is outside of that window.
Please see TEC Driver setup and Laser Protection sections for details.

Over-temperature protection

The MLSC console has an automatic over-temperature protection. If the allowed internal operating temperature should be exceeded, the outputs will be switched off. After a temperature drop of 10 °C, the outputs of the MLSC console can be switched on again.

Defined states after switch-on

After turning on the MIR Laser System, the laser and TEC output are by default switched off. The setup allows the TEC output to be switched on when starting the device.

Line failure monitoring

In case of line failure / line interruption the MIR Laser System will restart anew, as if it has been turned on with most recent power-on settings.

3.5 Getting Started

Warning

Laser emission can cause serious eye damage: never look directly into the emitting aperture. Reflected laser light can also be hazardous. Always wear the appropriate laser goggles, manage beam reflections, and observe the safety instructions supplied with the laser. Use the shutter to block laser emission.

Laser Head

1. The front panel LED indicates the laser operational status. When the laser is turned on from the controller the LED will blink twice to indicate the system is in process of enabling the laser. When the LED illuminates continuously, the laser is being emitted at the user defined power level.
2. The articulated (swivel) feet can be adjusted by loosening the lock nut with a hex key inserted into the locking nut while using a hex key to hold the base stationary. A hex key can also loosen or tighten the feet by turning the hex nut located on the bottom of the feet. See the Thorlabs website, part number **SWB/M** for additional details and available accessories.

Note

Some screen shots in this document are taken from a MLQD9550 MIR Laser System using a 9.55 µm DFB-QCL laser module. This is not a standard product but custom units are available upon request. Please contact Thorlabs for more information.

1. Connect the laser head to the 26 pin D-Sub connector (4) using the supplied special cable and tighten the fixing screws.

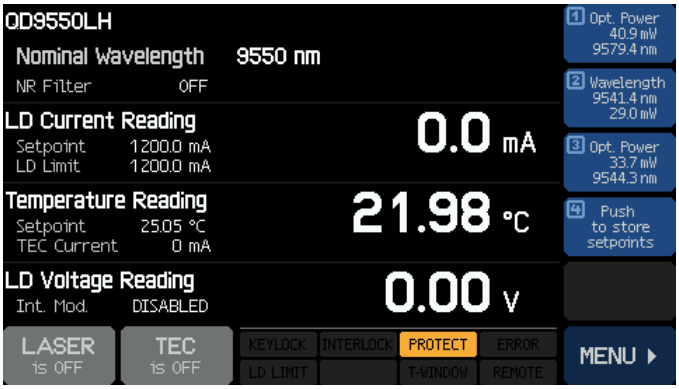
   Attention

   The cable **must not** be disconnected or connected while the MLSC is switched on! The components of the MIR Laser System are not Hot Swap capable!
2. Ensure that the interlock jumper or an external emergency switch is installed to the INTERLOCK connector (5), see section Interlock for details.
3. Insert the key into the lock (6). For normal operation turn the key clockwise enabling the laser current output. In this position, the key cannot be removed.
4. Connect the power supply to the DC input (2) and switch the MIR Laser System on (1).
5. The MLSC console turns on and the boot screen appears breifly, displaying basic system information.

MLSC Boot Screen

During the boot process, a variety of hardware and software self tests are conducted. If any of these tests fail, an appropriate error message will be displayed in the boot screen. Please note this error message and contact Thorlabs Tech Support.

5. After a successful power-up, the standard ("HOME") operation panel is displayed.



DFB Standard Operation (HOME) Panel

FP Standard Operation (HOME) Panel

Note

The information displayed in the HOME panel parameters is specific to detected laser head and to the most recent operation state. Above pictures are taken from a system with factory default state of operation.

The PROTECT message indicates that the laser protection is enabled and the laser is either switched off or paused due to exceeding the given temperature window.
If the Laser Current output is locked, KEYLOCK illuminates. If the interlock is open, INTERLOCK illuminates.

Note

In factory default state, the Noise reduction (NR) filter is disabled. This allows the laser emission to be modulated at any frequency within modulation frequency range, but with the trade-off that the noise level in the output signal is approximately two times higher than when the NR filter is enabled. For low-noise operation, turn the NR filter on. It will limit the modulation frequency range, depending on the shape of the modulation signal.

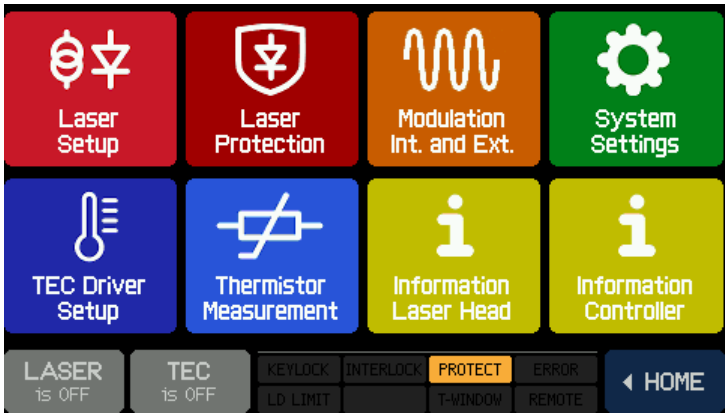
4 Operating Instruction

The MIR Laser System starts up showing the last used configuration. The factory default is the HOME panel, with interpolation disabled.

DFB Laser Head - Interpolation OFF

FP Laser Head - Interpolation OFF

Prior to switching on the TEC and Laser output, configure the MIR Laser System according to your laser head specification. The following sections explain these settings in detail. All setting menus are available via the MENU button in the lower right corner of the HOME screen.



Main Menu

All menu items, except the "Thermistor Measurement" and "Information" menus, have a side bar that allows a menu item to be selected and edited.

:

Menu Sidebar

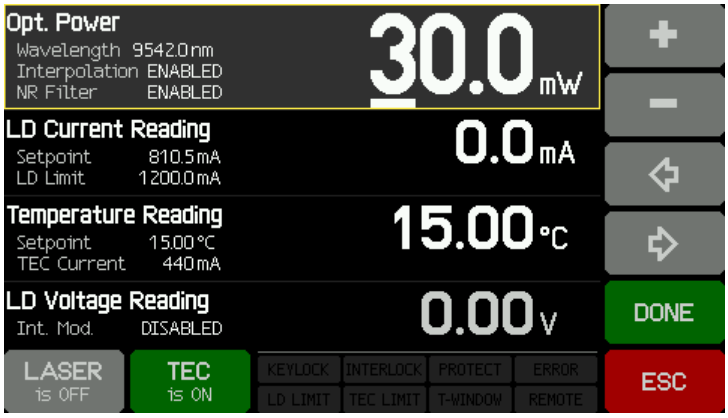
Select menu topic up

Select menu topic down

Edit menu topic (change value)
(alternatively, push the highlighted topic a 2nd time)

Exit and return to Main Menu

The operation via the touch panel is simple and intuitive. In the center of the HOME display, the actual readings are displayed. The main parameters are shown in large characters this way providing a good visibility even from some distance.



The settings can easily be changed - touch the desired parameter or value and the mode changes from read-only to set values.

Edit the set-point values using the + − buttons. Use the ◁ ▷ buttons to select the decimal place to be edited.

Tap DONE to save the settings or ESC to discard the changes.

Touching a not editable parameter results in an appropriate warning message in the display.

Edit sidebar

Increase value

Decrease value

Shift cursor left

Shift cursor right

Save changes

Discard changes

Note

The appearance of the sidebar may vary, depending on the selected menu item.

Switch on the temperature controller by pushing the TEC button. During the settling time of the TEC, the upper box of the display starts to blink (only if power or wavelength interpolation is enabled, see section Interpolation Modes) until the temperature falls within the given temperature window.

Switch on the laser by pushing the LASER button. The button changes to , the controller starts to beep, and the green LED on the front of the laser head simultaneously begins to blink. After a minimum switch-on delay of 3 s, which can be increased in the Laser Protection panel, the laser is activated and emits radiation. This switch-on delay safety feature is mandatory for Class 3B and Class 4 Laser Products.

Warning

The MIR Laser System emits invisible laser radiation at high power levels. This laser emission is dangerous dangerous to eyes and skin. Even reflected laser light may be hazardous.

Do not look into the emitting aperture. Always wear the appropriate laser goggles, and observe all applicable safety instructions.

Depending on type of the laser head, the MIR Laser System is either a Class 3B or Class 4 laser product.

4.1 Interpolation Modes

The MIR Laser System offers interpolation modes that allow the user to directly set the desired optical output, depending on the type of the laser head connected to the MLSC console. See the section Laser Setup to select the interpolation mode.

- For FP laser heads, power interpolation is available to set the output power in mW.
- For DFB laser heads, the user can select either power interpolation mode or output spectrum interpolation mode. Output spectrum interpolation is available as wavenumbers (cm^{-1}) or wavelength (nm) based on the options chosen in System Settings.

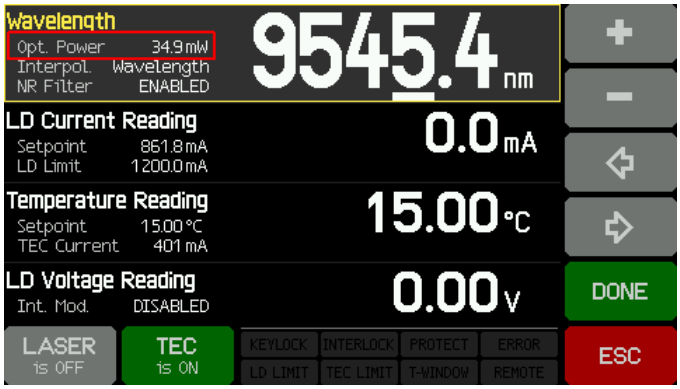
When operating in interpolation mode, the MLSC console will adjust the laser temperature and current to reach the interpolation value set by the user. The calibration table is set at the factory stored in the laser head and is not adjustable.

4.1.1 DFB Laser

Interpolation OFF

The factory default interpolation mode "OFF". The panel displays the nominal spectrum. Laser current and temperature can be set.

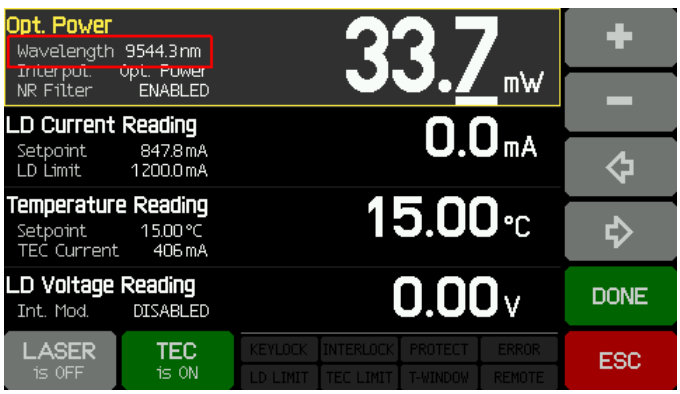
Note: When changing current and temperature, changes in power and spectrum are not reflected in the display!



Interpolation Mode: Wavelength

In Spectrum Interpolation mode, the wavelength or wavenumber is set by the user. The values of laser current and temperature are set, based on values stored in a calibration table, to maintain operation at the desired spectral output.

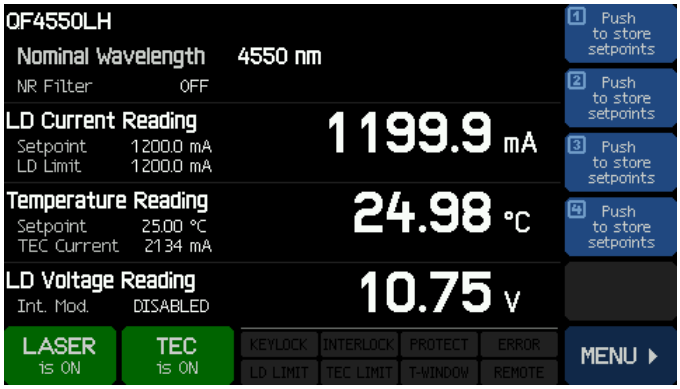
The optical power is displayed to the left of the wavelength or wavenumber value.



Interpolation Mode: Power

In Optical Power Interpolation mode, the value of the optical power is set by the user. The values of laser current and temperature are set, based on values stored in a calibration table, to maintain operation at the desired optical power. The wavelength or wavenumber are displayed to the left of the optical power.

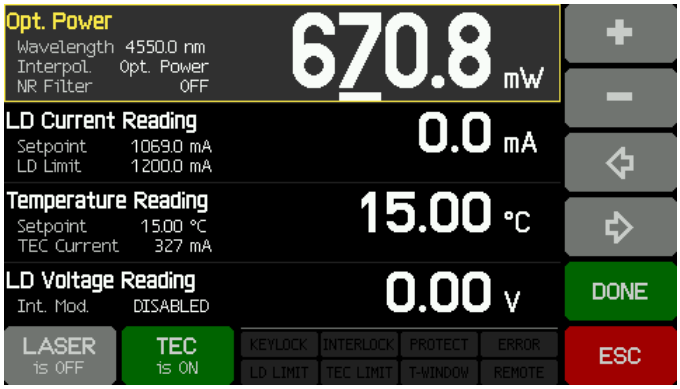
4.1.2 FP Laser Head



Interpolation OFF

The factory default interpolation mode is "OFF". The panel displays the nominal wavelength. Laser current and temperature can be set.

Note: When changing current and temperature, the change of power is not reflected in the display!



Interpolation Mode: Power

In Optical Power Interpolation mode, the value of the optical power is set by the user. The values of laser current and temperature are set, based on the values stored in a calibration table, to maintain operation at the desired optical power.

4.2 Setpoint Memories

Up to 4 setpoints can be stored. A setpoint contains information on the interpolation mode and depending on the laser type (DFB or FP laser head) the information of optical power and /or spectral output. Alternatively, values for laser current and laser temperature can be saved.

To create a setpoint, simply touch the setpoint memory icon and hold for about 3 seconds. A beep, accompanied by the message "Set points stored" will confirm the setpoint has been saved.
The setpoints are stored to the laser head's memory and remain available unless cleared.

Note

In case the memory is not empty, new setpoint data will overwrite setpoint data stored in memory.

A setpoint can be retrieved by a short touch of the icon. The retrieved settings will immediately take effect. If the memory data are related to a different interpolation mode, the laser must be switched off before the MLSC can load the setpoint. If the laser is on, an appropriate warning message appears.

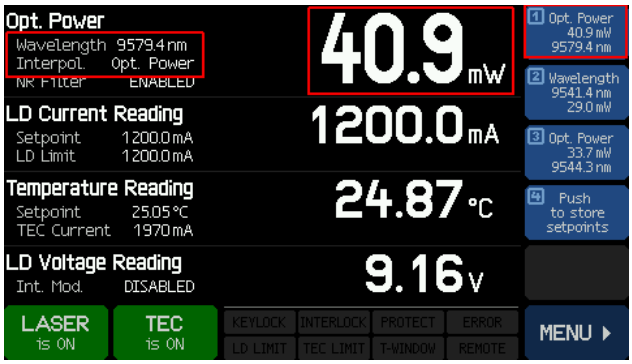
Single setpoint memories can not be deleted. All setpoint memories can be deleted entirely by selecting the **Clear Memories** button in the Information Laser Head and Information Controller panels.

4.2.1 DFB Laser

A setpoint stored in memory can only be retrieved when the laser is switched off. If the interpolation mode of the MIR Laser System was set to NONE, it automatically changes to Power or Wavelength interpolation when a setpoint button is pressed, depending on the setpoint "content". And vice versa, if an interpolation mode was active, and recalling a setpoint that was saved with no interpolation, the recent interpolation mode will be switched off.

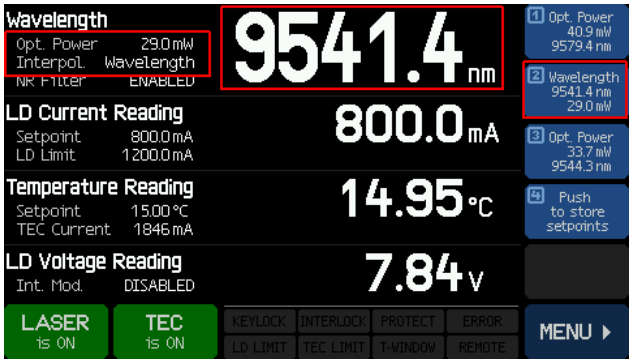
The data are read out from the laser head's memory and are applied.

For a setpoint "Optical power", the power value (large numbers) and the resulting wavelength (to the left of the power) are displayed:



Setpoint "Optical Power" retrieved

For a setpoint "Wavelength", the wavelength value (large numbers) and the resulting optical power (to the left of the wavelength) are displayed.



Setpoint "Wavelength" retrieved

Note

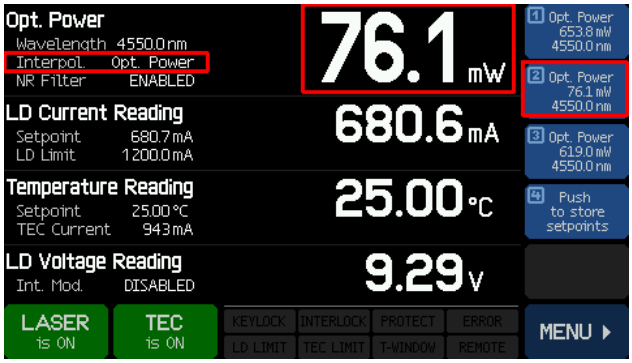
The MIR Laser System saves the last settings (current, temperature and interpolation mode) to the memory of the laser head at any time. These settings are applied automatically when the MIR Laser System is switched on again.

This is the case also after retrieving a setpoint memory - their values remain in force

- after switching off and on again
- after changing the interpolation mode back to "NONE".

4.2.2 FP Laser

A setpoint stored in memory can only be retrieved when the laser is switched off. If the interpolation mode of the MIR Laser System was set to NONE, it automatically changes to Power interpolation when a setpoint is recalled that was saved with Power Interpolation. And vice versa, if Power interpolation was active, and recalling a setpoint that was saved with no interpolation, the Power interpolation mode will be switched off. The data are read out from the laser head's memory and are applied; the setpoint optical power is displayed:



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The MIR Laser System saves the last settings (current, temperature and interpolation mode) to the memory of the laser head at any time. These settings are applied automatically when the MIR Laser System is switched on again.

This is the case also after retrieving a setpoint memory - the values remain in force

- after switching off and on again
- after changing the interpolation mode back to "NONE".

4.3 Main Panel Status Messages

Indicator	System Message	Solution / Explanation
KEYLOCK	LD current output is locked	Turn locking key (7) on the rear panel to "enable" position
INTERLOCK	Interlock circuit is open	Close interlock circuit, e.g. by installing the jumper (5)
PROTECT PROTECT	Laser Protection active	Laser **Paused** or **Switched Off** due to exceeding the given temperature window. Make sure the TEC controller is ON.
LD LIMIT	Laser Current Limit reached	The laser current set value reached the limit.
TEC LIMIT	TEC Current Limit reached	May appear for a short time after switching the TEC on.
T-WINDOW	Actual temperature exceeded window.	Switch on TEC.

4.4 Main Panel Error Messages

Error messages are displayed as text pop-ups in the lower part of the display replacing the status messages and are displayed for 7 seconds. Typical error messages are:

The instrument is overheated.

The temperature inside of the enclosure exceeded the maximum allowed. Laser current and TEC switched off. Switch off the instrument and let it cool down.

Outputs switched off. Laser failure detected.

A failure in the laser head was detected. TEC and laser current are switched off. Check the laser connections and laser head fixturing. If the error persists, please contact Thorlabs.

Laser output can't switch on while interlock is open.

The interlock circuit was found interrupted when trying to switch on the laser current. Check the interlock connector (5) for properly installed jumper or, if applicable, the external interlock circuit.

Laser output can't switch on while key switch is in locked position.

Insert the key (7) and turn it to the UNLOCK position.

Laser output switched off. Voltage protection was tripped.

Possible reasons are a interruption of the laser current (connection of the laser) or a too-high forward voltage of the installed laser. The forward voltage of the installed laser must not exceed the specified "Compliance Voltage" of your MLSC console.

Laser output switched off due to temperature protection.

The laser temperature exceeded the given temperature window. Possible reasons are:

- TEC settings: If the TEC current is at its limit as well, increase the limit. Check the set temperature.
- Temperature window is set too small.

Output switched off due to a temperature sensor failure.

In order to prevent damage to the laser as a result of overheating, the MIR Laser System switches off if the temperature sensor fails.

The laser is overheated.

The High-Heat load (HHL) laser package is overheated, the MLSC console switches off the laser current.

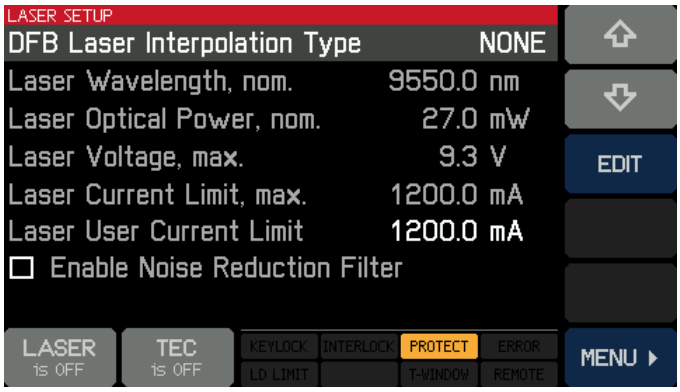
The laser head is overheated.

The laser head is overheated. As a consequence, the MLSC console switched off the laser current.

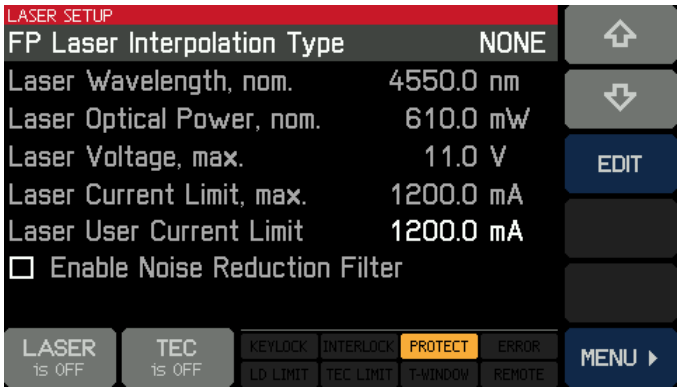
Output switched off due to a laser head supply failure.

A failure of the laser head power supply was detected. As a consequence, the MLSC console switched off the laser current.

4.5 Laser Setup



Laser Driver Setup - QCL-DFB Laser Head



Laser Driver Setup - QCL-FP Laser head

Seven items are displayed, and four of them show values that are read out from the laser head and not editable:

- Laser Wavelength or Wavenumber, nominal
- Laser Optical Power, nominal
- Laser maximum forward voltage
- Laser maximum current limit.

Use the arrow buttons to select an editable parameter, then push EDIT button, or push the selected topic a second time.

- **DFB Laser Interpolation Type** Possible selections are:
  NONE No interpolation - the nominal wavelength and optical power are used.

  WAVELEN The wavelength/wavenumber can be changed, the optical power changes accordingly.

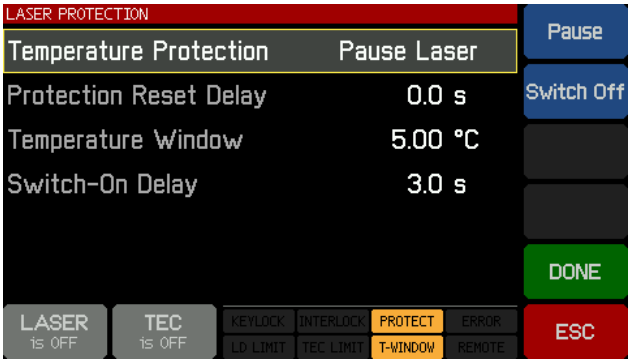
  POWER The optical power can be changed, the wavelength/wavenumber changes accordingly.

- **FP Laser Interpolation Type** Possible selections are:
  NONE No interpolation - the nominal optical power is used.

  POWER The optical power can be changed.

- **Laser User Current Limit**: Set the current limit below the **Laser Maximum Current Limit** to protect the laser diode.
- **Noise reduction filter**: Enabling this filter reduces the output current noise by a factor of approximately 2, but significantly reduces the modulation bandwidth range. For more information, see Specifications. The filter can be enabled / disabled only with the laser switched off.

4.6 Laser Protection

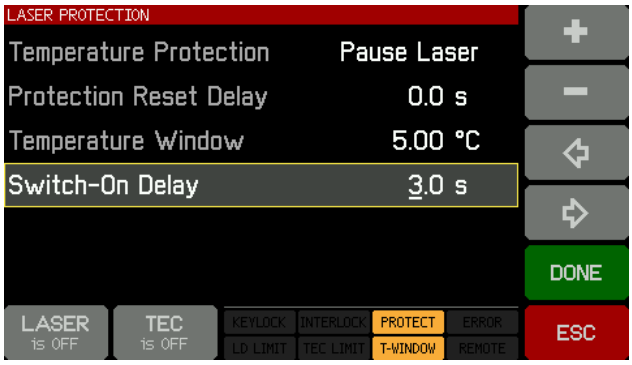


Use the arrow buttons to select a parameter, then push the EDIT button, or push the selected topic a second time.

- **Temperature protection**: Select the system response to the laser temperatures outside of the desired operating temperature range ("Temperature window").
The temperature window is the range above and below the laser Temperature Set Point. Available actions are:

1. Pause - the laser current is switched off and automatically switches on again, when the temperature is back within the given range. The return of the laser to operation can be delayed additionally (see *Protection Reset Delay* below).
2. Switch off - the laser current is switched off when the temperature window is exceeded. After the temperature returns to the allowed range, the laser can be switched on manually only.

- **Protection Reset Delay**: The return to operation can be delayed for up to 600 s.
- **Temperature Window**: Defines the allowed operating temperature range to ($T_{set} \pm T_{win}$).
- **Switch-On Delay**

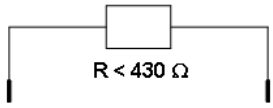


As required by Laser Safety Regulations, laser products of Class 3B and 4 are required to have a delay between switching on the laser and emitting radiation. The MIR Laser System has a has a minimum delay of 3 s and can be extended to 60 s.

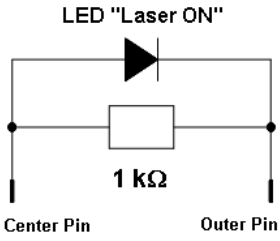
Select this menu item and select EDIT to extend the Switch-On Delay.

- **Interlock**

Another safety feature is the hardware interlock, accessible via the I-LOCK connector (5) on the rear panel. A short circuit jumper is attached to the plastic bag with the switch keys and can be installed to the jack.
The interlock interface represents a current source (~16 mA when laser is switched on), where the voltage across the external circuit is observed. As soon as this voltage rises above a certain threshold (~ 2.5 V), the external circuit is considered "open" and the laser current output is disabled.



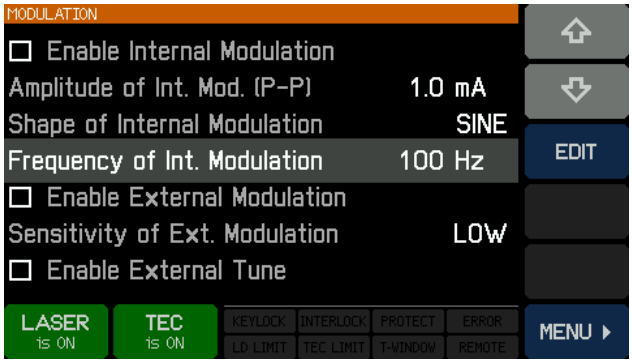
Instead of the jumper, an external emergency switch (opener) can be connected to the interlock, as well as an external circuit (total resistance < 430 Ω) or by a LED (anode to center pin, cathode to outer pin, connect in parallel resistor R=1 k) alerting that the laser is switched on.



Note

Do not use a blue LED due to their high forward voltage.

4.7 Modulation



Use the arrow buttons to select a parameter, then push the EDIT button, or push the selected topic a second time.

- **Enable Internal Modulation**: Tap the EDIT button to enable or disable the internal amplitude modulation of the laser current. See section Internal Modulation for details.
- **Enable External Modulation**: Tap the EDIT button to enable or disable the external amplitude modulation of the laser current.
- **Sensitivity of External Modulation**: This is the modulation coefficient - two ranges are available: HIGH and LOW. Tap the EDIT button to select HIGH or LOW.
  See section External Modulation for details.
- **Enable External Tune**: Tap the EDIT button to enable or disable the external fine tuning input.

4.7.1 Internal Modulation

- **Amplitude of Internal Modulation**: The amplitude of the internal modulation current (peak-to-peak) can be adjusted between 0 and a maximum value equal to the Laser User Current Limit.
- **Shape of Internal Modulation**: Three shapes are available - sine, triangle and square.
- **Frequency of Internal Modulation**: Can be selected between 10 Hz and 100 kHz (for sine signal). For triangular and square waveforms the upper limit is lower, because such signals contain harmonics of their original frequency. The limitation impacts not only the modulation amplitude, but also the shape of the signal. The table below states the maximum modulation frequency for a sine signal and for triangular and square modulation. With the Noise Reduction filter (Low-Pass filter) switched on, the maximum modulation frequency is lowered depending on the modulation waveform. The following table lists the internal modulation frequency setting range with respect to waveform and Noise Reduction Filter state:

Waveform	Internal Modulation Frequency Setting Range	
	NR Filter OFF	NR Filter ON
Sine	10 Hz to 100 kHz	10 Hz to 1 kHz
Triangle	10 Hz to 10 kHz	10 Hz to 300 Hz
Square	10 Hz to 10 kHz	10 Hz to 300 Hz

The criteria for the maximum modulation frequencies are:

- Sine; NR filter OFF: At modulation frequencies ≤ 30 kHz, the modulation current amplitude remains within ±5 % of the user-set value. Beyond 30 kHz, this tolerance worsens, up to a max. of 3 dB. A warning displays when 30 kHz is exceeded.
- Triangle / Square: Waveform deformation.

Attention

Avoid clipping of the modulated laser current - this leads to distortions of the modulated signal. In order to prevent this, be careful when adjusting modulation, laser current setpoint, and laser user current limit. Please see detailed explanations in the appendix.

- **SYNC OUT** provides the synchronization signal from the internal modulation generator as a TTL signal. Its rising edge appears when the internal modulation increases beyond the zero line.

Note

The modulated laser current is delayed with respect to the SYNC OUT signal by approximately 3 µs when the Noise Reduction filter is OFF and approximately 30 µs when the Noise Reduction filter is ON.

4.7.2 External Modulation

To generate a time dependent laser diode injection current "ILD", this current can be modulated via an independent ground-symmetric, DC coupled modulation input "MOD IN". Its input resistance is >10 kΩ, the maximum input voltage range reaches from -10 V to +10 V. The current generated by the external modulation current is superposed to the laser current setpoint ILD SET.

The relation between the externally applied modulation voltage and the resulting laser current is described by the modulation coefficient $\boldsymbol{m}$.

The MIR Laser System maximum output current is 1.2 A. The maximum external modulation voltage (-10 V or +10 V) is related to 1.2 A.
The modulation coefficient is $\boldsymbol{m}$ = 1.2 A / 10V = 120 mA/V.

Further, the sensitivity of the external modulation input can be selected to HIGH or LOW. The LOW sensitivity corresponds to 1/10 (10%) of the HIGH sensitivity:

$\boldsymbol{m}_{HIGH}$ = 1.2 A / 10V = 120 mA/V
$\boldsymbol{m}_{LOW}$ = 12 mA/V

The modulated laser current "ILD" is calculated as ILD = ILD SET + UMOD * $\boldsymbol{m}$

Note

Clipping of the modulated laser current leads to distortions of the modulated signal. In order to prevent this, be careful when adjusting modulation, laser current setpoint, and laser user current limit. Detailed explanations please see in the appendix.

Note

Please be aware of the fact that changing the DFB laser current setpoint impacts not only the optical output power, but also the wavelength.

Connect the modulation source to the jack "MOD IN" (7). Avoid ground loops when connecting the function generator.

If the injection current "ILD" reaches the current limit "ILIM" in operation, the status message LD LIMIT lights up and the laser current is limited to the value of the current limit "ILIM". In this case, ripple and noise do no longer correspond to the specifications for normal operation. However the set maximum current "ILIM" cannot be exceeded.

Modulation waveform and maximum modulation frequency

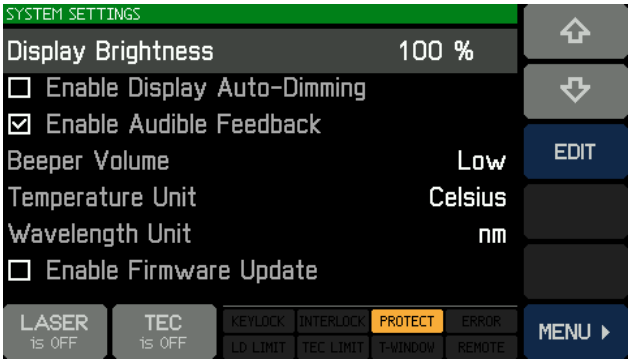
Please see Technical Data for the external laser diode current modulation bandwidth. The criteria for the maximum modulation frequencies are:

- Sine; NR filter OFF: For modulation frequencies ≤30 kHz the modulation amplitude variation is within ±5 %. Frequencies >30 kHz, up to a maximum of 100 kHz, can be set.
- Triangle / Square: Waveform deformation.

4.7.3 External Tune

The external fine tuning input at the rear panel is a SMA DC input (range: -10 to +10 V) that allows to fine tune the laser current for a maximum of ±5 % of the maximum output current, i.e. for ±60 mA.
The tuning coefficient is 6 mA/V.

4.8 System Settings

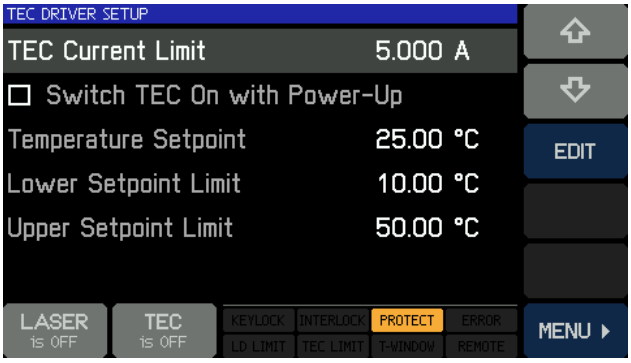


Use the arrow buttons to select a parameter, then push the EDIT button, or push the selected topic a second time.

- **Display Brightness** can be set between 20% and 100%
- **Auto Dimming**: When enabled, the display will dim after 30 s of non-use. Touching the panel will cause it to brighten again.

- **Audible feedback**: A click sound confirming touch panel operation.
- **Beeper Volume**: Volume of the alert sound.
- **Temperature Unit**: The temperature can be displayed in °C, °F and K (Kelvin).
- **Wavelength Unit** can be selected as nm (wavelength) or cm^{-1} (wavenumbers)
- **Enable Firmware Update**: If enabled, the MLSC console responds as a DFU device to an external control PC (see Firmware Upgrade), else the MLSC console is recognized as a USB Test and Measurement Device.

4.9 TEC Driver Setup



Use the arrow buttons to select a parameter, then push the EDIT button, or push the selected topic a second time.

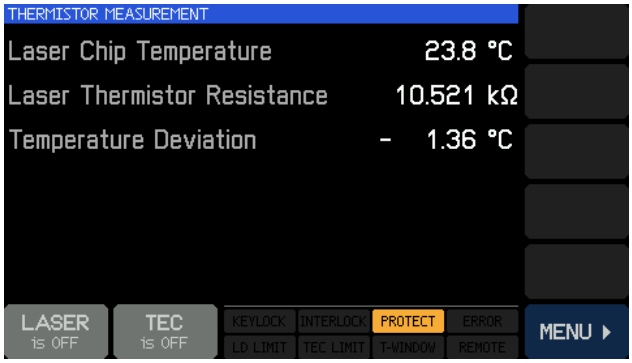
- **TEC Current Limit**: The TEC current limit must not exceed the specified maximum rating of the laser head. If the temperature setpoint is close to the ambient temperature, a reduced TEC current limit may be helpful to decrease the temperature settling time (reduce number of overshoots during settling time). The maximum TEC current limit of the MLSC console is 5.0 A.

- **Switch TEC on when Power-Up**: By default, the TEC is switched off at power-up. If required, the TEC can be switched on at power-up. Check the appropriate box if required.

- **Temperature Setpoint**: Edit this value to set the target temperature to the desired value. In certain cases (e.g. DFB laser diodes) it is recommended that this value be set to the reference temperature given in the laser's individual test report.

- **Lower / Upper Setpoint Limits**: This parameter can be used to limit the range of setpoint values in order to avoid operating the laser at excessive temperatures. The absolute limits depend on the thermistor parameters and are given by the measurement limits of the MLSC console.

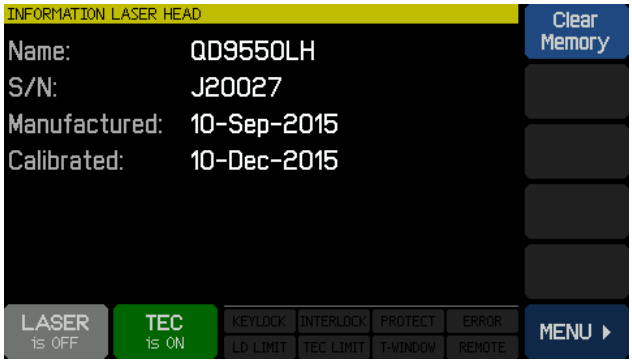
4.10 Thermistor Measurement



The MIR Laser System is designed to use the built-in thermistor for temperature sensing. Therefore, the resistance is measured and from this, the temperature can be calculated.

The third parameter - Temperature Deviation - is the difference between the actual measured temperature and the setpoint temperature.

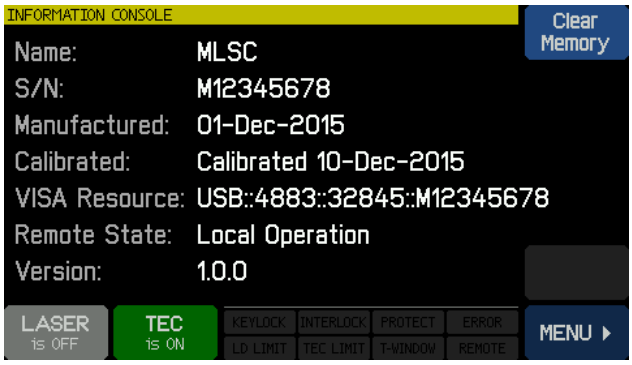
4.11 Information Laser Head



This screen gives information about the laser head.

The button at the upper-right of the display clears the setpoint memories.

4.12 Information Controller



This screen gives information about the MLSC console.

There is a button to clear the set point memories.

5 Remote Operation

The MLSC console provides a USB 2.0 Full Speed link according to the USB 2.0 specification, the USBTMC specification and the USBTMC USB488 specification. It allows sending commands from a host computer to the instrument. The connection to the PC is accomplished by a USB cable with a 'A' type connector at the PC side and a 'Mini B' connector on the instrument side.

Thorlabs provides an VXIpnp Instrument Driver and a NI VISA engine. An individual remote control software (GUI) for the MIR Laser System is not available.

Prior to connect the MLSC first time, make sure that the required software is installed.

When connecting the instrument to the PC the first time, on Windows systems the "New Hardware Found" wizard will be displayed.

Third party data logging, data acquisition and data analysis software (e.g. MATLAB, NI LabVIEW® Signal Express, Agilent VEE) can easily be connected via the instrument's USB interface.

For basic instrument communication, the *Thorlabs Instrument Communicator* Software can be used. Please see also the Write your Own Application section for a detailed description of the instrument's command set.

When receiving a command, the MIR Laser System will enter remote mode:

Remote Mode panel

Operated remotely, the touch panel control is disabled in order to avoid accidental entries and settings conflicts. This also includes the LASER and TEC on/off buttons.

The LOCAL button returns the device to local operation mode.

Compatibility with development environments

The MIR Laser System drivers require:

- NI VISA Runtime 5.4.1 (delivered with the driver package)
- LabVIEW® 8.5 or higher (for 32 bit LabVIEW® driver)
- LabVIEW® 2009 or higher (for 64 bit LabVIEW® driver)

5.1 Installing Driver Software

Note

Do not connect the MIR Laser System to the PC prior to driver software installation!
For software installation, you need administrator privileges on your computer!

Attention

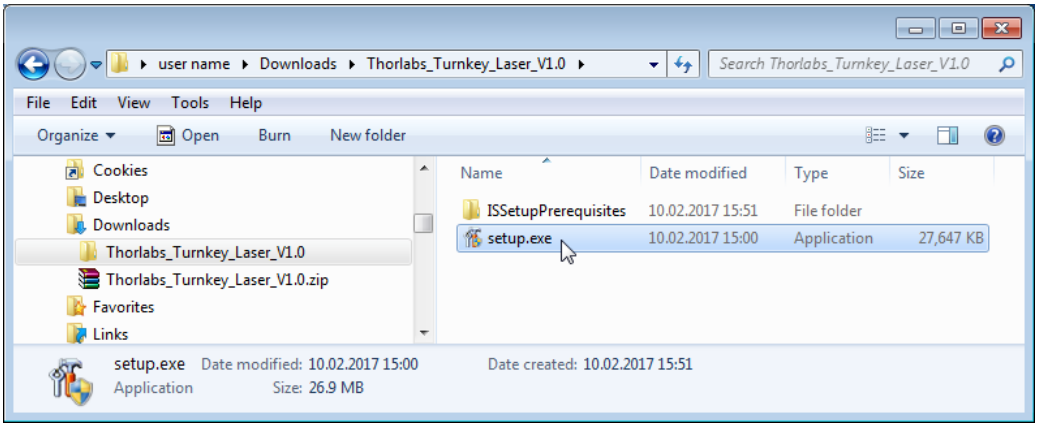
Exit all running applications on your PC as the installer may require a reboot of your PC during installation!

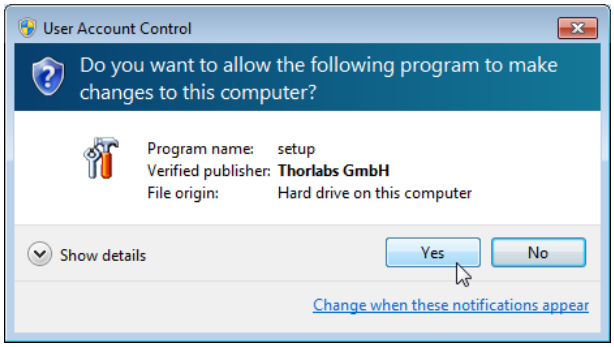
Thorlabs is working to become a greener and more environmentally friendly company. In order to reduce the amount of plastic we use, this item is not shipped with a software CD. The most recent version of compatible software will always be available online.

Download the MIR Laser System driver package from Thorlabs website:

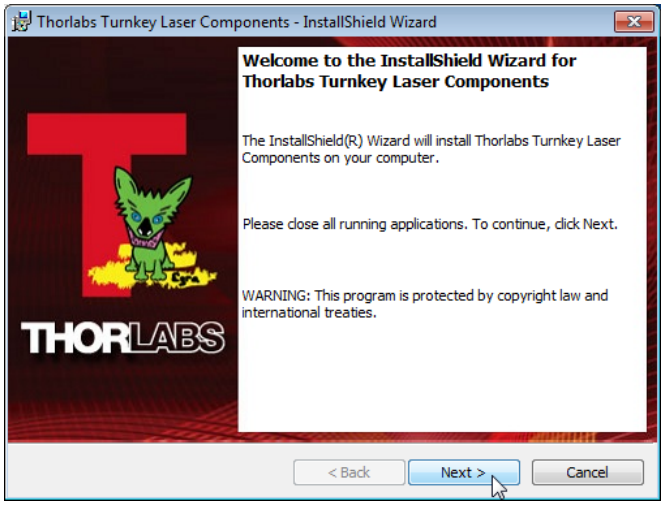
https://www.thorlabs.com/software/MUC/MLQ/TKL_MIR_V1.0.6.zip

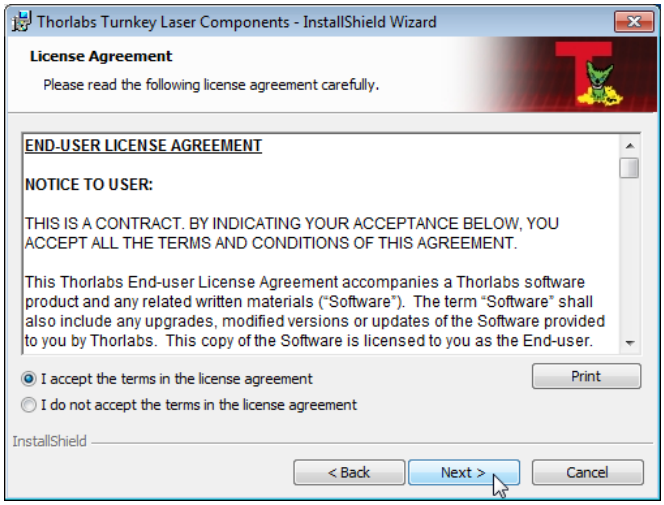
In the following, an installation to an Win7 64 bit operating system is described. Download the software package to your computer, unzip it and execute the setup.exe:



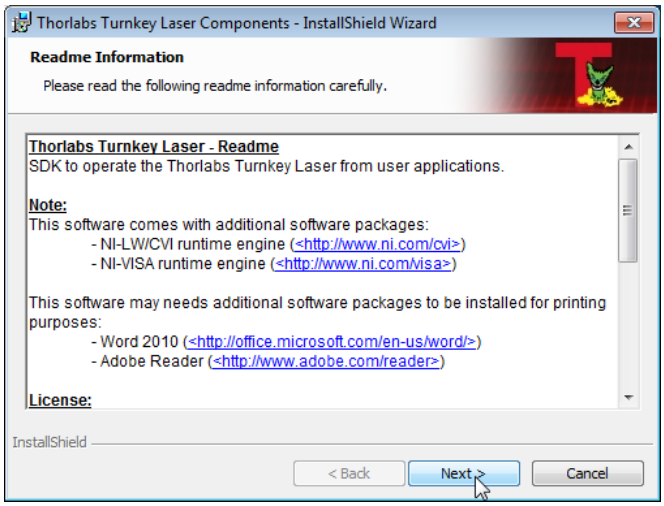


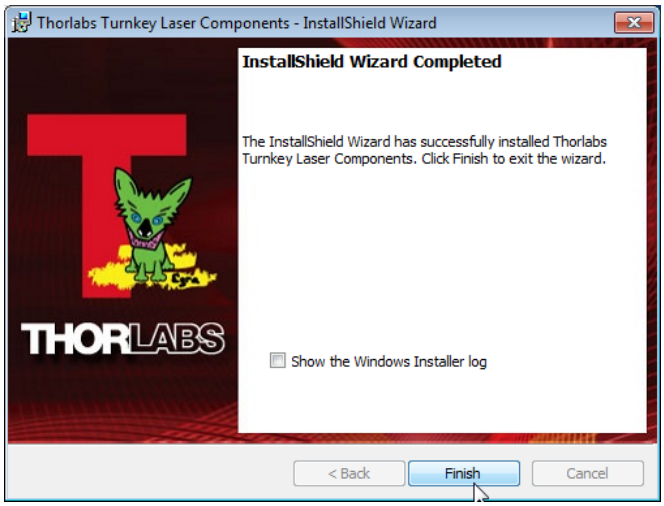
Click **Yes** to allow installation.





Select **I accept...**, then click **Next** to proceed. Then follow the instructions in the subsequent panels.





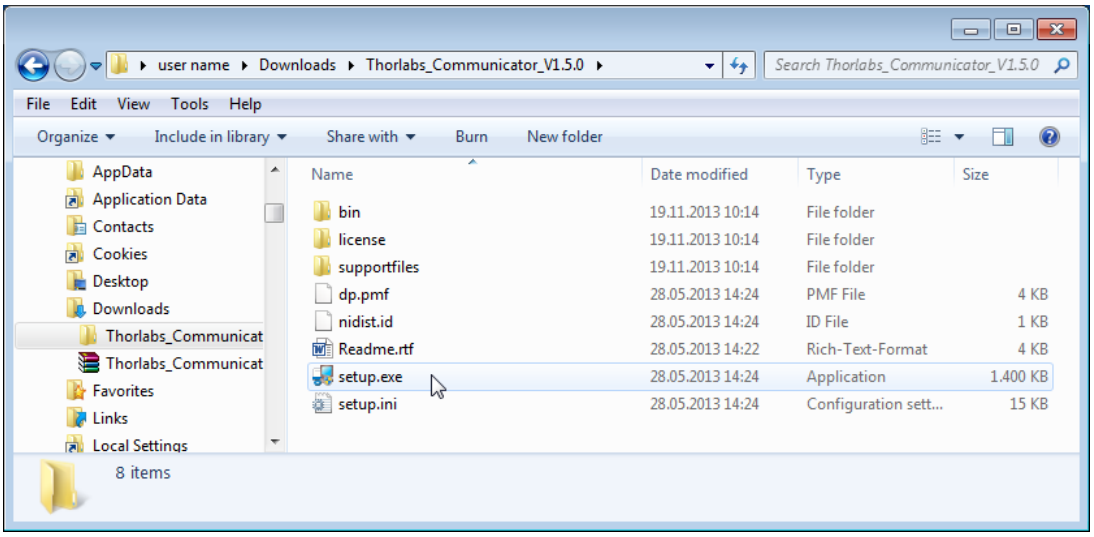
Click **Finish** to finalize the MIR Laser System driver installation.

Note

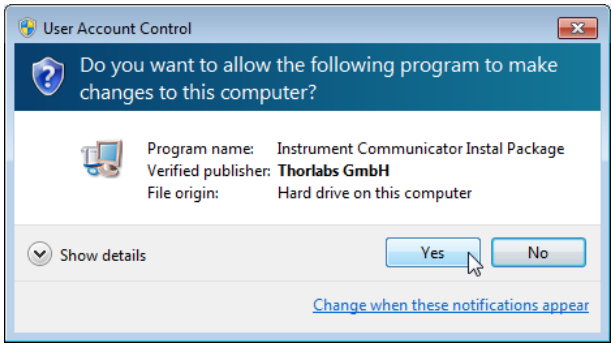
Please see section Write Your Own Application for driver installation location etc.

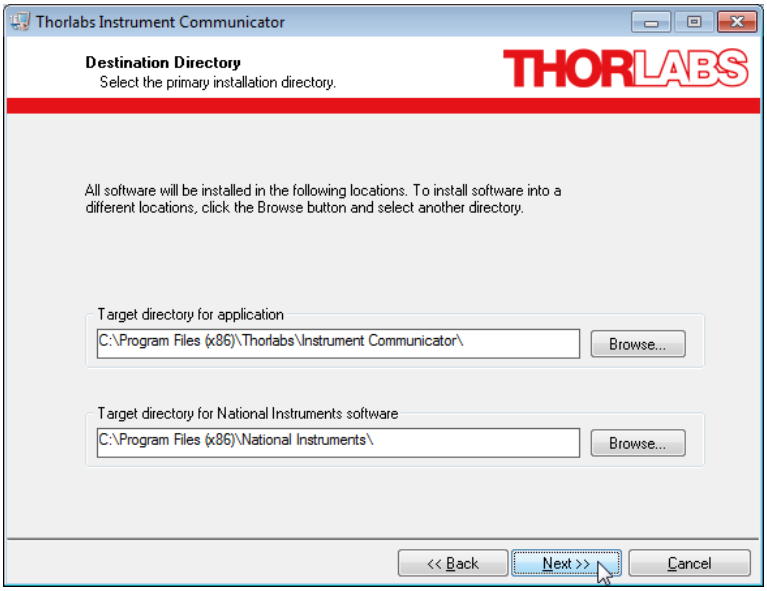
5.2 Instrument Communicator

The Thorlabs Instrument Communicator is a simple tool for basic communication (based on the common IEEE488.2 commands) with the MIR Laser System. Please download it: www.thorlabs.com/software/MUC/Utilities/Communicator2/Thorlabs_Communicator_V1.5.0.zip and unpack the ZIP archive. Then open the folder Thorlabs_Instrument_Communicator_V1.5.0 in Downloads and run the **setup.exe**:

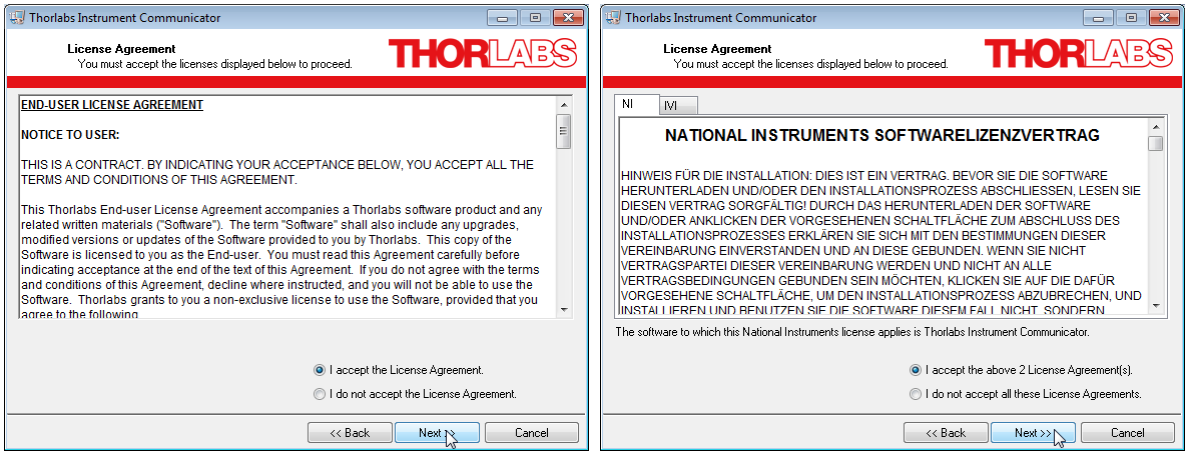


A security warning appears, please confirm:

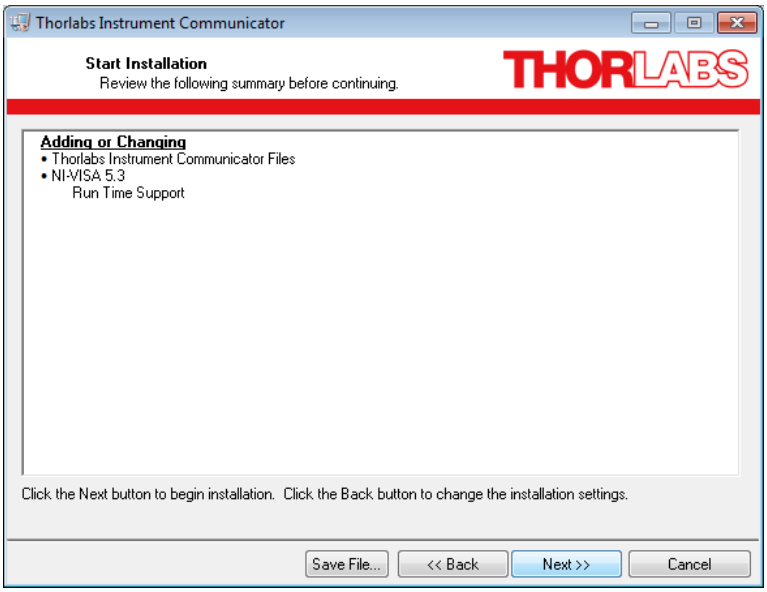




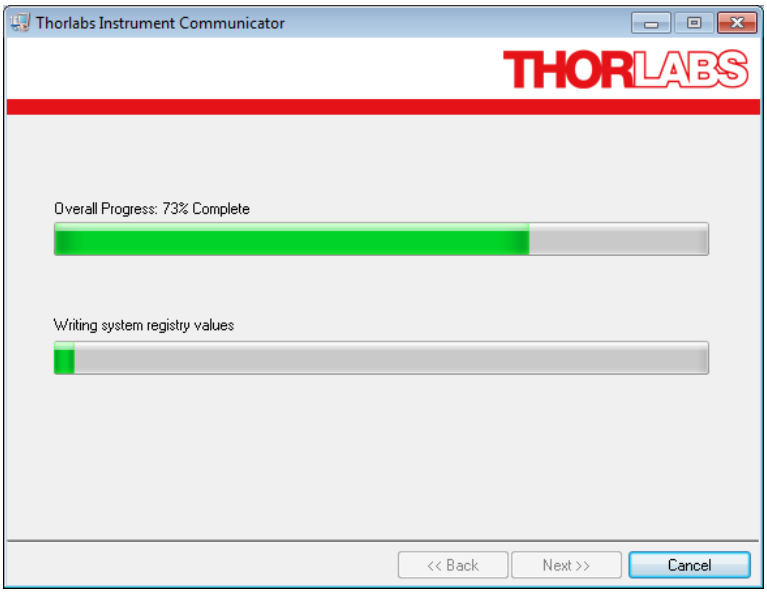
Click 'Next>>' to continue.

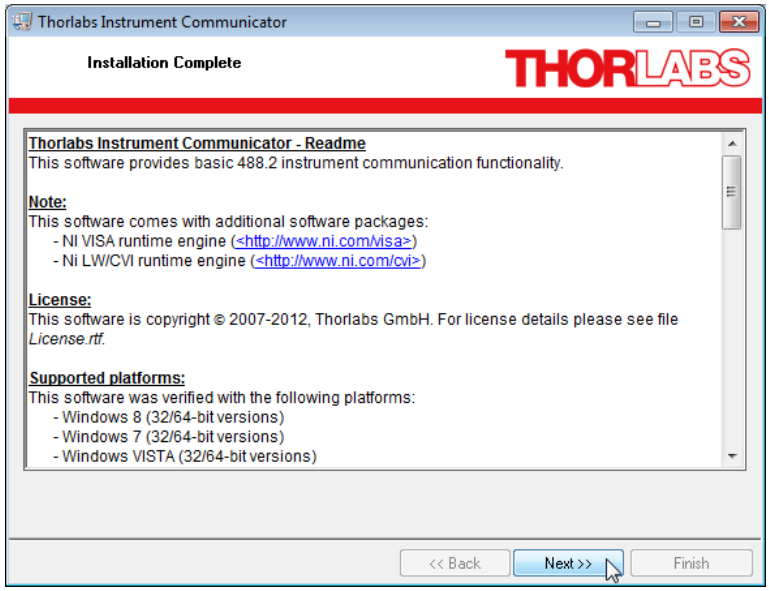


Select "I accept..." if you do so, then click 'Next>>' to continue.

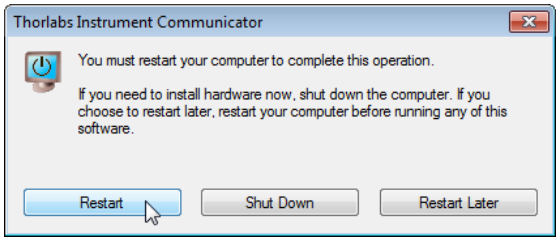


Click 'Next>>' to continue.





Click 'Next>>' to continue. You may be prompted to restart your computer.

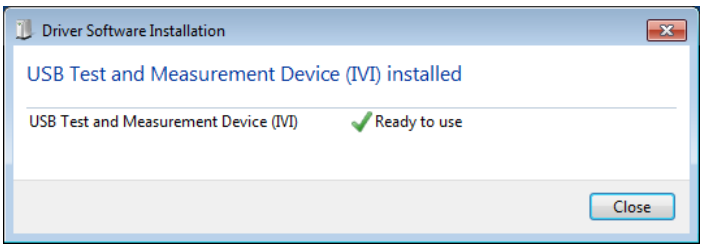


Note

In this case, a proper operation is possible only after restart!

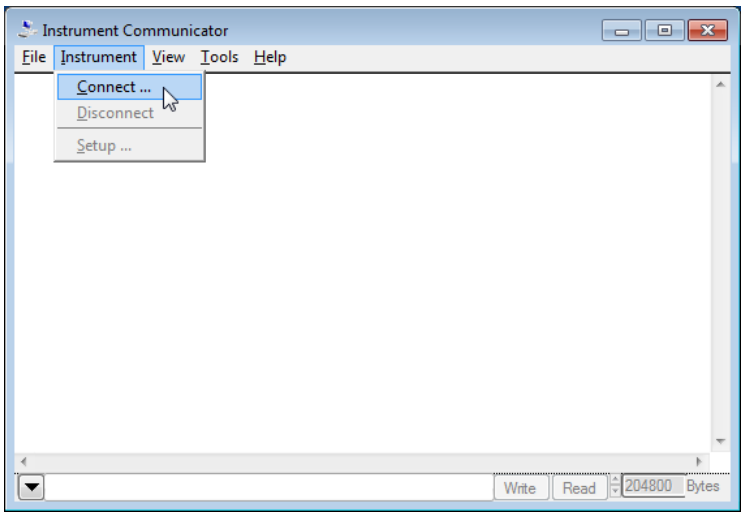
Connecting the MIR Laser System

Switch on the MIR Laser System and connect it to a free USB port of the computer. The instrument is recognized by the operating system and the appropriate drive software is being installed:

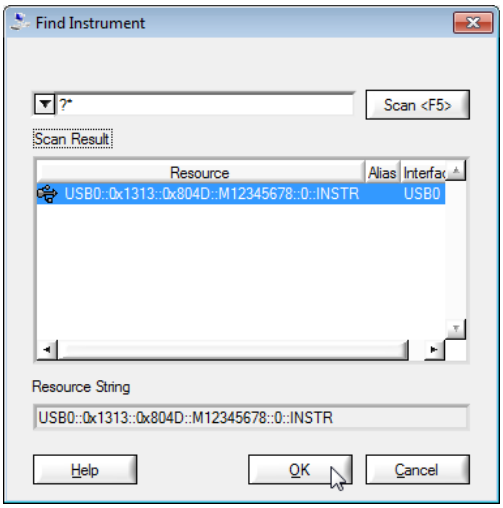


Starting the Instrument Communicator

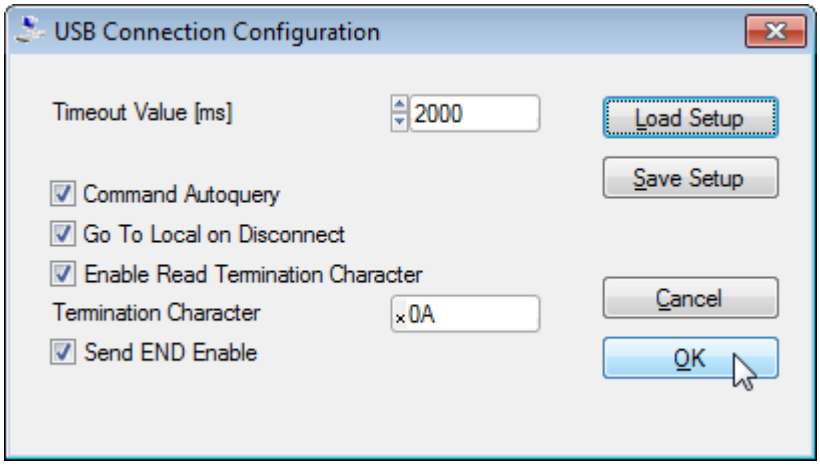
Select from Windows button 'All Programs' -> Thorlabs -> Instrument Communicator -> Instrument Communicator. The GUI opens.



Select 'Connect...'

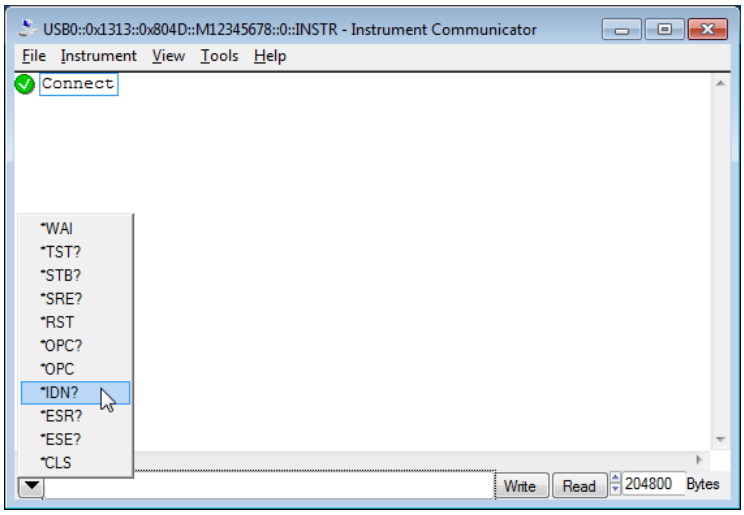


A list of available instruments appears. Select the MIR Laser System (can be recognized by serial number), then click 'OK'. The next screen allows to configure the USB connection and command line terminators. Click 'OK' to connect.

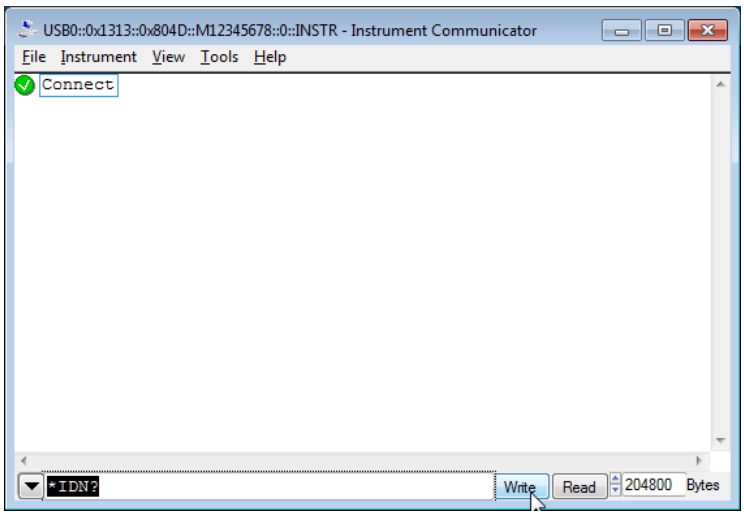


Note

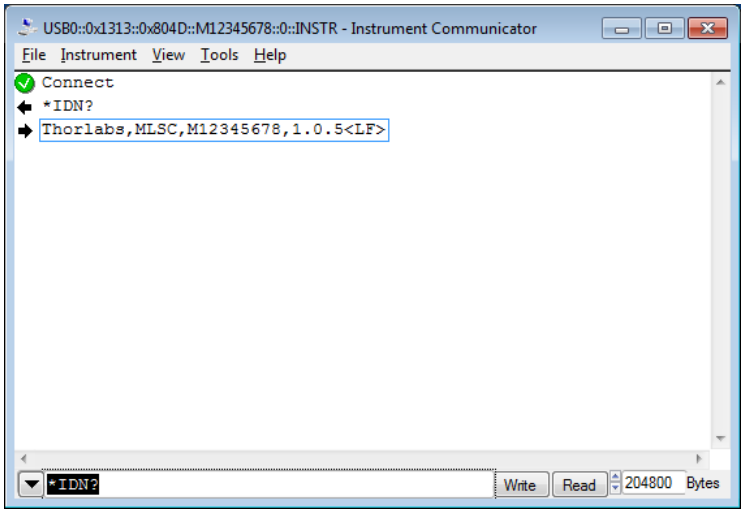
The above setup is recommended. **Command Autoquery** means, that after sending a query command, the Communicator automatically sends a Read command in order display the device response.



Enter a IEEE488.2 command (see list of supported commands), alternatively a command can be selected from the drop down list. Click the 'Write' button.



The Instrument communicator lists the sent command and the query result in the log panel:



In above example, the *IDN? command retrieves the identification information, which is being returned in the format "[manufacturer], [device name], [serial number], [firmware version]".

6 Write Your Own Application

In order to write your own application, you need a specific instrument driver and some tools for use in different programming environments. The driver and tools are being installed to your computer during software installation and cannot be found in the installation package.

In this section the location of drivers and files, required for programming in different environments, are given for installation under Windows VISTA, Windows 7, Windows 8.x and Windows 10 (32 and 64 bit).

In order to fully support 64 bit LabView version, the installation offers two installer versions:

- for Windows VISTA (32/64 bit), Windows 7 (32/64 bit), Windows 8.x (32/64 bit) and Windows 10 (32/64 bit): Install "TLTKL VXIpnp Instrument Driver (32bit)"
- for Windows VISTA (64 bit), Windows 7 (64 bit), Windows 8.x (64 bit) and Windows 10 (64 bit): Install "TLTKL VXIpnp Instrument Driver (64 bit)"

In other words, the 32 bit VXIpnp driver works with both 32 and 64 bit operating systems, while the 64 bit driver requires a 64 bit operating system.

In the table below you will find a summary of what files you need for particular programming environments.

Programming environment	Necessary files
C, C++, CVI	*.h (header file) *.lib (static library)
C#	.net wrapper dll
Visual Studio	*.h (header file) *.lib (static library) or .net wrapper dll
LabView®	*.fp (function panel) and VXIpnp Instrument Driver Beside that, LabVIEW® driver vi's are provided with the *.llb container file

Note

All above environments require also the VXIpnp Instrument Driver dll !

In the next sections the locations of above files are described in detail.

6.1 32 bit Version

Note

According to the VPP6 (Rev6.1) Standard the installation of the 32 bit VXIpnp driver includes both the WINNT and GWINNT frameworks.

VXIpnp Instrument driver:

`C:\Program Files\IVI Foundation\VISA\WinNT\Bin\TLTKL_32.dll`

Note

This instrument driver is required for all development environments!

Header file

`C:\Program Files\IVI Foundation\VISA\WinNT\include\TLTKL.h`

Static Library

`C:\Program Files\IVI Foundation\VISA\WinNT\lib\msc\TLTKL_32.lib`

Function Panel

`C:\Program Files\IVI Foundation\VISA\WinNT\TLTKL\TLTKL.fp`

Online Help for VXIpnp Instrument driver:

`C:\Program Files\IVI Foundation\VISA\WinNT\TLTKL\Manual\TLTKL.html`

NI LabVIEW® driver

The LabVIEW® Driver is a 32 bit driver and compatible with 32bit NI-LabVIEW® versions 8.5 and higher only.

`C:\Program Files\National Instruments\LabVIEW xxxx\instr.lib\TLTKL…`
`…\TLTKL.llb`

(LabVIEW® container file with driver vi's and an example. "LabVIEW xxxx" stands for actual LabVIEW® installation folder.)

.net wrapper dll

`C:\Program Files\Microsoft.NET\Primary Interop Assemblies…`
`…\Thorlabs.TLTKL_32.interop.dll`

`C:\Program Files\IVI Foundation\VISA\VisaCom\…`
`…\Primary Interop Assemblies\Thorlabs.TLTKL_32.interop.dll`

Example for NI LabWindows/CVI (C)

Source file:

`C:\Program Files\IVI Foundation\VISA\WinNT\TLTKL\Examples\C\…`
`…sample.c`

Executable sample demo:

`C:\Program Files\IVI Foundation\VISA\WinNT\TLTKL\Examples\C\…`
`…sample.exe`

MS Visual Studio, .NET (C#)

Solution file:

```
C:\Program Files\IVI Foundation\VISA\WinNT\TLTKL\Examples…
…\CSharp\Thorlabs.TLTKL.CSharpSample.sln
```

Project file:

```
C:\Program Files\IVI Foundation\VISA\WinNT\TLTKL\Examples…
…\CSharp\Thorlabs.TLTKL.CSharpSample\…
…Thorlabs.TLTKL.CSharpSample.csproj
```

Executable sample demo:

```
C:\Program Files\IVI Foundation\VISA\WinNT\TLTKL\Examples…
…\CSharp\Thorlabs.TLTKL.CSharpSample\bin\Release\…
…Thorlabs.TLTKL.CSharpSample.exe
```

(Select the correct type and device mode, e.g., TMC or DFU, and enter serial number, then connect)

Example for LabVIEW®

```
C:\Program Files\National Instruments\LabVIEW xxxx\Instr.lib\TLTKL…
…\TLTKL.llb
```

(LabVIEW® container file with driver vi's and an example. "LabVIEW xxxx" stands for actual LabVIEW® installation folder.)

6.2 64 bit Version

Note

According to the VPP6 (Rev6.1) Standard the installation of the 64 bit VXIpnp driver includes the WINNT, WIN64, GWINNT and GWIN64 frameworks. That means, that the 64 bit driver includes the 32 bit driver as well.

In case of a 64 bit operating system, 64bit drivers and applications are installed to

“C:\Program Files”

while the 32 bit files - to

“C:\Program Files (x86)”

Below are listed both installation locations, so far applicable.

VXIpnp Instrument driver:

`C:\Program Files (x86)\IVI Foundation\VISA\WinNT\Bin\TLTKL_32.dll`

`C:\Program Files\IVI Foundation\VISA\Win64\Bin\TLTKL_64.dll`

Note

This instrument driver is required for all development environments!

Header file

`C:\Program Files (x86)\IVI Foundation\VISA\WinNT\include\TLTKL.h`

`C:\Program Files\IVI Foundation\VISA\Win64\include\TLTKL.h`

Static Library

`C:\Program Files (x86)\IVI Foundation\VISA\WinNT\lib\msc…`
`…\TLTKL_32.lib`

`C:\Program Files\IVI Foundation\VISA\Win64\Lib_x64\msc\TLTKL_64.lib`

Function Panel

`C:\Program Files (x86)\IVI Foundation\VISA\WinNT\TLTKL\TLTKL.fp`

Online Help for VXIpnp Instrument driver:

`C:\Program Files (x 86)\IVI Foundation\VISA\WinNT\TLTKL\Manual…`
`…\TLTKL.html`

NI LabVIEW® driver

The LabVIEW® Driver supports 32bit and 64bit NI-LabVIEW2009 and higher.

32 bit NI-LabVIEW® version

`C:\Program Files (x86)\National Instruments\LabVIEW xxxx\instr.lib…`
`…\TLTKL\TLTKL.llb`

64 bit NI-LabVIEW® version

`C:\Program Files\National Instruments\LabVIEW xxxx\instr.lib…`
`…\TLTKL\TLTKL.llb`

(LabVIEW® container file with driver vi's and an example. "LabVIEW® xxxx" stands for actual LabVIEW® installation folder.)

.net wrapper dll

```
C:\Program Files (x86)\Microsoft.NET\Primary Interop Assemblies…
…\Thorlabs.TLTKL_32.interop.dll
```

```
C:\Program Files (x86)\IVI foundation\VISA\VisaCom\…
…\Primary Interop Assemblies\Thorlabs.TLTKL_32.interop.dll
```

```
C:\Program Files\IVI foundation\VISA\VisaCom64\…
…\Primary Interop Assemblies\Thorlabs.TLTKL_64.interop.dll
```

Example for NI LabWindows/CVI (C)

Source file:

```
C:\Program Files (x86)\IVI Foundation\VISA\WinNT\TLTKL\Examples\C\…
…sample.c
```

Executable sample demo:

```
C:\Program Files (x86)\IVI Foundation\VISA\WinNT\TLTKL\Examples\C\…
…sample.exe
```

MS Visual Studio, .NET (C#)

Solution file:

```
C:\Program Files (x86)\IVI Foundation\VISA\WinNT\TLTKL\Examples…
…\CSharp\Thorlabs.TLTKL.CSharpSample.sln
```

Project file:

```
C:\Program Files (x86)\IVI Foundation\VISA\WinNT\TLTKL\Examples…
…\CSharp\Thorlabs.TLTKL.CSharpSample…
…\Thorlabs.TLTKL.CSharpSample.csproj
```

Executable sample demo:

```
C:\Program Files (x86)\IVI Foundation\VISA\WinNT\TLTKL\Examples…
…\CSharp\Thorlabs.TLTKL.CSharpSample…
…\bin\Release\Thorlabs.TLTKL.CSharpSample.exe
```

(Select the correct type and device mode, e.g., TMC or DFU, and enter serial number, then connect)

Example for LabVIEW®

```
C:\Program Files\National Instruments\LabVIEW xxxx\Instr.lib\TLTKL…
…\TLTKL.llb
```

(LabVIEW® container file with driver vi's and an example. "LabVIEW® xxxx" stands for actual LabVIEW® installation folder.)

6.3 Command Reference

6.3.1 IEEE488.2 Common Commands

Common commands are device commands that are common to all devices according to the IEEE488.2 standard. These commands are designed and defined by this standard. Most of the commands are described in detail in this section. The following common commands associated with the status structure are covered in the "Status Structure" section: *CLS, *ESE, *ESE?, *ESR?, *SRE,

Command summary

Mnemonic	Name	Description
***CLS**	Clear status	Clears all event registers and Error Queue
***ESE <NRf>**	Event enable command	Sets the Standard Event Enable Register
***ESE?**	Event enable query	Returns the Standard Event Enable Register
***ESR?**	Event status register query	Returns and clear the Standard Event Register
***IDN?**	Identification query	Returns the unit's identification string
***OPC**	Operation complete command	Sets the Operation Complete bit in the Standard Event Register
***OPC?**	Operation complete query	Places a "1" into the output queue when all device operations have been completed
***RST**	Reset command	Returns the unit to the *RST default condition
***SRE <NRf>**	Service request enable command	Sets the Service Request Enable Register
***SRE?**	Service request enable query	Returns the Service Request Enable Register
***STB?**	Status byte query	Returns the Status Byte Register
***TST?**	Self-test query	Performs the unit's self-test and returns the result.
***WAI**	Wait-to-continue command	Waits until all previous commands are executed

Command reference

1. *IDN? – identification query - read identification code

The identification code includes the manufacturer, model code, serial number, and firmware revision levels and is sent in the following format: `Thorlabs,MMM,SSS,X.X.X,` where

`MMM` is the model code
`SSS` is the serial number
`X.X.X` is the instrument firmware revision level

2. *IDN2?

This command is the identification query of the connected laser head.

3. *OPC – operation complete - set OPC bit

4. *OPC? – operation complete query – places a "1" in output queue

When `*OPC` is sent, the OPC bit in the Standard Event Register will set after all pending command operations are complete. When `*OPC?` is sent, an ASCII "1" is placed in the Output Queue after all pending command operations are complete.
Typically, either one of these commands is sent after the `INITiate` command. The `INITiate` command is used to take the instrument out of idle in order to perform measurements. While operating within the trigger model layers, many sent commands will not execute. After all programmed operations are completed, the instrument returns to the idle state at which time all pending commands (including `*OPC` and/or `*OPC?`) are executed. After the last pending command is executed, the OPC bit and/or an ASCII "1" is placed in the Output Queue.

5. *RST – reset – return instrument to defaults

When the *RST command is sent, the instrument performs the following operations:

- Returns the instrument to default conditions
- Cancels all pending commands.
- Cancels response to any previously received *OPC and *OPC? commands.

6. *TST? – self-test query – run self test and read result

Use this query command to perform the instrument self-test routine. The command places the coded result in the Output Queue. A returned value of zero (0) indicates that the test passed, other values indicate that the test failed.

7. *WAI – wait-to-continue – wait until previous commands are completed

The *WAI command is not relevant for the instrument and thus, is not used. It was included only for conformance with IEEE488.2.

6.3.2 SCPI Command Reference

SYSTem subsystem commands

Command	Description	SCPI
SYSTem	Path to SYSTem subsystem.	☑
:BEEPer		☑
[:IMMediate]	Issues an audible signal	☑
:STATe {ON|1|OFF|0}	Activates/deactivates the beeper	☑
:STATe?	Returns the state of the beeper	☑
:VOLume <value>	Sets the beeper volume	☑
:VOLume?	Returns the beeper volume	☑
:ERRor		☑
[:NEXT]?	Returns the latest error code and message	☑
:MOUNt		
[:TYPE]?	Returns the mount type (<NR1>,description)	
:VERSion?	Returns level of SCPI standard (1999.0)	☑
:USED {ON|1|OFF|0}	Sets the used by remote state	
:USED?	Returns the used by remote state	

DISPlay subsystem commands

Command	Description	SCPI
DISPlay	Path to DISPlay subsystem.	☑
:BRIGhtness <value>	Sets the display brightness	☑
:BRIGhtness?	Returns the display brightness value	☑
:CALibration[:TOUCh][:INITiate]	Initiates Touchscreen calibration	
:FADeout		
[:STATe] {ON|1|OFF|0}	Activates/deactivates automatic dimming	
[:STATe]?	Returns the state of automatic dimming	

STATus subsystem commands

Command	Description	SCPI
STATus		☑
:MEASurement	Path to control measurement event registers	
[:EVENt]?	Returns the event register	
:CONDition?	Returns the condition register	
:PTRansition <value>	Sets the positive transition filter	
:PTRansition?	Returns the positive transition filter	
:NTRansition <value>	Sets the negative transition filter	
:NTRansition?	Returns the negative transition filter	
:ENABle <value>	Sets the enable register	
:ENABle?	Returns the enable register	
:OPERation	Path to control operation event registers	☑
[:EVENt]?	Returns the event register	☑
:CONDition?	Returns the condition register	☑
:PTRansition <value>	Sets the positive transition filter	☑
:PTRansition?	Returns the positive transition filter	☑
:NTRansition <value>	Sets the negative transition filter	
:NTRansition?	Returns the negative transition filter	☑
:ENABle <value>	Sets the enable register	☑
:ENABle?	Returns the enable register	☑
:QUEStionable	Path to control questionable event registers	☑
[:EVENt]?	Returns the event register	☑
:CONDition?	Returns the condition register	☑
:PTRansition <value>	Sets the positive transition filter	☑
:PTRansition?	Returns the positive transition filter	☑
:NTRansition <value>	Sets the negative transition filter	☑
:NTRansition?	Returns the negative transition filter	☑
:ENABle <value>	Sets the enable register	☑
:ENABle?	Returns the enable register	☑
:AUXiliary	Path to control auxiliary event registers	
[:EVENt]?	Returns the event register	
:CONDition?	Returns the condition register	
:PTRansition <value>	Sets the positive transition filter	
:PTRansition?	Returns the positive transition filter	
:NTRansition <value>	Sets the negative transition filter	
:NTRansition?	Returns the negative transition filter	
:ENABle <value>	Sets the enable register	
:ENABle?	Returns the enable register	
:PRESet	Return status registers to default states.	☑

LD output subsystem commands

Command	Description	SCPI
OUTPut[1]	**Path to LD output**	☑
[:STATe] {ON|1|OFF|0}	Enables (ON) or disables (OFF) LD output	☑
[:STATe]?	Returns output state	☑
:PON	**Path to LD power ON**	
:DELay {MIN|MAX|DEF|<seconds>}	Sets the LD output power-on delay	
:DELay? [{MIN|MAX|DEF}]	Returns the LD output power-on delay setting	
:CONDition?	Returns the output condition (query only, 1|0)	
:FILTer[:LPASs]	**Path to LD output filter**	☑
[:STATe] {ON|1|OFF|0}	Enables/disables LD output low pass filter	☑
[:STATe]?	Returns output filter state	☑
:PROTection	**Path to LD output protection**	☑
:INTLock[:TRIPped]?	Returns interlock circuit protection tripped	
:KEYLock[:TRIPped]?	Returns key lock protection tripped	
:OTEMperature[:TRIPped]?	Returns over temperature protection tripped	
:CONNection[:TRIPped]?	Returns connection failure protection tripped	
:TEMPerature		
:MODE {OFF|PROTection|ENABle}	Sets temperature protection mode	
:MODE?	Returns temperature protection mode	
{:TRIPped]?	Returns protection tripped	

LD current sensing subsystem commands

Command	Description	SCPI
SENSe3	**Path to laser diode current sensing**	☑
[:CURRent][:DC]		☑
[:DATA]? [{MIN|MAX}]	Returns the measured LD current	
:FAN:SPEEd? [{MIN|MAX}]	Returns the speed of the laser head fan	

LD voltage sensing subsystem commands

Command	Description	SCPI
SENSe4	**Path to laser diode voltage sensing**	☑
[:VOLTage][:DC]		☑
[:DATA]? [{MIN|MAX}]	Returns the measured LD voltage	

LD source subsystem commands

Command	Description	SCPI
SOURce[1]	**Path to Laser output**	☑
[:CURRent]	**Path to Laser output current**	☑
:LIMit		☑
[:AMPLitude] {MIN|MAX|<amps>}	Sets limit current value	☑
[:AMPLitude]? [{MIN|MAX}]	Returns limit current value	☑
:TRIPped?	Returns limit detection tripped	
[:LEVel][:IMMediate]		☑
[:AMPLitude] {MIN|MAX|<amps>}	Sets LD current setpoint value	☑
[:AMPLitude]? [{MIN|MAX}]	Returns LD current setpoint value	☑
:VOLTage	**Path to Laser output voltage**	☑
[:LEVel]		☑
[:IMMediate]		☑
[:AMPLitude]? [{MIN|MAX}]	Returns LD voltage setpoint value	☑
:DIODe[:CURRent][:IMMediate]	Sets LD power via photodiode current	
[:AMPLitude] {MIN|MAX|<amps>}	Sets photodiode current setpoint	
[:AMPLitude]? [{MIN|MAX}]	Returns the photodiode current setpoint	

Command	Description	SCPI
:AM	**Path to Laser output modulation**	☑
:INTernal		☑
[:STATe] {ON|1|OFF|0}	Enable (ON) or disable (OFF) internal mod.	
[:STATe]?	Returns internal modulation state	
:AMPLitude {MIN|MAX|<amps>}	Sets LD internal modulation amplitude	
:AMPLitude? [{MIN|MAX}]	Returns LD internal modulation amplitude	
:FREQency {MIN|MAX|<hertz>}	Sets LD internal modulation frequency	☑
:FREQency? [{MIN|MAX}]	Returns LD internal modulation frequency	☑
:FUNCtion[:SHAPe] {SINusoid|1|TRIangle|2|SQUare|3}	Sets LD internal modulation shape	
:FUNCtion[:SHAPe]?	Returns LD internal modulation shape	
:EXTernal		
[:STATe] {ON|1|OFF|0}	Enable (ON) or disable (OFF) external mod.	
[:STATe]?	Returns external modulation state	
:RANGe {LOW|0|HIGH|2}	Sets the external modulation range	
:RANGe?	Returns the external modulation range	
:TUNE:EXT	**Path to Laser output tuning**	
[:STATe] {ON|1|OFF|0}	Enable (ON) or disable (OFF) external tuning	
[:STATe]?	Returns external tuning state	

TEC output subsystem commands

Command	Description	SCPI
OUTPut2	**Path to TEC output**	☑
[:STATe] {ON|1|OFF|0}	Enable (ON) or disable (OFF) TEC output	☑
[:STATe]?	Returns output state	☑
:PON	**Path to TEC output power on**	
[:STATe] {ON|1|OFF|0}	Sets the power-on TEC output state	
[:STATe]?	Returns power-on TEC output state setting	
:PROTection	**Path to TEC output protection**	☑
:TRANsducer[:TRIPped]?	Returns temperature transducer failure tripped	
:OTEMperature[:TRIPped]?	Returns over temperature protection tripped	
:CONNection[:TRIPped]?	Returns connection failure protection tripped	

TEC driver source subsystem commands

Command	Description	SCPI
SOURce2	**Path to TEC output**	☑
:CURRent	**Path to TEC output current**	☑
:LIMit		☑
[:AMPLitude] {MIN|MAX|<amps>}	Sets limit current value	☑
[:AMPLitude]? [{MIN|MAX}]	Returns limit current value	☑
:TRIPped?	Returns limit detection tripped	
:DATA? [{MIN|MAX}]	Returns the TEC current value	
[:TEMPerature]	**Path to TEC output temperature**	☑
[:SPOint] {MIN|MAX|DEF|<temp>}	Sets temperature setpoint	☑
[:SPOint]? [{MIN|MAX|DEF}]	Returns temperature setpoint	☑
:LIMit		
[:UPPer] {MIN|MAX|<temp>}	Sets settable temperature high limit	
[:UPPer]? [{MIN|MAX}]	Returns settable temperature high limit	
:LOWer {MIN|MAX|<temp>}	Sets settable temperature low limit	
:LOWer? [{MIN|MAX}]	Returns settable temperature low limit	

Temperature sensing subsystem commands

Command	Description	SCPI
SENSe2		☑
[:TEMPerature]		
:DATA? [{MIN|MAX}]	Returns the temperature value	
:PROTection		
:DELay {MIN|MAX|DEF|<sec>}	Sets protection delay	
:DELay? [{MIN|MAX|DEF}]	Returns protection delay	
:WINDow[:AMPLitude] {MIN|MAX|DEF|<temp>}	Sets temperature window amplitude	
:WINDow[:AMPLitude]? [{MIN|MAX|DEF}]	Returns temperature window amplitude	
[:TRIPped]?	Returns protection tripped	
:RESistance		
[:DATA]? [{MIN|MAX}]	Returns the resistance value	
:FAN:SPEEd? [{MIN|MAX}]	Returns the controller's fan speed	

Laser head subsystem commands

Command	Description	SCPI
SOURce3		☑
:INTPol		
:TYPE {NONE|0|WLEN|1|POW|3}	Sets the interpolation type	
:TYPE?	Returns the interpolation type	
:WAVElength <value>	Sets the laser wavelength	
:WAVElength? [{MIN|MAX}]	Returns the laser wavelength	
:WAVElength:NOMinal?	Returns the nominal laser wavelength	
:POWer <watt>	Sets the laser output power	
:POWer? [{MIN|MAX}]	Returns the laser output power	
:POWer:NOMinal?	Returns the nominal laser output power	
:CURRent:LIMit?:MAXimum?	Returns the laser current limit	
:VOLTage:LIMit:MAXimum?	Returns the laser voltage limit	

UNIT subsystem commands

Command	Description	SCPI
UNIT		☑
:TEMPerature {C|CEL|CELSius|F|FAR|FAHReinheit|K|KELVin}	Sets the temperature unit	☑
:TEMPerature?	Returns the temperature unit	☑
:WAVElength {1|NM|2|WNUM}	Sets the WL unit to wavelength [nm] or wave number	
:WAVElength?	Returns the WL unit	

CALibration subsystem commands

Command	Description	SCPI
CALibration		☑
:STRing?	Returns the calibration string of the controller	
CALibration2		
:STRing?	Returns the calibration string of the laser head	

MANufacturer subsystem commands

Command	Description	SCPI
MANufacturer		
:STRing?	Returns the manufacturer string of the controller	
MANufacturer2		
:STRing?	Returns the manufacturer string of the laser head	

Measurement commands

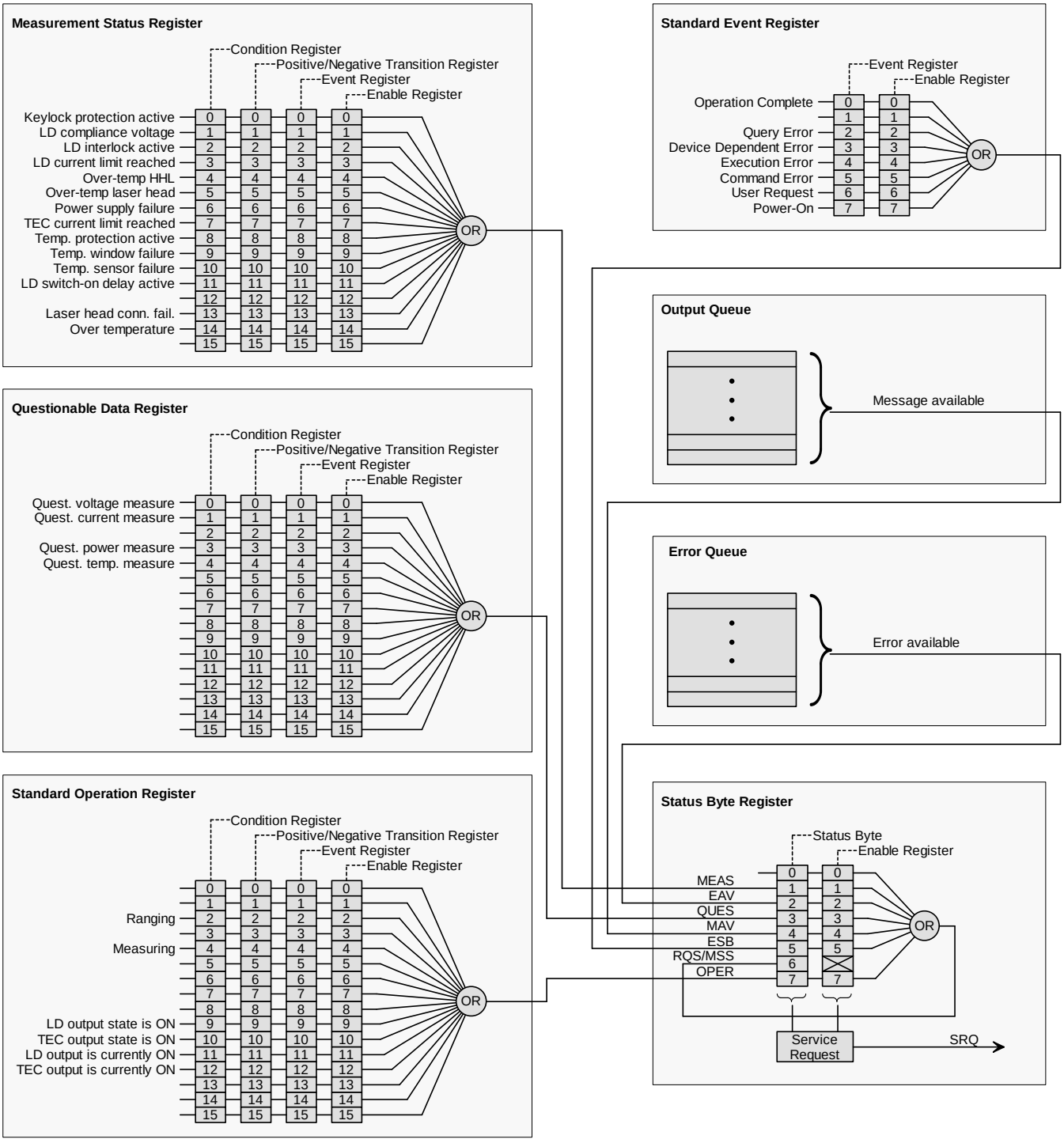
Command	Description	SCPI
ABORt	Aborts current measurement	☑
CONFigure[:SCALar]		☑
:CURRent[1][:DC]	Configures instrument LD current measurement	☑
:VOLTage[1][:DC]	Configures instrument LD voltage measurement	☑
:TEMPerature	Configures instrument for temperature measurement	☑
:RESistance	Configures instrument NTC resistance measurement	☑
CONFigure?	Query configuration	☑
INITiate[:IMMediate]	Starts measurement	☑
FETCh?	Returns last measurement data	☑
FETCh		
:CURRent[1][:DC]?	Return last LD current measurement	☑
:VOLTage[1][:DC]?	Return last LD voltage measurement	☑
:TEMPerature?	Return last temperature measurement	☑
:RESistance?	Return last NTC resistance measurement	☑
READ?	Starts new measurement (as configured) and read data	☑
MEASure[:SCALar]		
:CURRent[1][:DC]?	Perform LD current measurement	☑
:VOLTage[1][:DC]?	Perform LD voltage measurement	☑
:TEMPerature?	Perform LD temperature measurement	☑
:HHL?	Perform laser head High-Heat Load temperature measurement	
:T2?	Perform laser head transistor2 temperature measurement	
:SHUNt?	Perform laser head shunt temperature measurement	
:RESistance?	Perform NTC resistance measurement	☑

MEMory subsystem commands

Command	Description	SCPI
MEMory		☑
:SAVE [IMMediate]	Stores current device setup to flash memory	

6.3.3 Status Reporting

The figure below gives an overview of the device's status reporting structure. See also section STATus subsystem commands for a detailed description of the related commands and their syntax.



Status Byte Register

The Status Byte Register gives a summary of all underlying status structures. See also IEEE488.2-1992-§11.2.

Bit #	Mnemonic	Description
7	**OPER**	Standard Operation Status Structure Summary Bit
6	**RQS/MSS**	Request Service / Master Summary Status
5	**ESB**	Standard Event Status Bit
4	**MAV**	Message Available. There is response data available for readout
3	**QUES**	Questionable Status Structure Summary Bit
2	**EAV**	Error Available. There is at least one error in the error queue.
1	**MEAS**	Measurement Status Structure Summary Bit
0		reserved, read as 0

Standard Event Status Structure

The Standard Event Status Structure is described in IEEE488.2-1992-§11.5.

Standard Operation Register

The Standard Operation Status Structure is described in SCPI1999.0-Vol1-§9.3. In addition bit 8 to 12 are used as output state/on indicators.

Bit #	Mnemonic	Description
15..13		See SCPI1999.0-Vol1-§9.3
12	**TECON**	TEC output is currently ON
11	**LDON**	LD output is currently ON
10	**TECST**	TEC output state is ON
9	**LDST**	LD output state is ON
8		reserved, read as 0
7..0		See SCPI1999.0-Vol1-§9.3

Questionable Data Register

The Questionable Data Status Structure is described in SCPI1999.0 Vol1 §9.4.

Measurement Status Register

The Measurement Status Register Status Byte Register reports device operation and measurement states.

Bit #	Description
15	reserved, read as 0
14	Over temperature (Instrument is too hot)
13	Laser head connection failure (Laser head missing or unknown laser head detected)
12	reserved, read as 0
11	LD switch-on delay active
10	Temperature sensor failure.
9	Temperature window failure.
8	Temperature protection is active.
7	TEC current limit reached
6	Power supply failure
5	Over-temperature of the laser head
4	Over-temperature of the HHL high-heat load
3	LD current limit reached
2	LD interlock is active
1	LD output compliance voltage reached
0	Keylock protection is active

6.3.4 Error Reporting

The device stores errors in a queue containing up to 10 entries. The error queue may be read out by the 'SYSTem:ERRor[:NEXT]?'command. The following table lists all error numbers and the according descriptive messages. Note: negative numbers are defined by SCPI while positive error numbers are device dependent.

Error	Description
0	No error
1	The error couldn't be specified more precisely
3	Device temperature too high
4	General GUI error
5	Authentication required for operation
6	Authentication process failed
7	Operation is not allowed in service mode
8	Operation is allowed in service mode only
11	Not allowed to change value in REMOTE mode
12	Not allowed to modify value in REMOTE mode
13	Not allowed to switch outputs in REMOTE mode
14	Laser head missing
15	Power supply error
17	Over-temperature laser head
20	Operation not allowed while LD output is on
22	INTERLOCK circuit is open
23	KEYLOCK is active
24	Operation not allowed because of a 'OPEN CIRCUIT' condition
25	TEC is off
26	TEC goes off
27	Temperature Protection is active
28	NTC failure - LD output cannot switch on
29	Power supply laser head failure
30	Operation not allowed while interpolation is on
31	Operation not allowed while wavelength interpolation is off
32	Operation not allowed while wavenumber interpolation is off
33	Operation not allowed while power interpolation is off
34	Modulation amplitude is decreased by frequency above specs for sinusoidal shape without NR filter
35	Modulation frequency reduced to maximum for triangle shape without NR filter
36	Modulation frequency reduced to maximum for square shape without NR filter
37	Modulation frequency reduced to maximum for sinusoidal shape without NR filter
38	Modulation frequency reduced to maximum for triangle shape with NR filter
39	Modulation frequency reduced to maximum for square shape with NR filter

Error	Description
50	Operation not allowed while TEC output is on
51	Wrong operating mode for this operation
52	Operation not allowed while a procedure is running
53	Operation not allowed because of a 'SENSOR FAILURE' condition
93	Erroneous connection to thermistor A/D converter
100	I²C wires stuck - bus 0
101	Illegal START/STOP condition - bus 0
102	Slave address not acknowledged (Not a valid bus address?) - bus 0
103	Incomplete write operation (Slave rejected to receive all data in the buffer) - bus 0
104	Arbitration lost - bus 0
110	I²C wires stuck - bus 1
111	Illegal START/STOP condition - bus 1
112	Slave address not acknowledged (Not a valid bus address?) - bus 1
113	Incomplete write operation (Slave rejected to receive all data in the buffer) - bus 1
114	Arbitration lost - bus 1
120	I²C wires stuck - bus 2
121	Illegal START/STOP condition - bus 2
122	Slave address not acknowledged (Not a valid bus address?) - bus 2
123	Incomplete write operation (Slave rejected to receive all data in the buffer) - bus 2
124	Arbitration lost - bus 2
130	EEPROM Timeout
131	EEPROM Check-sum error
132	EEPROM memory address overflow
133	EEPROM memory not supported
134	EEPROM memory not detected
135	EEPROM asynchronous transfer already running
150	MLSC fan controller not responding
151	MLSC fan not spinning
152	MLSC heat sink temperature sensor failure
153	Laser head heat sink temperature sensor failure
154	MLSC over-temperature signal failure
155	Laser head fan controller not responding
156	Laser head fan not spinning

Error	Description
160	External power supply failure
161	Internal analog power supply failure
170	RAM device failure
171	RAM address failure
172	RAM data bus failure
181	Touch controller interrupt signal failure
182	Touch controller command error
183	Touch controller unrecognized command
184	Touch controller unrecognized header
185	Touch controller command time-out
186	Touch panel is not calibrated
187	Touch calibration canceled
188	Touch calibration already running
189	Touch calibration is not running
190	Touch calibration point is out of bounds
200	GUI value not editable
210	Numeric value error
211	Numeric value is at minimum
212	Numeric value is at maximum
213	Entry digit is at minimum
214	Entry digit is at maximum
220	Selection limit reached
230	Value is out of range
251	Values from memory button have been corrected
252	Value not stored in memory button
253	No value stored in memory button
254	Values stored to memory button (hint only)
-100	General command error
-102	Syntax error
-108	Parameter not allowed
-113	Undefined header (Unknown command)
-115	Unexpected number of parameters

Error	Description
-120	Numeric data error
-130	Suffix error
-131	Invalid suffix
-150	String data error
-151	Invalid string data
-220	Parameter error
-221	Settings conflict
-222	Data out of range
-224	Parameter value illegal
-230	Data corrupt or stale
-240	Hardware error
-310	System error
-311	Memory error
-313	Calibration memory lost
-314	Save/recall memory lost
-315	Configuration memory lost
-321	Out of memory
-330	Self-test failed
-350	Queue overflow
-363	Input buffer overrun
-410	Query INTERRUPTED

7 Maintenance and Service

Protect the MIR Laser System from adverse weather conditions. The MIR Laser System is not water resistant.

Attention

To avoid damage to the instrument, do not expose it to spray, liquids or solvents.

The unit does not need a regular maintenance by the user. It does not contain any modules and/or components that could be repaired by the user himself. If a malfunction occurs, please contact Thorlabs for return instructions.

Do not remove covers!

7.1 Version Information

All available information on the MIR Laser System is displayed at power up and can be retrieved from the Information menu as well:

7.2 Firmware Upgrade

In order to proceed a firmware update, the new firmware (file extension *.dfu) and the Thorlabs DFU Wizard are required.

Please download the firmware image from the Thorlabs website
https://www.thorlabs.com/software/MUC/MLQ/TKL_MIR_V1.0.6.zip
and remember the location you have saved it to.

In the next sections you will find a detailed description of all steps that need be executed.

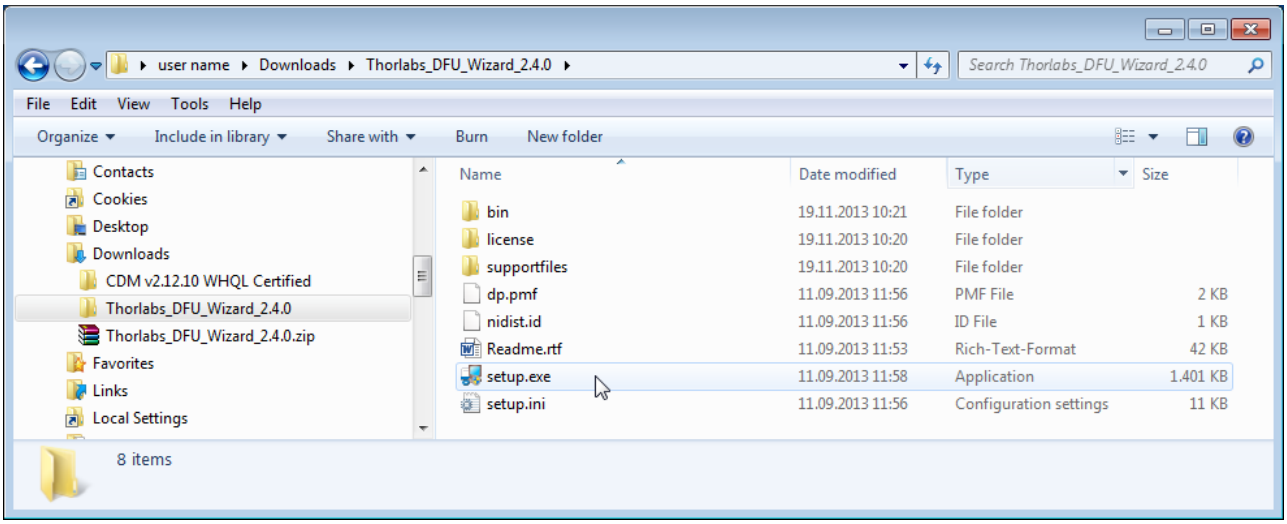
7.2.1 Installing the DFU Wizard

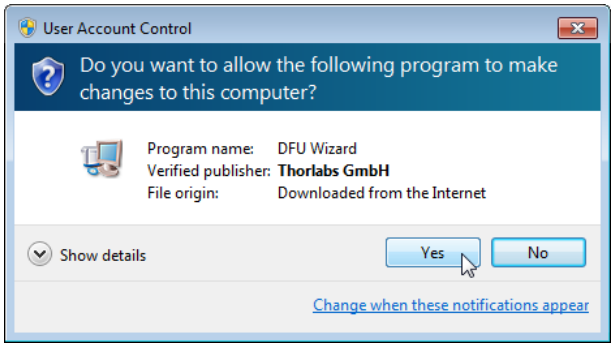
Download the DFU wizard from the Thorlabs web site:

www.thorlabs.com/software/MUC/Utilities/DFU_Wizard/Thorlabs_DFU_Wizard_2.4.0.zip

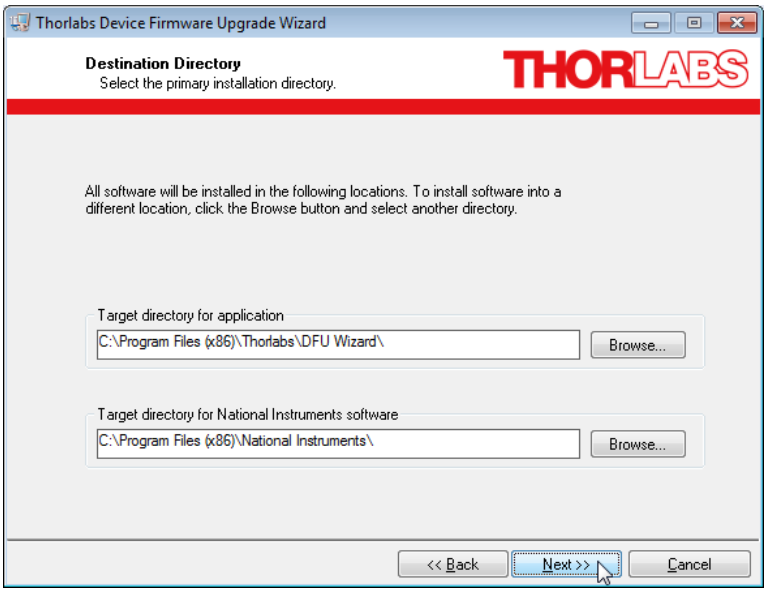
Save the ZIP file and unpack it.

Start the installation by running the setup.exe:

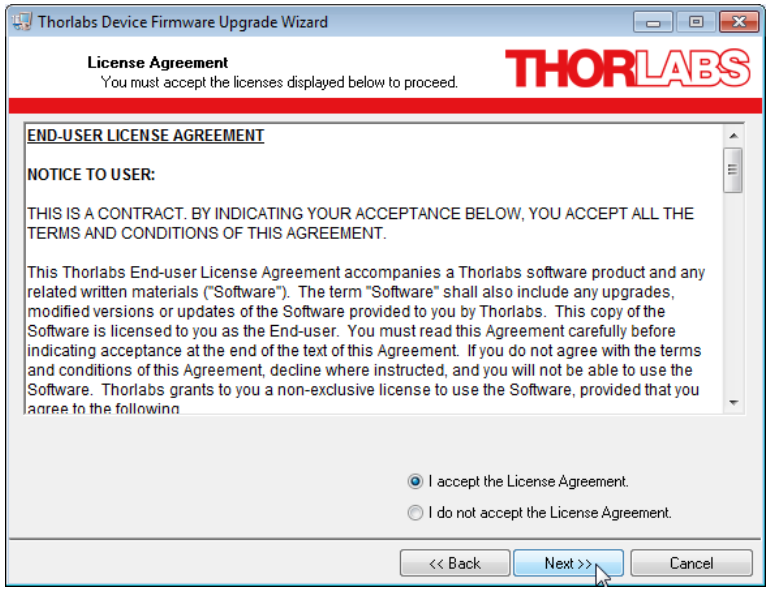




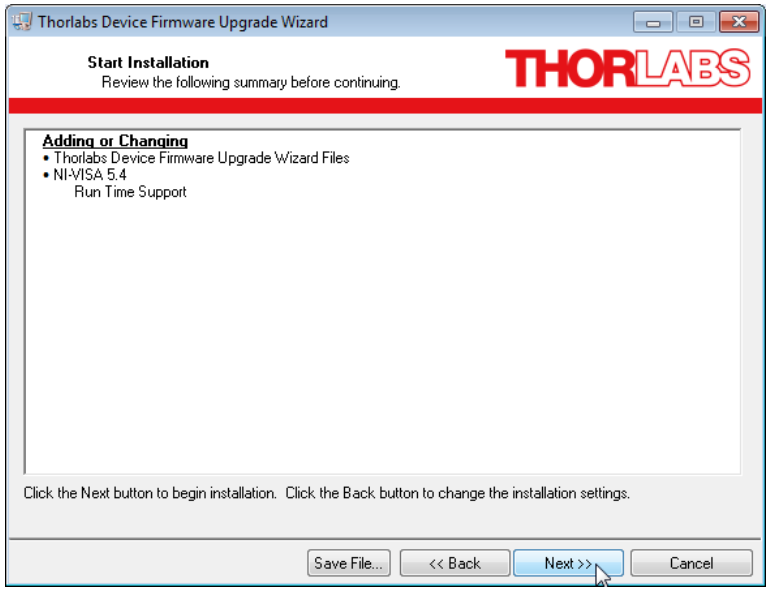
Click 'Yes' to continue.



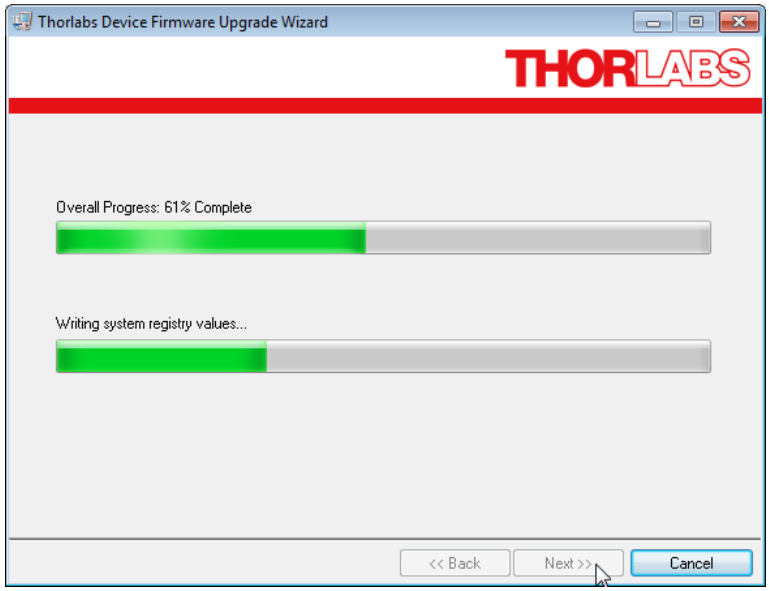
Click "Next>>" to continue.

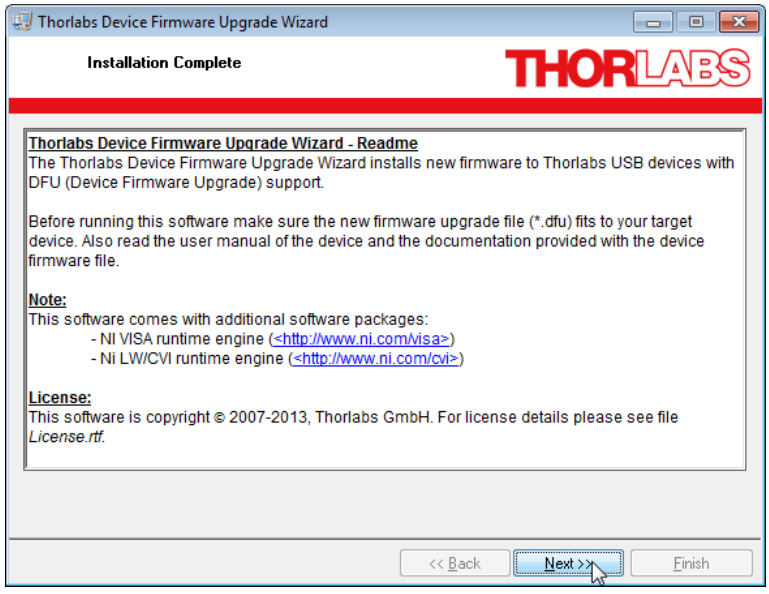


Check "I accept..." if you do so, then 'Next>>' to continue.

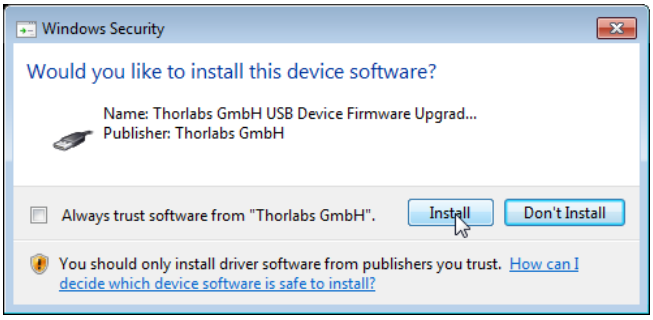


Click 'Next>>' to continue.





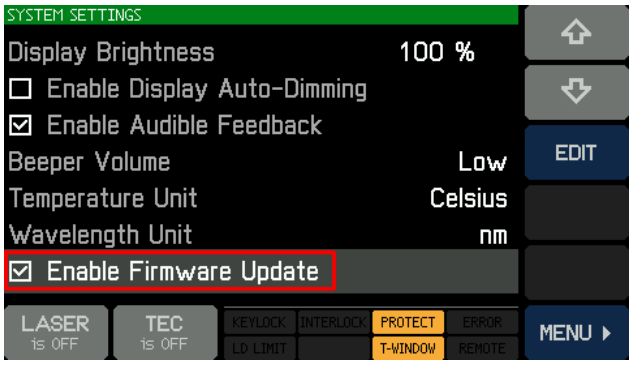
Click 'Next>>' to continue. A DOS command window opens in the background, and you will be asked to allow Windows to install the driver:



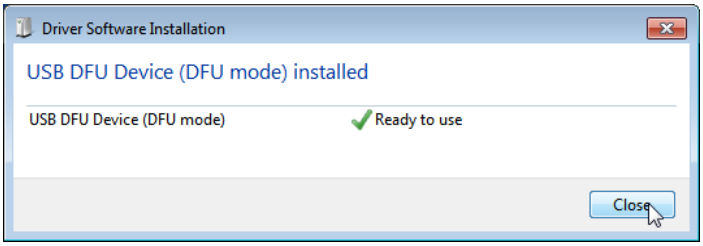
With that, the installation is finished.

7.2.2 Uploading new firmware

As a next step, enable the Firmware Update in the MLSC console:

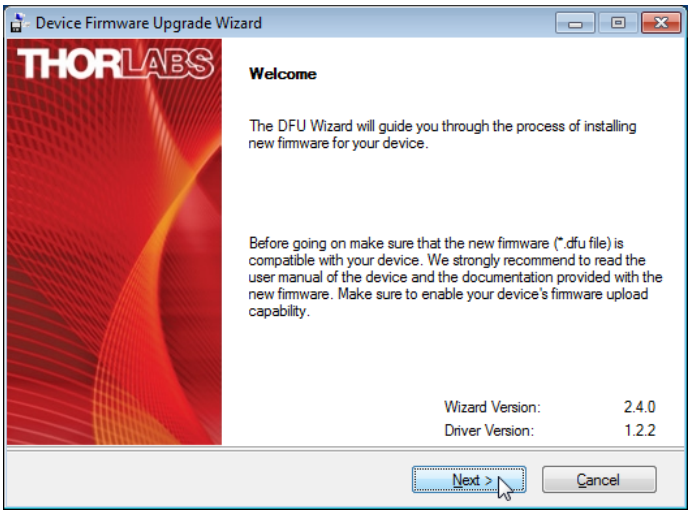


Then connect the MLSC console to the PC via the USB cable. The operating system recognizes a DFU capable device and installs the necessary driver software:

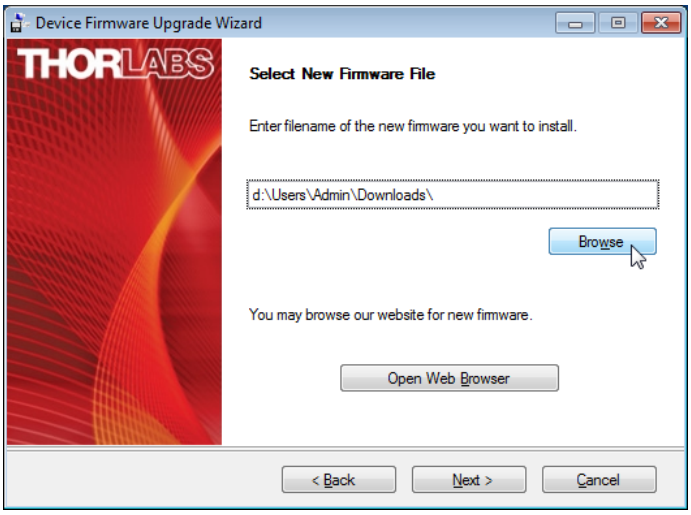


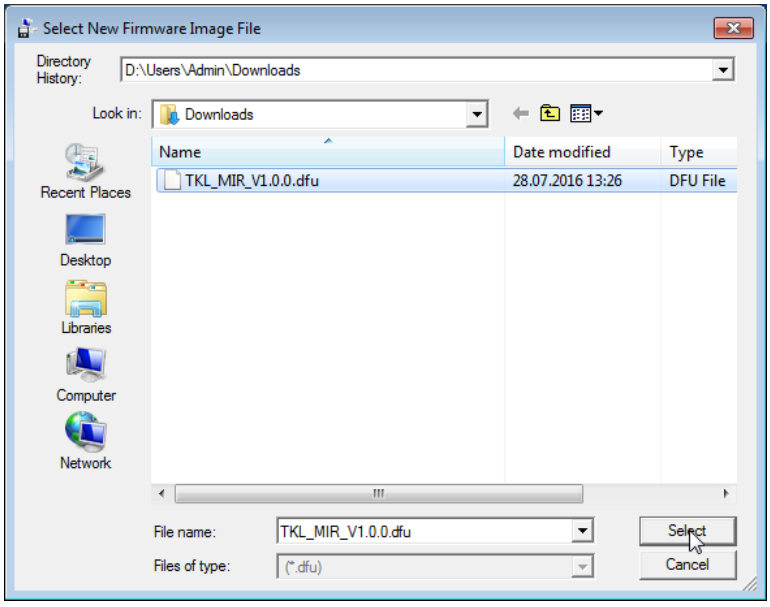
Start from the WINDOWS button All Programs -> Thorlabs -> Device Firmware Upgrade Wizard -> DFU Wizard.

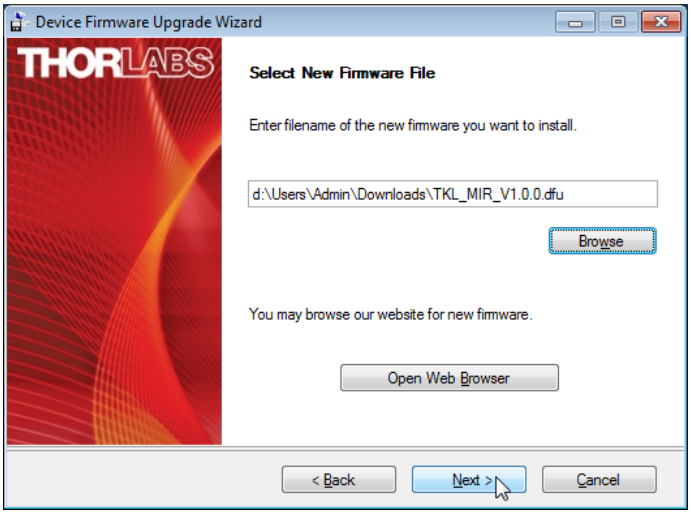
(Can be found also at C:\Program Files\Thorlabs\DFU Wizard\DFU_Wizard.exe).

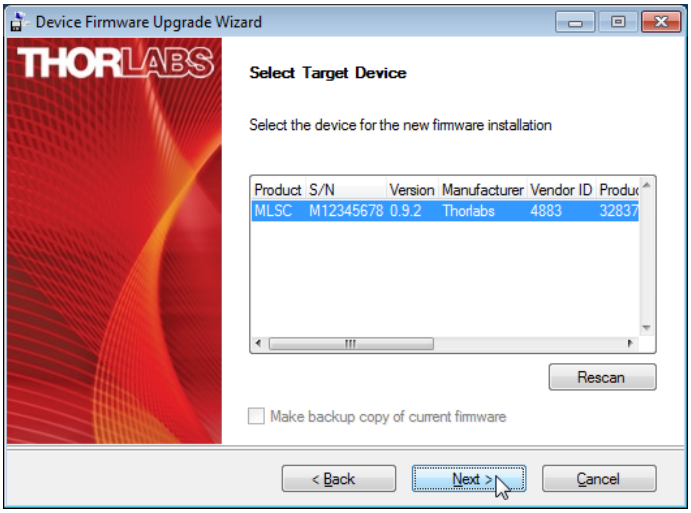


Click 'Next>>' to continue. Select the new firmware to be uploaded and follow the steps as shown in the following screen shots:







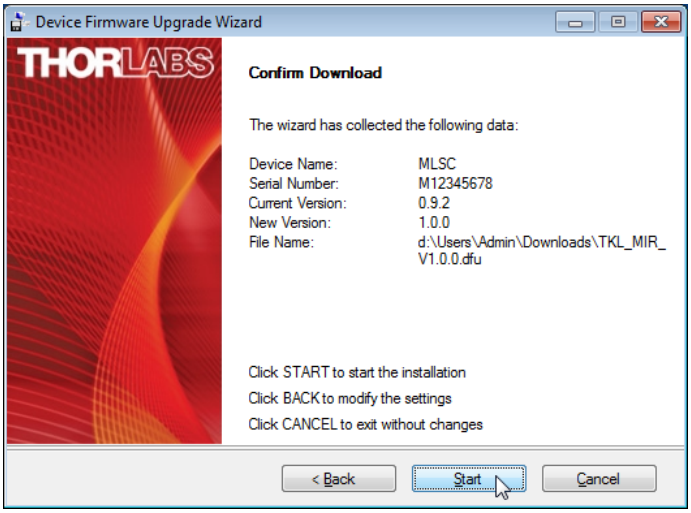


The DFU Wizard recognizes the connected DFU device. If you wish to save a backup copy of the present firmware, check the appropriate box.

Note

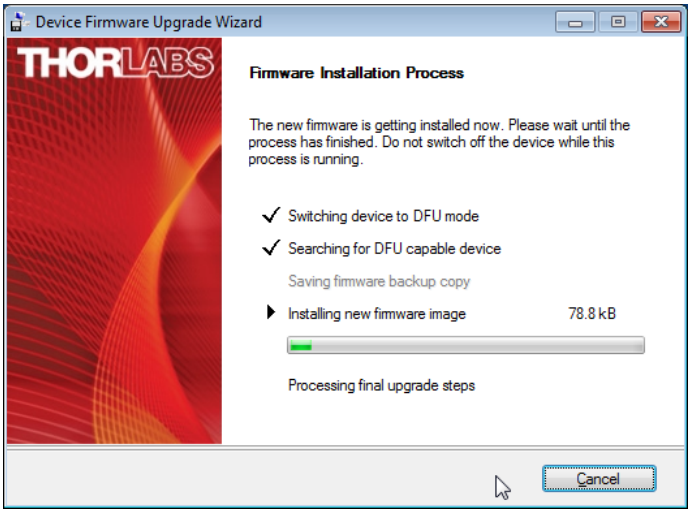
The check box "Make backup copy of current firmware" is disabled for MLSC bootloader versions 3.2.0 and later. These later versions do not support retrieving firmware backups from the MLSC console. In this case, the check box "Make backup copy of current firmware" is disabled.

Click 'Next>>' to continue.

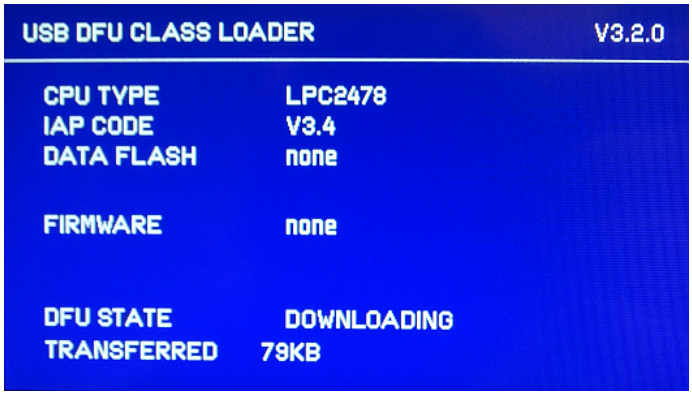


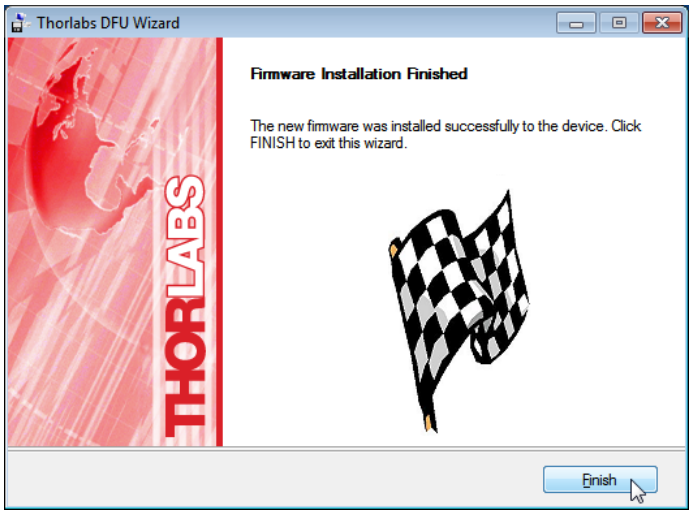
Click 'Start' to proceed with the required actions.

If a backup copy is to be saved, the DFU wizard requests a file location. Select the destination folder and click 'Save'



The DFU Wizard connects to the MLSC console and switches it to the DFU mode, which is reflected in a change of the LCD panel. Information on the DFU state and the process status is now displayed to the screen.





After the firmware is uploaded, the DFU Wizard switches the MLSC console back to normal operation. Click 'Finish' to complete.

7.3 Troubleshooting

Cannot switch on the TEC

- NTC resistance measurement resulted in invalid values (too high or too low values)
- Temperature reading shows "FAILURE" (NTC "OPEN" or "SHORT")

Cannot switch on the laser

- The display shows LASER is PAUSED when the laser is switched on 

  ⇨ In general, the laser can be switched on only
    - if the TEC is switched on,
    - if the actual temperature is within the temperature window,
    - after the Protection Reset Delay time has elapsed and
    - after the Switch-On Delay time has elapsed.
  ⇨ The laser protection feature "Pause Laser" was activated due to laser temperature out of range. The display shows as well PROTECT and T-WINDOW
  ⇨ Switch on TEC. A as soon as the laser temperature falls within the allowed range, the laser switches on automatically.
  ⇨ If the problem persists, this might be caused by a too-narrow temperature window. Example: The laser set temperature is set to 15 °C; the temperature window is 1 °C. When the laser is first turned on, it quickly heats up and briefly exceeds the upper temperature limit of the temperature window. This triggers the protection.
- The display shows PROTECT and T-WINDOW. When trying to switch the laser on, an error message "LD output can't switch on" is displayed.
  ⇨ The laser protection feature "Switch off Laser" was activated due to laser temperature out of range.
  ⇨ Switch on TEC - as soon as the laser temperature is within the allowed range, the PROTECT and T-WINDOW icons are going out. Now, the laser can be switched on.

- The display shows KEYLOCK or INTERLOCK. When trying to switch the laser on, an error message "LD output can't switch on" comes up:
  ⇨ If KEYLOCK: Make sure the key switch (7) is in unlock position
  ⇨ If INTERLOCK: Check interlock circuit.

The display readout for optical power or wavelength is blinking

- This is a normal behavior when an adjustment made to wavelength or power value requires a temperature change. The blinking display readout in such case indicates that the temperature control loop has not settled yet to the new temperature.

Most recent manual settings are not restored after power up

- Some settings were changed, and the MLSC was switched off. After switching it on again, these most recent changes are not restored.
  ⇨ The settings are being saved to a non-volatile memory (EEPROM). In order to protect the EEPROM that has a limited number of write / read cycles, changed settings or parameters are saved only 10 s after the last entry. If switching off the MLSC within less than 10 s after the last entry, these changes are discarded.
    - Wait more that 10 s prior to switching off the MLSC.

8 Appendix

8.1 Technical Data

Specification MLSC Console	Front Panel [1]	Remote Control [1]
Current Control (Constant Current Mode)		
Polarity	Cathode Grounded (CG)	
Control Range	0 to 1.2 A	
Compliance Voltage	20 V	
Resolution	100 µA	20 µA
Accuracy	±(0.1% + 500 µA)	
Noise and Ripple (10 Hz to 10 MHz, rms, typ.) w/o Noise Reduction Filter with Noise Reduction Filter	(Load 33 Ω, current < 600 mA) 10 µA 5 µA	
Drift, 24 hours (0-10 Hz, typ., at Constant Ambient Temp.)	<50 µA	
Temperature Coefficient	<50 ppm/°C	
Current Limit		
Setting Range	10 mA to 1.2 A	
Resolution	100 µA	20 µA
Accuracy	±(0.2% + 1 mA)	
Laser Voltage Measurement		
Resolution	10 mV	1 mV
Accuracy	±(0.2% + 10 mV)	
LD Current External Modulation Bandwidth Small Signal 3dB Bandwidth [2])		
Sine Wave w/o Noise Reduction Filter with Noise Reduction Filter	 DC to 100 kHz DC to 4 kHz	
Triangular Wave w/o Noise Reduction Filter with Noise Reduction Filter	 DC to 40 kHz DC to 1.5 kHz	
Square Wave w/o Noise Reduction Filter with Noise Reduction Filter	 DC to 20 kHz DC to 1 kHz	
Internal Modulation		
Waveforms	Sine, Triangle, Square	
Modulation Current (Peak-to-Peak)	0 mA to LD Current Limit	
Frequency Range Sine w/o Noise Reduction Filter with Noise Reduction Filter	 10 Hz to 100 kHz [3]) 10 Hz to 1 kHz	
Triangular Wave w/o Noise Reduction Filter with Noise Reduction Filter	 10 Hz to 10 kHz 10 Hz to 300 Hz	
Square Wave w/o Noise Reduction Filter with Noise Reduction Filter	 10 Hz to 10 kHz 10 Hz to 300 Hz	

[1]) Via front panel the resolution is limited by the display. Via Remote Control a higher resolution is offered.
[2]) Measured with resistive load 5 Ω.
[3]) At frequencies ≤ 30 kHz, the modulation current amplitude remains within ±5 % of the user-set value. Beyond 30 kHz, this tolerance worsens, up to a max. of 3 dB. A warning displays when 30 kHz is exceeded.
All technical data are valid at 23 ± 5°C and 45 ± 15% rel. humidity (non condensing)

Specification MLSC Console	Front Panel [1]	Remote Control [1]
External Modulation Input		
Input Impedance	10 kΩ	
Input Voltage	0 to ±10 V	
Modulation Coefficient Sensitivity LOW Sensitivity HIGH	 12 mA/V ±5 % 120 mA/V ±5 %	
TUNE Input		
Input Impedance	10 kΩ	
Input Voltage	0 to ±10 V	
Modulation Coefficient	6 mA/V ±5 %	
SYNC Output		
Logic Level	TTL	
LOW Level	< 0.3 V	
HIGH Level 50 Ω Load 10 kΩ Load	 > 2.5 V > 3.5 V	
Laser Output Delay related to SYNC OUT w/o Noise Reduction Filter with Noise Reduction Filter	 3 µs 30 µs	
TEC Current Output		
Control Range	-5.0 A to +5.0 A	
Compliance Voltage	15 V	
Max. Output Power	75 W	
Resolution	1 mA	100 µA
Accuracy	± (0.2% + 20 mA)	
TEC Current Limit		
Setting Range	50 mA to 5.0 A	
Resolution	1 mA	100 µA
Accuracy	± (0.2% + 20 mA)	

[1]) Via front panel the resolution is limited by the display. Via Remote Control a higher resolution is offered.
All technical data are valid at 23 ± 5°C and 45 ± 15% rel. humidity (non condensing)

Specification MLSC Console	Front Panel [1]	Remote Control [1]
NTC Thermistor Sensors		
Resistance Measurement Range	300 Ω to 150 kΩ	
Control Range Max. [4])	0 °C to +50 °C	
Temperature Resolution	0.01 °C	
Resistance Resolution	1 Ω	
Accuracy	± (0.1% + 1 Ω)	
Temperature Stability, 24 hrs, typ. [4])	<0.005 °C	
Temperature Coefficient	<5 mK/°C	
Temperature Window Protection		
Setting Range T_{win}	0.01 °C to 25.0 °C	
Protection Reset Delay	0 to 600 s	
Interface		
USB2.0	According to USBTMC/USBTMC-USB488 Specification Rev. 1.0	
Protocol	SCPI Compliant Command Set	

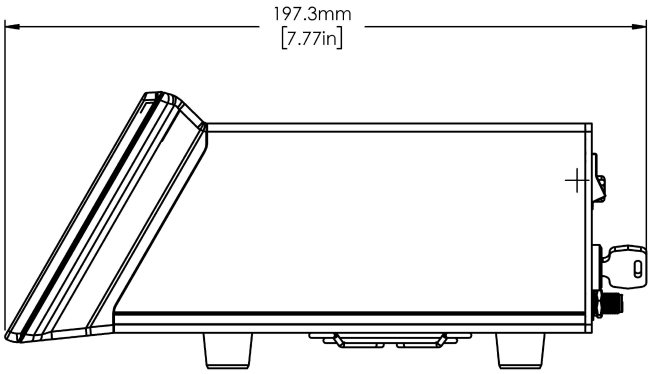
[1]) Via front panel the resolution is limited by the display. Via Remote Control a higher resolution is offered.
[4]) Control range and thermal stability depend on thermistor parameters and operating point.
All technical data are valid at 23 ± 5°C and 45 ± 15% rel. humidity (non condensing)

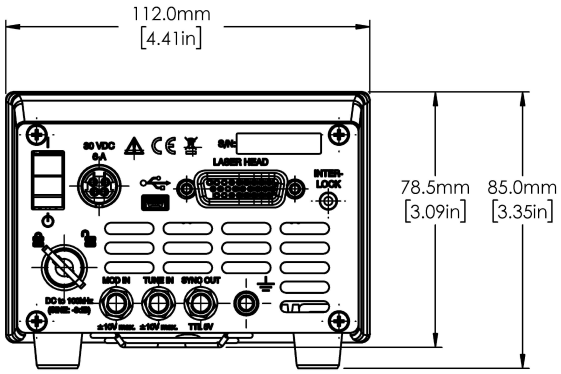
General Data MLSC Controller	
Safety Features	• Interlock • Keylock Switch • Laser Current Limit • Soft Start • Over Temperature Protection • Temperature Window Protection • Switch-On Delay (3 to 60 sec.)
Display	4.3 " LCD TFT, 480 x 272 Pixel
Connector for DC Power Input	Mini DIN 4 Pin
Connector for External Modulation Input	SMA
Connector for TUNE Input	SMA
Connector for SYNC Output	SMA
Connector for Interlock & Laser On Signal	2.5 mm Mono Phone Jack
Connector for USB-Interface	USB Type Mini-B
Chassis Ground Connector	4 mm Banana Jack
Desktop Power Supply	AC: 100 to 240 V ±10%, 47 to 63 Hz DC: 30 V / 6.0 A
Maximum Power Consumption	180 VA
Operating Temperature [1])	0 to +40 °C
Storage Temperature	- 40 to +70°C
Warm-up Time for Rated Accuracy	30 min
Overall dimensions (W x H x D)	112.0 x 85.0 x 197.2 [mm] (4.41 x 3.35 x 7.77 [in])
General Data Laser Head	
Overall dimensions (W x H x D)	114.0 x 132.8 x 208.4 [mm] (4.49 x 5.23 x 8.21 [in])
Operating Temperature [1]) [2])	+15 to +35 °C
Storage Temperature	0 to +50 °C
General Data	
Total System Weight (MLSC, Laser Head, Power Supply)	5.9 kg

[1]) non-condensing

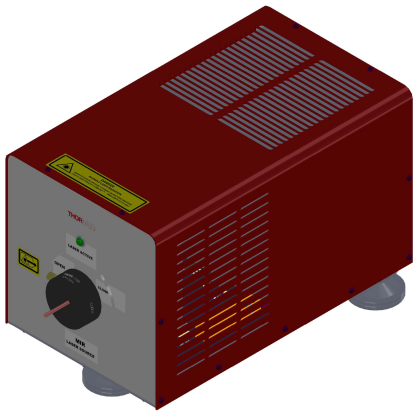
[2]) This temperature range is for the ambient room temperature.
All technical data are valid at 23 ± 5°C and 45 ± 15% rel. humidity (non condensing)

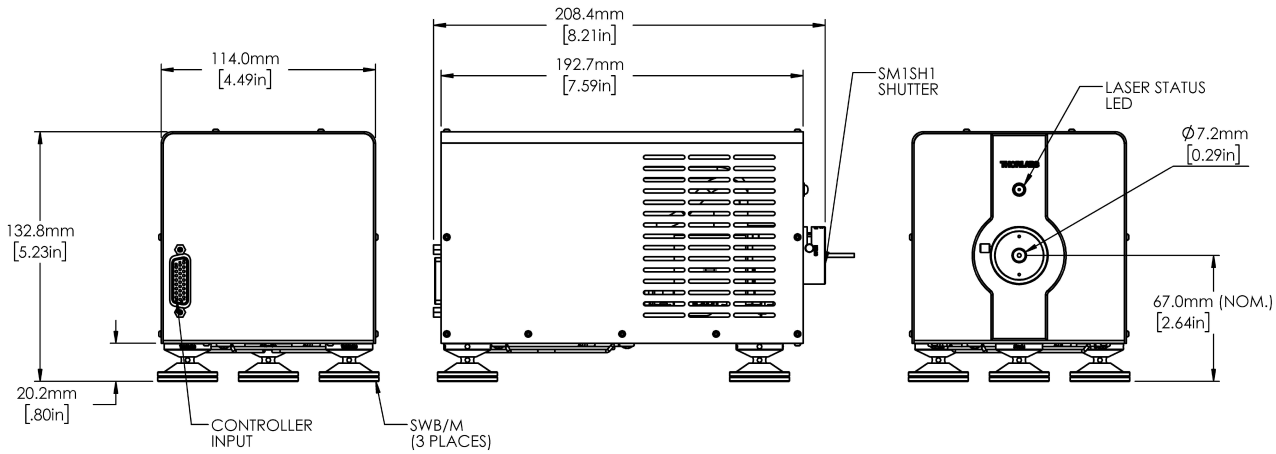
8.2 Dimensions MLSC





8.3 Dimensions Laser Head





8.4 Tutorial

ICL

Stands for Interband Cascade Lasers. These devices, composed of multiple quantum well heterostructures, utilize interband transitions in order to access the mid-infrared spectral region.

QCL

Stands for Quantum Cascade Lasers. These devices, composed of multiple quantum well heterostructures, utilize intersubband transitions in order to access the mid-infrared spectral region.

Fabry-Perot Lasers

Fabry-Perot Quantum Cascade Lasers and Interband Cascade Lasers exhibit broadband emission in a range spanning roughly 50 cm^{-1}. The laser's specified output power is the sum over the full spectral bandwidth. Because these lasers have broadband emission, they are well suited for medical imaging, illumination, and microscopy applications. The measured output spectrum and L-I-V curve of each serial-numbered Thorlabs device is available from the web site and is also included on a data sheet with the laser.

Though these QCLs and ICLs are specified for CW output, they are compatible with pulsed applications. To order a Fabry-Perot QCL or ICL with a tested and specified pulsed optical power or other custom features, please contact Thorlabs.

Distributed Feedback Lasers

Distributed Feedback Quantum Cascade Lasers emit at a single wavelength. By tuning the input current, the output frequency can be tuned over a narrow range between 2 cm^{-1} and 5 cm^{-1}. Because these lasers have a single wavelength, they are ideal for chemical sensing (see the Spectroscopy tab), optical communications, and other applications. The measured output spectrum, power, and L-I-V curve of each serial-numbered device is available from the web site and is also included on a data sheet with the laser. These QCLs are specified for CW output. While pulsed output is possible, this application prohibits current tuning, and performance is not guaranteed.

Wavenumbers

In the physical sciences, the wavenumber (also wave number) is the spatial frequency of a wave, either in cycles per unit distance or radians per unit distance. It can be envisaged as the number of waves that exist over a specified distance (analogous to frequency being the number of cycles or radians per unit time).

Wavenumber can be used to specify quantities other than spatial frequency. In optical spectroscopy, it is often used as a unit of temporal frequency assuming a certain speed of light. In this context, it is the number of cycles - not radians - per unit length, and the reference distance should be assumed to be cm. [1]

Important things to know about modulation

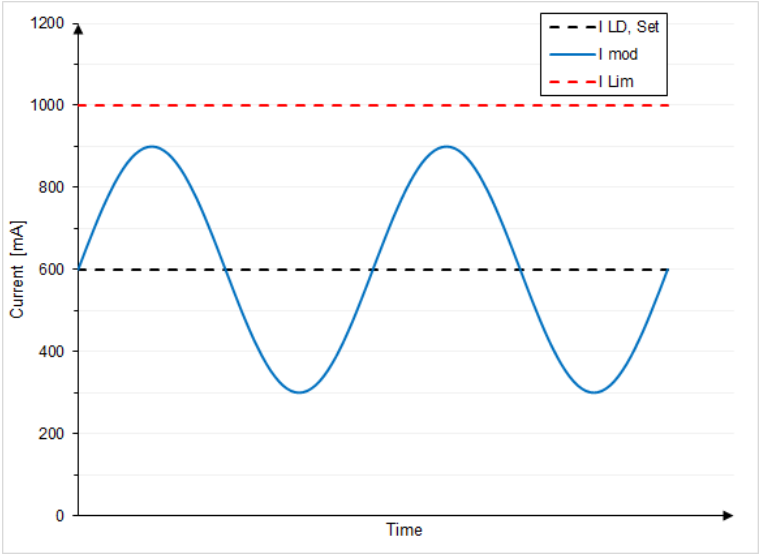
There are two ways to modulate the laser current - internally and externally.

In internal modulation mode, the internal generator delivers a modulation current with a defined shape (waveform), while in external modulation mode the modulation current is proportional to the applied external modulation voltage.

The resulting modulated current is superposed to the laser setpoint current. In order to avoid clipping of the modulated laser current, it is important to adjust the modulation current amplitude in such way, that the resulting current

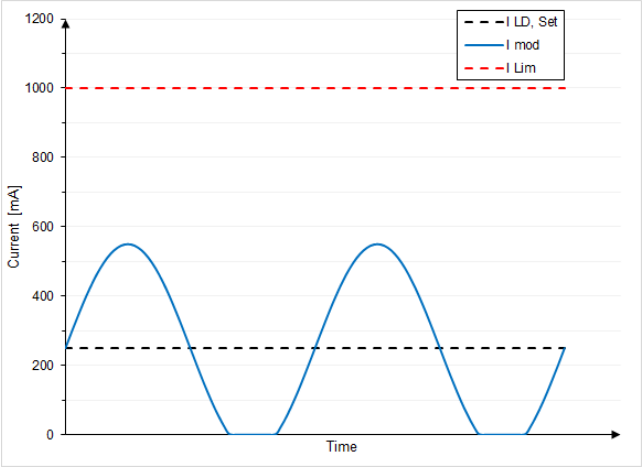
- does not exceed the laser user current limit that is adjusted in the Laser Setup panel
- does not underrun a zero current.

The diagram below shows an example of correct settings:

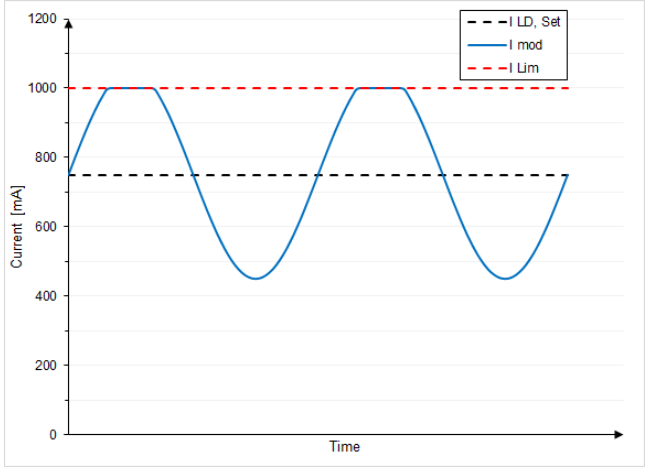


Laser User Current limit = 1000 mA
Laser Current Setpoint = 600 mA
Modulation Current Amplitude = 600 mA (peak-to-peak)

The diagrams below show examples settings that lead to laser current clipping:



Laser User Current limit = 1000 mA
Laser Current Setpoint = 250 mA
Modulation Current Amplitude = 600 mA (peak-to-peak)



Laser User Current limit = 1000 mA
Laser Current Setpoint = 750 mA
Modulation Current Amplitude = 600 mA (peak-to-peak)

Expressed mathematically, the settings are:

- for internal modulation:

$$I_{LD,Set} - I_{Mod,max} / 2 > 0 \quad \text{and} \quad I_{LD,Set} + I_{Mod,max} / 2 < I_{LD,Lim}$$

with: $I_{LD,Set}$ - Laser current setpoint

$I_{LD,Lim}$ - Laser limit current

$I_{Mod,max}$ - Peak-to-peak magnitude of internal modulation as set in the MLSC

- for external modulation:

$$I_{LD,Set} - m * U_{Mod,max} > 0 \quad \text{and} \quad I_{LD,Set} + m * U_{Mod,max} < I_{LD,Lim}$$

with: $I_{LD,Set}$ - Laser current setpoint

$I_{LD,Lim}$ - Laser limit current

m - Modulation coefficient

$U_{Mod,max}$ - Amplitude of the applied external modulation voltage

Note

The modulation coefficient depends on the setting of the external modulation sensitivity!

8.5 Certifications and Compliances

EU Declaration of Conformity

in accordance with EN ISO 17050-1:2010

We: Thorlabs Inc.

Of: 56 Sparta Avenue, Newton, New Jersey, 07860, USA

in accordance with the following Directive(s):

2014/35/EU	Low Voltage Directive (LVD)
2014/30/EU	Electromagnetic Compatibility (EMC) Directive
2011/65/EU	Restriction of Use of Certain Hazardous Substances (RoHS)

hereby declare that:

Model: ***MLQD4500, MLQF4550 and MLQF4000***

Equipment: ***MIR Laser System***

is in conformity with the applicable requirements of the following documents:

EN 61010-1	Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use.	2010
EN 61326-1	Electrical Equipment for Measurement, Control and Laboratory Use - EMC Requirements	2013
EN 60825-1	Safety of laser products	2014

and which, issued under the sole responsibility of Thorlabs, is in conformity with Directive 2011/65/EU of the European Parliament and of the Council of 8th June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, for the reason stated below:

does not contain substances in excess of the maximum concentration values tolerated by weight in homogenous materials as listed in Annex II of the Directive

I hereby declare that the equipment named has been designed to comply with the relevant sections of the above referenced specifications, and complies with all applicable Essential Requirements of the Directives.

Signed: *On:* 13 May 2016

Name: Ann Strachan

Position: Compliance Manager

EDC - MLQD4500, MLQF4550 and MLQF4...

CE

8.6 Warranty

Thorlabs warrants material and production of the MIR Laser System for a period of 24 months starting with the date of shipment. During this warranty period Thorlabs will see to defaults by repair or by exchange if these are entitled to warranty.

For warranty repairs or service the unit must be sent back to Thorlabs. The customer will carry the shipping costs to Thorlabs, in case of warranty repairs Thorlabs will carry the shipping costs back to the customer.

If no warranty repair is applicable the customer also has to carry the costs for back shipment.

In case of shipment from outside EU duties, taxes etc. which should arise have to be carried by the customer.

Thorlabs warrants the hard- and/or software determined by Thorlabs for this unit to operate fault-free provided that they are handled according to our requirements. However, Thorlabs does not warrant a fault free and uninterrupted operation of the unit, of the software or firmware for special applications nor this instruction manual to be error free. Thorlabs is not liable for consequential damages.

Restriction of Warranty

The warranty mentioned before does not cover errors and defects being the result of improper treatment, software or interface not supplied by us, modification, misuse or operation outside the defined ambient stated by us or unauthorized maintenance.

Further claims will not be consented to and will not be acknowledged. Thorlabs does explicitly not warrant the usability or the economical use for certain cases of application.

Thorlabs reserves the right to change this instruction manual or the technical data of the described unit at any time.

8.7 Copyright and Exclusion of Reliability

Thorlabs has taken every possible care in preparing this document. We however assume no liability for the content, completeness or quality of the information contained therein. The content of this document is regularly updated and adapted to reflect the current status of the hardware and/or software. We furthermore do not guarantee that this product will function without errors, even if the stated specifications are adhered to.

Under no circumstances can we guarantee that a particular objective can be achieved with the purchase of this product.

Insofar as permitted under statutory regulations, we assume no liability for direct damage, indirect damage or damages suffered by third parties resulting from the purchase of this product. In no event shall any liability exceed the purchase price of the product.

Please note that the content of this document is neither part of any previous or existing agreement, promise, representation or legal relationship, nor an alteration or amendment thereof. All obligations of *Thorlabs* result from the respective contract of sale, which also includes the complete and exclusively applicable warranty regulations. These contractual warranty regulations are neither extended nor limited by the information contained in this document. Should you require further information on this product, or encounter specific problems that are not discussed in sufficient detail in the document, please contact your local *Thorlabs* dealer or system installer.

8.8 Thorlabs 'End of Life' Policy (WEEE)

As required by the WEEE (Waste Electrical and Electronic Equipment Directive) of the European Community and the corresponding national laws, Thorlabs offers all end users in the EC the possibility to return “end of life” units without incurring disposal charges.

This offer is valid for Thorlabs electrical and electronic equipment

- sold after August 13th 2005
- marked correspondingly with the crossed out “wheelie bin” logo (see figure below)
- sold to a company or institute within the EC
- currently owned by a company or institute within the EC
- still complete, not disassembled and not contaminated

As the WEEE directive applies to self contained operational electrical and electronic products, this “end of life” take back service does not refer to other Thorlabs products, such as

- pure OEM products, that means assemblies to be built into a unit by the user (e. g. OEM laser driver cards)
- components
- mechanics and optics
- left over parts of units disassembled by the user (PCB’s, housings etc.).

Waste treatment on your own responsibility

If you do not return an “end of life” unit to Thorlabs, you must hand it to a company specialized in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

WEEE Number (Germany) : DE97581288

Ecological background

It is well known that waste treatment pollutes the environment by releasing toxic products during decomposition. The aim of the European RoHS Directive is to reduce the content of toxic substances in electronic products in the future.

The intent of the WEEE Directive is to enforce the recycling of WEEE. A controlled recycling of end-of-life products will thereby avoid negative impacts on the environment.

Crossed out "Wheelie Bin" symbol

8.9 List of Acronyms; Literature

The following acronyms and abbreviations are used in this manual:

AC	Alternating Current
CDRH	Center for Devices and Radiological Health
DC	Direct Current
DFB	Distributed Feedback
DFU	Device Firmware Upgrade
ESD	Electrostatic discharges
FP	Fabry-Perot
GND	Ground
GUI	Graphic User Interface
I²C	Inter-Integrated Circuit
ICL	Interband Cascade Laser
LCD	Liquid Crystal Display
LD	Laser Diode
µC	Micro-Controller
MIR	Mid-Infrared
MLSC	MIR Laser System Controller
NR	Noise Reduction (filter)
NTC	Negative Temperature Coefficient (synonym for thermistor)
PCB	Printed Circuit Board
PD	Photo Diode
PID	Proportional-Integral-Derivative
QCL	Quantum Cascade Laser
SCPI	Standard Commands for Programmable Instruments
TEC	Thermoelectric cooler
USB	Universal Serial Bus
USB TMC	USB Test and Measurement Class (device)

Literature

[1] Wikipedia Creative Commons Attribution - ShareAlike 3.0

8.10 Thorlabs Worldwide Contacts

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